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Audio/video, information and communication technology equipment – Part 1: Safety requirements

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

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

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CONTENTS

FOREWORD 20
INTRODUCTION 23
0 Principles of this product safety standard 23
0.1 Objective 23
0.2 Persons 23
0.2.1 General 23
0.2.2 Ordinary person 23
0.2.3 Instructed person 23
0.2.4 Skilled person 23
0.3 Model for pain and injury 24
0.4 Energy sources 24
0.5 Safeguards 25
0.5.1 General 25
0.5.2 Equipment safeguard 26
0.5.3 Installation safeguard 26
0.5.4 Personal safeguard 26
0.5.5 Behavioural safeguards 27
0.5.6 Safeguards during ordinary or instructed person service conditions 28
0.5.7 Equipment safeguards during skilled person service conditions 28
0.5.8 Examples of safeguard characteristics 28
0.6 Electrically-caused pain or injury (electric shock) 29
0.6.1 Models for electrically-caused pain or injury 29
0.6.2 Models for protection against electrically-caused pain or injury 30
0.7 Electrically-caused fire 31
0.7.1 Models for electrically-caused fire 31
0.7.2 Models for protection against electrically-caused fire 31
0.8 Injury caused by hazardous substances 32
0.9 Mechanically-caused injury 32
0.10 Thermally-caused injury (skin burn) 33
0.10.1 Models for thermally-caused injury 33
0.10.2 Models for protection against thermally-caused pain or injury 34
0.11 Radiation-caused injury 35
1 Scope 36
2 Normative references 38
3 Terms, definitions and abbreviated terms 45
3.1 Energy source abbreviations 45
3.2 Other abbreviations 46
3.3 Terms and definitions 47
3.3.1 Circuit terms 50
3.3.2 Enclosure terms 50
3.3.3 Equipment terms 51
3.3.4 Flammability terms 52
3.3.5 Electrical insulation 54
3.3.6 Miscellaneous 54
3.3.7 Operating and fault conditions 56
3.3.8 Persons 58

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3.3.9 Potential ignition sources 58
3.3.10 Ratings 58
3.3.11 Safeguards 59
3.3.12 Spacings 61
3.3.13 Temperature controls 61
3.3.14 Voltages and currents 61
3.3.15 Classes of equipment with respect to protection from electric shock 62
3.3.16 Chemical terms 63
3.3.17 Batteries 64
3.3.18 FIW terms 65
3.3.19 Sound exposure 65
4 General requirements 66
4.1 General 66
4.1.1 Application of requirements and acceptance of materials, components and subassemblies 66
4.1.2 Use of components 66
4.1.3 Equipment design and construction 67
4.1.4 Equipment installation 67
4.1.5 Constructions and components not specifically covered 67
4.1.6 Orientation during transport and use 67
4.1.7 Choice of criteria 68
4.1.8 ~~Conductive liquids~~ Liquids and liquid filled components (LFC) 68
4.1.9 Electrical measuring instruments 68
4.1.10 Temperature measurements 68
4.1.11 Steady state conditions 69
4.1.12 Hierarchy of safeguards 69
4.1.13 Examples mentioned in this document 69
4.1.14 Tests on parts or samples separate from the end-product 69
4.1.15 Markings and instructions 69
4.2 Energy source classifications 69
4.2.1 Class 1 energy source 69
4.2.2 Class 2 energy source 70
4.2.3 Class 3 energy source 70
4.2.4 Energy source classification by declaration 70
4.3 Protection against energy sources 70
4.3.1 General 70
4.3.2 Safeguards for protection of an ordinary person 70
4.3.3 Safeguards for protection of an instructed person 72
4.3.4 Safeguards for protection of a skilled person 73
4.3.5 Safeguards in a restricted access area 74
4.4 Safeguards 74
4.4.1 Equivalent materials or components 74
4.4.2 Composition of a safeguard 74
~~Accessible parts of a safeguard~~ .....
4.4.3 Safeguard robustness 74
4.4.4 Displacement of a safeguard by an insulating liquid 77
4.4.5 Safety interlocks 77
4.5 Explosion 77
4.5.1 General 77

IECNORM.COM : Click to view the full PDF of IEC 62368-1:ed 3.0 (RLV):2018

4.5.2 Requirements 78
4.6 Fixing of conductors 78
4.6.1 Requirements 78
4.6.2 Compliance criteria 78
4.7 Equipment for direct insertion into mains socket-outlets 78
4.7.1 General 78
4.7.2 Requirements 78
4.7.3 Compliance criteria 79
4.8 ~~Products~~ Equipment containing ~~lithium~~ coin / button cell batteries 79
4.8.1 General 79
4.8.2 Instructional safeguard 79
4.8.3 Construction 80
4.8.4 Tests 80
4.8.5 Compliance criteria 81
4.9 Likelihood of fire or shock due to entry of conductive objects 81
4.10 Components requirements 82
4.10.1 Disconnect device 82
4.10.2 Switches and relays 82
5 Electrically-caused injury 82
5.1 General 82
5.2 Classification and limits of electrical energy sources 82
5.2.1 Electrical energy source classifications 82
5.2.2 Electrical energy source ES1 and ES2 limits 83
5.3 Protection against electrical energy sources 88
5.3.1 General 88
5.3.2 Accessibility to electrical energy sources and safeguards 88
5.4 Insulation materials and requirements 91
5.4.1 General 91
5.4.2 Clearances 96
5.4.3 Creepage distances 106
5.4.4 Solid insulation 110
5.4.5 Antenna terminal insulation 120
5.4.6 Insulation of internal wire as a part of a supplementary safeguard 121
5.4.7 Tests for semiconductor components and for cemented joints 121
5.4.8 Humidity conditioning 122
5.4.9 Electric strength test 122
5.4.10 Safeguards against transient voltages from external circuits 126
5.4.11 Separation between external circuits and earth 128
5.4.12 Insulating liquid 129
5.5 Components as safeguards 130
5.5.1 General 130
5.5.2 Capacitors and RC units 130
5.5.3 Transformers 131
5.5.4 Optocouplers 131
5.5.5 Relays 132
5.5.6 Resistors 132
5.5.7 SPDs 133
5.5.8 Insulation between the mains and an external circuit consisting of a coaxial cable 134

IECNORM.COM : Click to view the full PDF of IEC 62368-1:2018 RLV:2018

5.5.9 Safeguards for socket-outlets in outdoor equipment 134
5.6 Protective conductor 134
5.6.1 General 134
5.6.2 Requirements for protective conductors 134
5.6.3 Requirements for protective earthing conductors 135
5.6.4 Requirements for protective bonding conductors 136
5.6.5 Terminals for protective conductors 138
5.6.6 Resistance of the protective bonding system 139
5.6.7 Reliable connection of a protective earthing conductor 141
5.6.8 Functional earthing 141
5.7 Prospective touch voltage, touch current and protective conductor current 142
5.7.1 General 142
5.7.2 Measuring devices and networks 142
5.7.3 Equipment set-up, supply connections and earth connections 142
5.7.4 Unearthed accessible parts 142
5.7.5 Earthed accessible conductive parts 143
~~Protective conductor current~~ .....
5.7.6 Requirements when touch current exceeds ES2 limits 143
5.7.7 Prospective touch voltage and touch current ~~due to~~ associated with external circuits 144
5.7.8 Summation of touch currents from external circuits 146
5.8 Backfeed safeguard in battery backed up supplies 147
6 Electrically-caused fire 148
6.1 General 148
6.2 Classification of power sources (PS) and potential ignition sources (PIS) 148
6.2.1 General 148
6.2.2 Power source circuit classifications 148
6.2.3 Classification of potential ignition sources 151
6.3 Safeguards against fire under normal operating conditions and abnormal operating conditions 152
6.3.1 Requirements 152
6.3.2 Compliance criteria 153
6.4 Safeguards against fire under single fault conditions 153
6.4.1 General 153
6.4.2 Reduction of the likelihood of ignition under single fault conditions in PS1 circuits 154
6.4.3 Reduction of the likelihood of ignition under single fault conditions in PS2 circuits and PS3 circuits 154
6.4.4 Control of fire spread in PS1 circuits 156
6.4.5 Control of fire spread in PS2 circuits 156
6.4.6 Control of fire spread in a PS3 circuit 157
6.4.7 Separation of combustible materials from a PIS 158
6.4.8 Fire enclosures and fire barriers 161
6.4.9 Flammability of an insulating liquid 168
6.5 Internal and external wiring 168
6.5.1 General requirements 168
~~Compliance criteria~~ .....
6.5.2 Requirements for interconnection to building wiring. 169
~~Compliance criteria~~ .....
6.5.3 Internal wiring for socket-outlets 169

IECNORM.COM : Click to view the full PDF of IEC 62368-1 ed 3.0 (RLV):2018

6.6 Safeguards against fire due to the connection of additional equipment 170
7 Injury caused by hazardous substances 170
7.1 General 170
7.2 Reduction of exposure to hazardous substances 170
7.3 Ozone exposure 170
7.4 Use of personal safeguards or personal protective equipment (PPE) 171
7.5 Use of instructional safeguards and instructions 171
7.6 Batteries and their protection circuits 171
8 Mechanically-caused injury 171
8.1 General 171
8.2 Mechanical energy source classifications 171
8.2.1 General classification 171
8.2.2 MS1 173
8.2.3 MS2 174
8.2.4 MS3 174
8.3 Safeguards against mechanical energy sources 174
8.4 Safeguards against parts with sharp edges and corners 174
8.4.1 Requirements 174
8.4.2 Compliance criteria 174
8.5 Safeguards against moving parts 175
8.5.1 Requirements 175
8.5.2 Instructional safeguard requirements 176
8.5.3 Compliance criteria 176
8.5.4 Special categories of equipment ~~comprising~~ containing moving parts 176
8.5.5 High pressure lamps 182
8.6 Stability of equipment 182
8.6.1 Requirements 182
8.6.2 Static stability 184
8.6.3 Relocation stability ~~test~~ 185
8.6.4 Glass slide ~~test~~ 186
8.6.5 Horizontal force test and compliance criteria 186
8.7 Equipment mounted to a wall, ceiling or other structure 186
8.7.1 Requirements 186
8.7.2 Test methods ~~and compliance criteria~~ 187
8.7.3 Compliance criteria 188
8.8 Handle strength 188
8.8.1 General 188
8.8.2 Test method 189
8.9 Wheels or casters attachment requirements 189
8.9.1 General 189
8.9.2 Test method 189
8.10 Carts, stands, and similar carriers 190
8.10.1 General 190
8.10.2 Marking and instructions 190
8.10.3 Cart, stand or carrier loading test and compliance criteria 191
8.10.4 Cart, stand or carrier impact test 191
8.10.5 Mechanical stability 191
8.10.6 Thermoplastic temperature stability 192

IECNORM.COM : Click to view the full PDF of IEC 62368-1 ed 3.0 (RLV):2018

8.11 Mounting means for ~~rack mounted equipment~~ slide-rail mounted equipment (SRME) 192
8.11.1 General 192
8.11.2 Requirements 192
8.11.3 Mechanical strength test 193
8.11.4 Compliance criteria 194
8.12 Telescoping or rod antennas 194
9 Thermal burn injury 194
9.1 General 194
9.2 Thermal energy source classifications 194
~~General ..... ~~
9.2.1 TS1 195
9.2.2 TS2 195
9.2.3 TS3 195
9.3 Touch temperature limits 195
9.3.1 Requirements 195
9.3.2 Test method and compliance criteria 195
~~Touch temperature levels ..... ~~
9.4 Safeguards against thermal energy sources 197
9.5 Requirements for safeguards 198
9.5.1 Equipment safeguard 198
9.5.2 Instructional safeguard 198
9.6 Requirements for wireless power transmitters 199
9.6.1 General 199
9.6.2 Specification of the foreign objects 199
9.6.3 Test method and compliance criteria 201
10 Radiation 202
10.1 General 202
10.2 Radiation energy source classifications 202
10.2.1 General classification 202
10.2.2 RS1 205
10.2.3 RS2 206
10.2.4 RS3 206
10.3 Safeguards against laser radiation 206
~~Requirements ..... ~~
~~Compliance criteria ..... ~~
10.4 Safeguards against ~~visible, infra-red, and ultra-violet radiation~~ optical radiation from lamps and lamp systems (including LED types) 207
10.4.1 General requirements 207
10.4.2 Requirements for enclosures 209
10.4.3 Instructional safeguard 209
10.4.4 Compliance criteria 211
10.5 Safeguards against X-radiation 211
10.5.1 Requirements 211
10.5.2 Compliance criteria 211
10.5.3 Test method 212
10.6 Safeguards against acoustic energy sources 212
10.6.1 General 212
10.6.2 Classification 213

IECNORM.COM : Click to view the full PDF of IEC 62368-1:ed 3.0 (RLV):2018

10.6.3 Requirements for dose-based systems 215
10.6.4 Measurement methods 215
10.6.5 Protection of persons 215
10.6.6 Requirements for listening devices (headphones, earphones, etc.) 216
Annex A (informative) Examples of equipment within the scope of this document 218
Annex B (normative) Normal operating condition tests, abnormal operating condition tests and single fault condition tests 219
B.1 General 219
B.1.1 ~~Introduction~~ Test applicability 219
B.1.2 Type of test 219
B.1.3 Test samples 219
B.1.4 Compliance by inspection of relevant data 219
B.1.5 Temperature measurement conditions 219
B.2 Normal operating conditions 220
B.2.1 General 220
B.2.2 Supply frequency 220
B.2.3 Supply voltage 220
B.2.4 Normal operating voltages 221
B.2.5 Input test 221
B.2.6 Operating temperature measurement conditions 222
B.2.7 Battery charging and discharging under normal operating conditions 222
B.3 Simulated abnormal operating conditions 222
B.3.1 General 222
B.3.2 Covering of ventilation openings 223
B.3.3 DC mains polarity test 224
B.3.4 Setting of voltage selector 224
B.3.5 Maximum load at output terminals 224
B.3.6 Reverse battery polarity 224
B.3.7 Audio amplifier abnormal operating conditions 224
B.3.8 Compliance criteria during and after abnormal operating conditions 224
B.4 Simulated single fault conditions 224
B.4.1 General 224
B.4.2 Temperature controlling device 225
B.4.3 Motor tests 225
B.4.4 Functional insulation 225
B.4.5 Short-circuit and interruption of electrodes in tubes and semiconductors 226
B.4.6 Short-circuit or disconnection of passive components 226
B.4.7 Continuous operation of components 226
B.4.8 Compliance criteria during and after single fault conditions 227
B.4.9 Battery charging and discharging under single fault conditions 227
Annex C (normative) UV radiation 228
C.1 Protection of materials in equipment from UV radiation 228
C.1.1 General 228
C.1.2 Requirements 228
C.1.3 Test method and compliance criteria 228
C.2 UV light conditioning test 229
C.2.1 Test apparatus 229
C.2.2 Mounting of test samples 229
C.2.3 Carbon-arc light-exposure test 229

IECNORM.COM : Click to view the full PDF of IEC 62368-1 ed 3.0 (RLV):2018

C.2.4 Xenon-arc light-exposure test 229
Annex D (normative) Test generators 230
D.1 Impulse test generators 230
D.2 Antenna interface test generator 230
D.3 Electronic pulse generator 231
Annex E (normative) Test conditions for equipment containing audio amplifiers 232
E.1 Electrical energy source classification for audio signals 232
E.2 Audio amplifier normal operating conditions 232
E.3 Audio amplifier abnormal operating conditions 234
Annex F (normative) Equipment markings, instructions, and instructional safeguards 235
F.1 General 235
F.2 Letter symbols and graphical symbols 235
F.2.1 Letter symbols 235
F.2.2 Graphical symbols 235
F.2.3 Compliance criteria 235
F.3 Equipment markings 235
F.3.1 Equipment marking locations 235
F.3.2 Equipment identification markings 236
F.3.3 Equipment rating markings 236
F.3.4 Voltage setting device 238
F.3.5 Markings on terminals and operating devices 239
F.3.6 Equipment markings related to equipment classification 240
F.3.7 Equipment IP rating marking 241
F.3.8 External power supply output marking 241
F.3.9 Durability, legibility and permanence of markings 241
F.3.10 Test for the permanence of markings 242
F.5 Instructional safeguards 243
Annex G (normative) Components 246
G.1 Switches 246
G.1.1 General 246
G.1.2 Requirements 246
G.1.3 Test method and compliance criteria 247
G.2 Relays 247
G.2.1 Requirements 247
G.2.2 Overload test 248
G.2.3 Relay controlling connectors supplying power to other equipment 248
G.2.4 Test method and compliance criteria 248
G.3 Protective devices 248
G.3.1 Thermal cut-offs 248
G.3.2 Thermal links 249
G.3.3 PTC thermistors 250
G.3.4 Overcurrent protective devices 251
G.3.5 Safeguard components not mentioned in G.3.1 to G.3.4 251
G.4 Connectors 251
G.4.1 Clearance and creepage distance requirements 251
G.4.2 Mains connectors 251
G.4.3 Connectors other than mains connectors 252
G.5 Wound components 252

IECNORM.COM : Click to view the full PDF of IEC 62368-1 ed 3.0 (RLV):2018

G.5.1 Wire insulation in wound components 252
G.5.2 Endurance test 252
G.5.3 Transformers 254
G.5.4 Motors 262
G.6 Wire insulation 266
G.6.1 General 266
G.6.2 ~~Solvent-based enamel winding insulation~~ Enamelled winding wire insulation 267
G.7 Mains supply cords 268
G.7.1 General 268
G.7.2 Cross sectional area 268
G.7.3 Cord anchorages and strain relief for non-detachable power supply cords 270
G.7.4 Cord entry 271
G.7.5 Non-detachable cord bend protection 271
G.7.6 Supply wiring space 272
G.8 Varistors 274
G.8.1 General 274
~~G.8.2 Safeguards against electric shock ..... 275~~
G.8.2 Safeguards against fire 275
G.9 Integrated circuit (IC) current limiters 277
G.9.1 Requirements 277
G.9.2 Test program 279
~~Test program 1 .....~~
~~Test program 2 .....~~
~~Test program 3 .....~~
G.9.3 Compliance criteria 280
G.10 Resistors 280
G.10.1 General 280
G.10.2 Conditioning 280
G.10.3 Resistor test 281
~~Resistors serving as safeguards between the mains and an external circuit consisting of a coaxial cable .....~~
G.10.4 Voltage surge test 281
G.10.5 Impulse test 281
G.10.6 Overload test 281
G.11 Capacitors and RC units 282
G.11.1 General 282
G.11.2 Conditioning of capacitors and RC units 282
G.11.3 Rules for selecting capacitors 282
~~Examples of the application of capacitors .....~~
G.12 Optocouplers 286
G.13 Printed boards 286
G.13.1 General 286
G.13.2 Uncoated printed boards 286
G.13.3 Coated printed boards 286
G.13.4 Insulation between conductors on the same inner surface 288
G.13.5 Insulation between conductors on different surfaces 289
G.13.6 Tests on coated printed boards 289
G.14 Coatings on component terminals 291

IECNORM.COM : Click to view the full PDF of IEC 62368-1 ed 3.0 (RLV):2018

G.14.1 Requirements 291
G.14.2 Test method and compliance criteria 291
G.15 Pressurized liquid filled components 292
~~General~~ .....
G.15.1 Requirements 292
G.15.2 Test methods and compliance criteria 292
G.15.3 Compliance criteria 293
G.16 IC that includes a capacitor discharge function (ICX) 293
G.16.1 Requirements 293
G.16.2 Tests 294
G.16.3 Compliance criteria 294
Annex H (normative) Criteria for telephone ringing signals 295
H.1 General 295
H.2 Method A 295
H.3 Method B 298
H.3.1 Ringing signal 298
H.3.2 Tripping device and monitoring voltage 298
Annex I (informative) Overvoltage categories (see IEC 60364-4-44) 300
Annex J (normative) Insulated winding wires for use without interleaved insulation 301
J.1 General 301
J.2 Type tests 301
J.2.1 General 301
J.2.2 Electric strength 301
J.2.3 Flexibility and adherence 302
J.2.4 Heat shock 302
J.2.5 Retention of electric strength after bending 303
J.3 Testing during manufacturing 303
J.3.1 General 303
J.3.2 ~~Routine~~ Spark test 303
J.3.3 Sampling test 304
Annex K (normative) Safety interlocks 305
K.1 General 305
K.1.1 General requirements 305
K.1.2 Test method and compliance criteria 305
K.2 Components of the safety interlock safeguard mechanism 305
K.3 Inadvertent change of operating mode 306
K.4 Interlock safeguard override 306
K.5 Fail-safe 306
K.5.1 Requirement 306
K.5.2 Test method and compliance criteria 306
K.6 Mechanically operated safety interlocks 307
K.6.1 Endurance requirement 307
K.6.2 Test method and compliance criteria 307
K.7 Interlock circuit isolation 307
K.7.1 Separation distances for contact gaps and interlock circuit elements 307
K.7.2 Overload test 308
K.7.3 Endurance test 308
K.7.4 Electric strength test 308

IECNORM.COM : Click to view the full PDF of IEC 62368-1 ed 3.0 (RLV):2018

Annex L (normative) Disconnect devices 309
L.1 General requirements 309
L.2 Permanently connected equipment 309
L.3 Parts that remain energized 309
L.4 Single-phase equipment 309
L.5 Three-phase equipment 310
L.6 Switches as disconnect devices 310
L.7 Plugs as disconnect devices 310
L.8 Multiple power sources 310
L.9 Compliance criteria 311
Annex M (normative) Equipment containing batteries and their protection circuits 312
M.1 General requirements 312
M.2 Safety of batteries and their cells 312
M.2.1 Requirements 312
M.2.2 Compliance criteria 312
M.3 Protection circuits for batteries provided within the equipment 313
M.3.1 Requirements 313
M.3.2 Test method 313
M.3.3 Compliance criteria 314
M.4 Additional safeguards for equipment containing a portable secondary lithium battery 314
M.4.1 General 314
M.4.2 Charging safeguards 314
M.4.3 Fire enclosure 316
M.4.4 Drop test of equipment containing a secondary lithium battery 316
M.5 Risk of burn due to short-circuit during carrying 317
M.5.1 Requirements 317
M.5.2 Test method and compliance criteria 317
M.6 ~~Prevention of short-circuits and protection from other effects of electric current~~ Safeguards against short-circuits 317
~~Short-circuits~~ .....
M.6.1 requirements 317
M.6.2 Compliance criteria 318
~~Leakage currents~~ .....
M.7 Risk of explosion from lead acid and NiCd batteries 318
M.7.1 Ventilation preventing an explosive gas concentration 318
M.7.2 Test method and compliance criteria 319
M.7.3 Ventilation tests 323
M.7.4 Marking requirement 324
M.8 Protection against internal ignition from external spark sources of batteries with aqueous electrolyte 324
M.8.1 General 324
M.8.2 Test method 324
M.9 Preventing electrolyte spillage 327
M.9.1 Protection from electrolyte spillage 327
M.9.2 Tray for preventing electrolyte spillage 327
M.10 Instructions to prevent reasonably foreseeable misuse 327
Annex N (normative) Electrochemical potentials (V) 329
Annex O (normative) Measurement of creepage distances and clearances 330

IECNORM.COM : Click to view the full PDF of IEC 62368-1 ed 3.0 (RLV):2018

Annex P (normative) Safeguards against conductive objects 339
P.1 General 339
P.2 Safeguards against entry or consequences of entry of a foreign object 339
P.2.1 General 339
P.2.2 Safeguards against entry of a foreign object 339
P.2.3 Safeguards against the consequences of entry of a foreign object 340
P.3 Safeguards against spillage of internal liquids 342
P.3.1 General 342
P.3.2 Determination of spillage consequences 342
P.3.3 Spillage safeguards 342
P.3.4 Compliance criteria 343
P.4 Metallized coatings and adhesives securing parts 343
P.4.1 General 343
P.4.2 Tests 343
Annex Q (normative) Circuits intended for interconnection with building wiring 345
Q.1 Limited power source 345
Q.1.1 Requirements 345
Q.1.2 Test method and compliance criteria 345
Q.2 Test for external circuits – paired conductor cable 346
Annex R (normative) Limited short-circuit test 347
R.1 General 347
R.2 Test setup 347
R.3 Test method 347
R.4 Compliance criteria 348
Annex S (normative) Tests for resistance to heat and fire 349
S.1 Flammability test for fire enclosure and fire barrier materials of equipment where the steady state power does not exceed 4 000 W 349
S.2 Flammability test for fire enclosure and fire barrier integrity 350
S.3 Flammability tests for the bottom of a fire enclosure 352
S.3.1 Mounting of samples 352
S.3.2 Test method and compliance criteria 352
S.4 Flammability classification of materials 352
S.5 Flammability test for fire enclosure materials of equipment with a steady state power exceeding 4 000 W 353
Annex T (normative) Mechanical strength tests 355
T.1 General 355
T.2 Steady force test, 10 N 355
T.3 Steady force test, 30 N 355
T.4 Steady force test, 100 N 355
T.5 Steady force test, 250 N 355
T.6 Enclosure impact test 355
T.7 Drop test 356
T.8 Stress relief test 356
T.9 Glass impact test 357
T.10 Glass fragmentation test 357
T.11 Test for telescoping or rod antennas 358
Annex U (normative) Mechanical strength of CRTs and protection against the effects of implosion 359
U.1 General 359

IECNORM.COM : Click to view the full PDF of IEC 62368-1 ed3.0 (RLV):2018

U.2 Test method and compliance criteria for non-intrinsically protected CRTs 360
U.3 Protective screen 360
Annex V (normative) Determination of accessible parts 361
V.1 Accessible parts of equipment 361
V.1.1 General 361
V.1.2 Test method 1 – Surfaces and openings tested with jointed test probes 361
V.1.3 Test method 2 – Openings tested with straight unjointed test probes 361
V.1.4 Test method 3 – Plugs, jacks, connectors 364
V.1.5 Test method 4 – Slot openings 364
V.1.6 Test method 5 – Terminals intended to be used by an ordinary person 365
V.2 Accessible part criterion 366
Annex W (informative) Comparison of terms introduced in this document 367
W.1 General 367
W.2 Comparison of terms 367
Annex X (normative) Alternative method for determining clearances for insulation in circuits connected to an AC mains not exceeding 420 V peak (300 V RMS) 384
Annex Y (normative) Construction requirements for outdoor enclosures 386
Y.1 General 386
Y.2 Resistance to UV radiation 386
Y.3 Resistance to corrosion 386
Y.3.1 General 386
Y.3.2 Test apparatus 387
Y.3.3 Water – saturated sulphur dioxide atmosphere 387
Y.3.4 Test procedure 387
Y.3.5 Compliance criteria 388
Y.4 Gaskets 388
Y.4.1 General 388
Y.4.2 Gasket tests 388
Y.4.3 Tensile strength and elongation tests 388
Y.4.4 Compression test 389
Y.4.5 Oil resistance 390
Y.4.6 Securing means 390
Y.5 Protection of equipment within an outdoor enclosure 391
Y.5.1 General 391
Y.5.2 Protection from moisture 391
Y.5.3 Water spray test 392
Y.5.4 Protection from plants and vermin 394
Y.5.5 Protection from excessive dust 395
Y.6 Mechanical strength of enclosures 395
Y.6.1 General 395
Y.6.2 Impact test 396
Bibliography 397

~~Figure – Rotated separation requirements due to forced air flow .....~~
~~Figure – Materials with different CTI values .....~~
~~Figure – Materials with different CTI values having an air gap of less than X mm .....~~
~~Figure – Materials with different CTI values having an air groove of less than X mm .....~~

IECNORM.COM : Click to view the full PDF of IEC 62368-1:2018 Ed 3.0 (RLV):2018

~~Figure – Materials with different CTI values having an air groove not smaller than *X* mm .....~~
Figure 1 – Three block model for pain and injury 24
Figure 2 – Three block model for safety.....25
Figure 3 – Schematic and model for electrically-caused pain or injury 30
Figure 4 – Model for protection against electrically-caused pain or injury 30
Figure 5 – Model for electrically-caused fire 31
Figure 6 – Models for protection against fire 32
Figure 7 – Schematic and model for thermally-caused injury 34
Figure 8 – Model for protection against thermally-caused injury 34
Figure 9 – Model for protection of an ordinary person against a class 1 energy source 70
Figure 10 – Model for protection of an ordinary person against a class 2 energy source 71
Figure 11 – Model for protection of an ordinary person against a class 2 energy source during ordinary person servicing conditions 71
Figure 12 – Model for protection of an ordinary person against a class 3 energy source 72
Figure 13 – Model for protection of an instructed person against a class 1 energy source 72
Figure 14 – Model for protection of an instructed person against a class 2 energy source 72
Figure 15 – Model for protection of an instructed person against a class 3 energy source 73
Figure 16 – Model for protection of a skilled person against a class 1 energy source.....73
Figure 17 – Model for protection of a skilled person against a class 2 energy source.....73
Figure 18 – Model for protection of a skilled person against a class 3 energy source.....73
Figure 19 – Model for protection of a skilled person against class 3 energy sources during equipment servicing conditions 74
Figure 20 – Test hook 81
Figure 21 – Illustration showing ES limits for voltage and current 83
Figure 22 – Maximum values for combined AC current and DC current.....85
Figure 23 – Maximum values for combined AC voltage and DC voltage.....85
Figure 24 – Contact requirements to bare internal conductive parts 89
Figure 25 – Mandrel.....114
Figure 26 – Initial position of mandrel.....115
Figure 27 – Final position of mandrel.....115
Figure 28 – Position of metal foil on insulating material.....116
Figure 29 – Example of electric strength test instrument for solid insulation 125
Figure 30 – Application points of test voltage.....126
Figure 31 – Test for separation between an external circuit and earth 129
Figure 32 – Test circuit for touch current of single-phase equipment 145
Figure 33 – Test circuit for touch current of three-phase equipment 146
Figure 34 – Power measurement for worst-case fault.....149
Figure 35 – Power measurement for worst-case power source fault 150
Figure 36 – Illustration of power source classification 151
Figure 37 – Minimum separation requirements from a PIS 158

IECNORM.COM : Click to view the full PDF of IEC 62368-1:2018 ed3.0 (RLV):2018

Figure 38 – Extended separation requirements from ~~an arcing~~ a PIS 159
Figure 39 – Deflected separation requirements from a PIS when a fire barrier is used 160
Figure 40 – Determination of top, bottom and side openings 162
Figure 41 – Top openings 163
Figure 42 – Bottom openings 165
Figure 43 – Baffle plate construction 166
Figure 44 – PIS trajectory downwards 167
Figure 45 – Limits for moving fan blades made of non-plastic materials 173
Figure 46 – Limits for moving fan blades made of plastic materials 173
Figure 47 – Steel disc 199
Figure 48 – Aluminium ring 200
Figure 49 – Aluminium foil 201
Figure 50 – Example of a warning label for a lamp with multiple hazard spectral regions 211
Figure D.1 – 1,2/50 μs and 10/700 μs voltage impulse generator 230
Figure D.2 – Antenna interface test generator circuit 231
Figure D.3 – Example of an electronic pulse generator 231
Figure E.1 – Band-pass filter for wide-band noise measurement 233
Figure F.1 – Example of an instructional safeguard 244
Figure G.1 – Determination of arithmetic average temperature 257
Figure G.2 – Test voltages 262
Figure G.3 – Thermal ageing time 290
Figure G.4 – Abrasion resistance test for coating layers 291
Figure H.1 – Definition of ringing period and cadence cycle 296
Figure H.2 – I_{TS1} limit curve for cadenced ringing signal 297
Figure H.3 – Peak and peak-to-peak currents 297
Figure H.4 – Ringing voltage trip criteria 299
Figure M.1 – Distance d as a function of the rated capacity for various charge currents I (mA/Ah) 327
Figure O.1 – Narrow groove 330
Figure O.2 – Wide groove 331
Figure O.3 – V-shaped groove 331
Figure O.4 – Intervening unconnected conductive part 331
Figure O.5 – Rib 331
Figure O.6 – Uncemented joint with narrow groove 332
Figure O.7 – Uncemented joint with wide groove 332
Figure O.8 – Uncemented joint with narrow and wide grooves 332
Figure O.9 – Narrow recess 333
Figure O.10 – Wide recess 333
Figure O.11 – Coating around terminals 334
Figure O.12 – Coating over printed wiring 334
Figure O.13 – Example of measurements in an enclosure of insulating material 335
Figure O.14 – Cemented joints in multi-layer printed boards 335
Figure O.15 – Device filled with insulating compound 336

IECNORM.COM : Click to view the full PDF of IEC 62368-1 ed 3.0 (RLV):2018

Figure O.16 – Partitioned bobbin 336
Figure P.1 – Examples of cross-sections of designs of top openings which prevent vertical entry 340
Figure P.2 – Examples of cross-sections of designs of side opening louvres which prevent vertical entry 340
Figure P.3 – Internal volume locus for foreign object entry 341
Figure S.1 – Top openings / surface of fire enclosure or fire barrier 351
Figure T.1 – Impact test using sphere 356
Figure V.1 – Jointed test probe for equipment likely to be accessible to children 362
Figure V.2 – Jointed test probe for equipment not likely to be accessible to children 363
Figure V.3 – Blunt probe 364
Figure V.4 – Wedge probe 365
Figure V.5 – Terminal probe 365
Figure Y.1 – Gasket test 390
Figure Y.2 – Water-spray test spray-head piping 393
Figure Y.3 – Water-spray test spray head 394

~~Table – Electrical energy source limits for repetitive pulses ..... ~~
~~Table – Size and spacing of holes in metal bottoms of fire enclosures ..... ~~
~~Table – Examples of the application of Y capacitors based on the test voltages of Table 26 ..... ~~
~~Table – Examples of the application of Y capacitors based on the test voltages of Table 27 ..... ~~
~~Table – Examples of the application of Y capacitors based on the test voltages of Table 28 ..... ~~
~~Table – Examples of the application of X capacitors, line to line or line to neutral ..... ~~
~~Table – Values of f_g and f_s ..... ~~
Table 1 – Response to energy class 24
Table 2 – Examples of body response or property damage related to energy sources 25
Table 3 – Examples of safeguard characteristics 29
Table 4 – Electrical energy source limits for steady state ES1 and ES2 84
Table 5 – Electrical energy source limits for a charged capacitor 86
Table 6 – Voltage limits for single pulses 87
Table 7 – Current limits for single pulses 87
Table 8 – Minimum air gap distance 90
Table 9 – Temperature limits for materials, components and systems 92
Table 10 – Minimum clearances for voltages with frequencies up to 30 kHz 98
Table 11 – Minimum clearances for voltages with frequencies above 30 kHz 99
Table 12 – Mains transient voltages 100
Table 13 – External circuit transient voltages 102
Table 14 – Minimum clearances using required withstand voltage 104
Table 15 – Electric strength test voltages 105
Table 16 – Multiplication factors for clearances and test voltages 106
Table 17 – Minimum creepage distances for basic insulation and supplementary insulation in mm 109

IECNORM.COM : Click to view the full PDF of IEC 62368-1 ed 3.0 (RLV):2018

Table 18 – Minimum values of creepage distances (in mm) for frequencies higher than 30 kHz and up to 400 kHz 110
Table 19 – Tests for insulation in non-separable layers 113
Table 20 – Electric field strength E_P for some commonly used materials 118
Table 21 – Reduction factors for the value of breakdown electric field strength E_P at higher frequencies 119
Table 22 – Reduction factors for the value of breakdown electric field strength E_P at higher frequencies for thin materials 119
Table 23 – Values for insulation resistance 121
Table 24 – Distance through insulation of internal wiring 121
Table 25 – Test voltages for electric strength tests based on transient voltages 123
Table 26 – Test voltages for electric strength tests based on the peak of the working voltages and recurring peak voltages 124
Table 27 – Test voltages for electric strength tests based on temporary overvoltages 124
Table 28 – Test values for electric strength tests 127
Table 29 – Overview of tests for resistor applications 133
Table 30 – Protective earthing conductor sizes for reinforced safeguards for permanently connected equipment 136
Table 31 – Minimum protective bonding conductor size of copper conductors 137
Table 32 – Sizes of terminals for protective conductors 139
Table 33 – Test duration, mains connected equipment 140
Table 34 – List of applicable IEC standards regarding insulating liquids 168
Table 35 – Classification for various categories of mechanical energy sources 172
Table 36 – Overview of requirements and tests 183
Table 37 – Torque to be applied to screws 188
Table 38 – Touch temperature limits for accessible parts 196
Table 39 – Radiation energy source classifications 203
Table 40 – Allowable radiation level according to IEC 62471 (all parts) for each hazard type 208
Table 41 – Hazard-related risk group marking of equipment 210
Table 42 – Explanation of marking information and guidance on control measures 210
Table C.1 – Minimum property retention limits after UV exposure 228
Table D.1 – Component values for Figure D.1 and Figure D.2 231
Table E.1 – Audio signal electrical energy source classes and safeguards 232
Table F.1 – Instructional safeguard element description and examples 244
Table F.2 – Examples of markings, instructions, and instructional safeguards 245
Table G.1 – Peak surge current 247
Table G.2 – Test temperature and testing time (days) per cycle 253
Table G.3 – Temperature limits for transformer windings and for motor windings (except for the motor running overload test) 256
Table G.4 – Test voltages for electric strength tests based on the peak of the working voltages 258
Table G.5 – Values of FIW wires with maximum overall diameter and minimum test voltages according to the enamel increase 261
Table G.6 – Temperature limits for running overload tests 263
Table G.7 – Sizes of conductors 269

IECNORM.COM : Click to view the full PDF of IEC 62368-1:2018 RLV

Table G.8 – Strain relief test force 270
Table G.9 – Range of conductor sizes to be accepted by terminals 273
Table G.10 – Varistor overload and temporary overvoltage test 275
Table G.11 – Performance test program for integrated circuit (IC) current limiters 280
Table G.12 – Capacitor ratings according to IEC 60384-14 282
Table G.13 – Minimum separation distances for coated printed boards 288
Table G.14 – Insulation in printed boards 289
Table I.1 – Overvoltage categories 300
Table J.1 – Mandrel diameter 302
Table J.2 – Oven temperature 303
Table M.1 – Values for current I_{float} and I_{boost}, factors f_g and f_s, and voltages U_{float} and U_{boost} 322
Table O.1 – Value of X 330
Table Q.1 – Limits for inherently limited power sources 345
Table Q.2 – Limits for power sources not inherently limited (overcurrent protective device required) 346
Table S.1 – Foamed materials 352
Table S.2 – Rigid materials 352
Table S.3 – Very thin materials 353
Table T.1 – Impact force 357
Table T.2 – Torque values for end-piece test 358
Table W.1 – Comparison of terms and definitions in IEC 60664-1:2007 and IEC 62368-1 368
Table W.2 – Comparison of terms and definitions in IEC 61140: ~~2001~~ 2016 and IEC 62368-1 370
Table W.3 – Comparison of terms and definitions in IEC 60950-1:2005 and IEC 62368-1 373
Table W.4 – Comparison of terms and definitions in IEC 60728-11:2016 and IEC 62368-1 377
Table W.5 – Comparison of terms and definitions in IEC 62151:2000 and IEC 62368-1 378
Table W.6 – Comparison of terms and definitions in IEC 60065:2014 and IEC 62368-1 381
Table X.1 – Alternative minimum clearances for insulation in circuits connected to ac mains not exceeding 420 V peak (300 V RMS) 384
Table X.2 – Additional clearances for insulation in circuits connected to ac mains not exceeding 420 V peak (300 V RMS) 385
Table Y.1 – Examples of the provision of pollution degree environments 391

IECNORM.COM : Click to view the full PDF of IEC 62368-1 ed 3.0 (RLV):2018

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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AUDIO/VIDEO, INFORMATION AND COMMUNICATION TECHNOLOGY EQUIPMENT –

Part 1: Safety requirements

FOREWORD

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This Redline version provides you with a quick and easy way to compare all the changes between this standard and its previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

International Standard IEC 62368-1 has been prepared by TC 108: Safety of electronic equipment within the field of audio/video, information technology and communication technology.

This third edition cancels and replaces the second edition published in 2014. This edition constitutes a technical revision.

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

– addition of requirements for outdoor equipment;
– new requirements for optical radiation;
– addition of requirements for insulating liquids;
– addition of requirements for work cells;
– addition of requirements for wireless power transmitters;
– addition of requirements for fully insulated winding wire (FIW);
– alternative method for determination of top, bottom and side openings for fire enclosures;
– alternative requirements for sound pressure.

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

FDIS	Report on voting
108/701/FDIS	108/707/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

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

A list of all parts in the IEC 62368 series, published under the general title *Audio/video, information and communication technology equipment*, can be found on the IEC website.

The “in some countries” notes regarding differing national practices are contained in the following clauses, subclauses and tables:

0.2.1, Clause 1, 3.3.8.1, 3.3.8.3, 4.1.15, 4.7.3, 5.2.2.2, 5.4.2.3.2.4, 5.4.2.5, 5.4.5.1, 5.4.10.2.1, 5.4.10.2.2, 5.4.10.2.3, 5.5.2.1, 5.5.6, 5.6.4.2.1, 5.6.8, 5.7.6, 5.7.7.1, 8.5.4.2.3, 10.5.3, 10.6.1, F.3.3.6, Y.4.1, Y.4.5, Table 12, Table 13 and Table 39.

In this document, the following print types or formats are used:

– requirements proper and normative annexes: in roman type;
– compliance statements and test specifications: *in italic type*;
– notes/explanatory matter: in smaller roman type;
– normative conditions within tables: in smaller roman type;
– terms that are defined in 3.3: **bold**.

In figures and tables, if colour is available:

– green colour denotes a class 1 energy source;
– yellow colour denotes a class 2 energy source;
– red colour denotes a class 3 energy source.

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A comparison of terms introduced in this document that are different from other existing IEC documents is given in Annex W.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://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.

NOTE Explanatory information related to IEC 62368-1 is contained in IEC TR 62368-2. It provides rationale together with explanatory information related to this document.

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 document using a colour printer.

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INTRODUCTION

0 Principles of this product safety standard

0.1 Objective

This part of IEC 62368 is a product safety standard that classifies energy sources, prescribes **safeguards** against those energy sources, and provides guidance on the application of, and requirements for, those **safeguards**.

The prescribed **safeguards** are intended to reduce the likelihood of pain, injury and, in the case of fire, property damage.

The objective of the INTRODUCTION is to help designers to understand the underlying principles of safety in order to design safe equipment. These principles are informative and not an alternative to the detailed requirements of this document.

0.2 Persons

0.2.1 General

This document describes **safeguards** for the protection of three kinds of persons: the **ordinary person**, the **instructed person**, and the **skilled person**. Unless otherwise specified, the requirements for an **ordinary person** apply. This document assumes that a person will not intentionally create conditions or situations that could cause pain or injury.

NOTE 1 In Australia, the work conducted by an **instructed person** or **skilled person** may require formal licensing from regulatory authorities.

NOTE 2 In Germany, a person may only be regarded as an **instructed person** or a **skilled person** if certain legal requirements are fulfilled.

0.2.2 Ordinary person

Ordinary person is the term applied to all persons other than **instructed persons** and **skilled persons**. **Ordinary persons** include not only users of the equipment, but also all persons who may have access to the equipment or who may be in the vicinity of the equipment. Under **normal operating conditions** or **abnormal operating conditions**, **ordinary persons** should not be exposed to parts comprising energy sources capable of causing pain or injury. Under a **single fault condition**, **ordinary persons** should not be exposed to parts comprising energy sources capable of causing injury.

0.2.3 Instructed person

Instructed person is a term applied to persons who have been instructed and trained by a **skilled person**, or who are supervised by a **skilled person**, to identify energy sources that may cause pain (see Table 1) and to take precautions to avoid unintentional contact with or exposure to those energy sources. Under **normal operating conditions**, **abnormal operating conditions** or **single fault conditions**, **instructed persons** should not be exposed to parts comprising energy sources capable of causing injury.

0.2.4 Skilled person

Skilled person is a term applied to persons who have training or experience in the equipment technology, particularly in knowing the various energies and energy magnitudes used in the equipment. **Skilled persons** are expected to use their training and experience to recognize energy sources capable of causing pain or injury and to take action for protection from injury from those energies. **Skilled persons** should also be protected against unintentional contact or exposure to energy sources capable of causing injury.

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0.3 Model for pain and injury

An energy source that causes pain or injury does so through the transfer of some form of energy to or from a body part.

This concept is represented by a three-block model (see Figure 1).

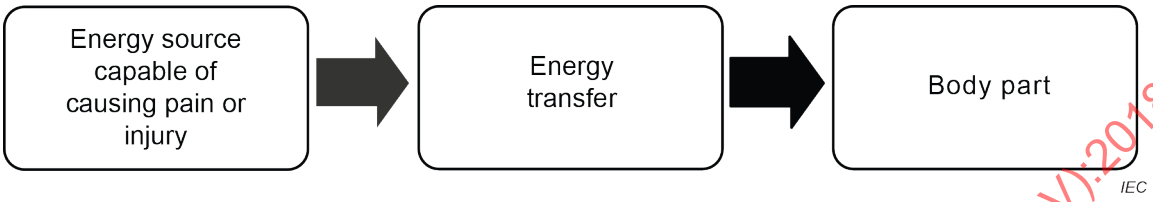


Figure 1 – Three block model for pain and injury

This safety standard specifies three classes of energy sources defined by magnitudes and durations of source parameters relative to ~~either~~ the body ~~or to **combustible material**~~ responses to those electrical and thermal energy sources (see Table 1). ~~Each energy class (see 4.2) is a function of the body part or the **combustible material** susceptibility to that energy magnitude (see Table 1).~~ Source parameters relative to responses to **combustible material**, mechanical energy sources and radiation energy sources are specified based on experience and basic safety standards.

Table 1 – Response to energy class

Energy source	Effect on the body	Effect on combustible materials
Class 1	Not painful, but may be detectable	Ignition not likely
Class 2	Painful, but not an injury	Ignition possible, but limited growth and spread of fire
Class 3	Injury	Ignition likely, rapid growth and spread of fire

The energy threshold for pain or injury is not constant throughout the population. For example, for some energy sources, the threshold is a function of body mass; the lower the mass, the lower the threshold, and vice-versa. Other body variables include age, state of health, state of emotions, effect of drugs, skin characteristics, etc. Furthermore, even where outward appearances otherwise appear equal, individuals differ in their thresholds of susceptibility to the same energy source.

The effect of duration of energy transfer is a function of the specific energy form. For example, pain or injury from thermal energy can be very short (1 s) for high skin temperature, or very long (several hours) for low skin temperature.

Furthermore, the pain or injury may occur some considerable time after the transfer of energy to a body part. For example, pain or injury from some chemical or physiological reaction may not be manifested for days, weeks, months, or years.

0.4 Energy sources

Energy sources are addressed by this document, together with the pain or injury that results from a transfer of that energy to the body, and the likelihood of property damage that results from fire escaping the equipment.

An electrical product is connected to an electrical energy source (for example, the **mains**), an external power supply, or a **battery**. An electrical product uses the electrical energy to perform its intended functions.

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In the process of using electrical energy, the product transforms the electrical energy into other forms of energy (for example, thermal energy, kinetic energy, optical energy, audio energy, electromagnetic energy, etc.). Some energy transformations may be a deliberate part of the product function (for example, moving parts of a printer, images on a visual display unit, sound from a speaker, etc.). Some energy transformations may be a by-product of the product function (for example, heat dissipated by functional circuits, X-radiation from a cathode-ray tube, etc.).

Some products may use energy sources that are non-electrical energy sources such as ~~**batteries**~~, moving parts or chemicals~~, etc~~. The energy in these other sources may be transferred to or from a body part, or may be transformed into other energy forms (for example, ~~a **battery** transforms chemical energy into electrical energy~~ chemical energy may be converted to electrical energy through a **battery**, or a moving body part transfers its kinetic energy to a sharp edge).

Examples of the types of energy forms and the associated injuries and property damage addressed in this document are in Table 2.

Table 2 – Examples of body response or property damage related to energy sources

Forms of energy	Examples of body response or property damage	Clause
Electrical energy (for example, energized conductive parts)	Pain, fibrillation, cardiac arrest, respiratory arrest, skin burn, or internal organ burn	5
Thermal energy (for example, electrical ignition and spread of fire)	Electrically-caused fire leading to burn-related pain or injury, or property damage	6
Chemical reaction (for example, electrolyte, poison)	Skin damage, organ damage, or poisoning	7
Kinetic energy (for example, moving parts of equipment, or a moving body part against an equipment part)	Laceration, puncture, abrasion, contusion, crush, amputation, or loss of a limb, eye, ear, etc.	8
Thermal energy (for example, hot **accessible** parts)	Skin burn	9
Radiated energy (for example, electromagnetic energy, optical energy, acoustic energy)	Loss of sight, skin burn, or loss of hearing	10

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0.5 Safeguards

0.5.1 General

Many products necessarily use energy capable of causing pain or injury. Product design cannot eliminate such energy use. Consequently, such products should use a scheme that reduces the likelihood of such energy being transferred to a body part. The scheme that reduces the likelihood of energy transfer to a body part is a **safeguard** (see Figure 2).



Figure 2 – Three block model for safety

A **safeguard** is a device or scheme or system that:

– is interposed between an energy source capable of causing pain or injury and a body part, and

– reduces the likelihood of transfer of energy capable of causing pain or injury to a body part.

NOTE **Safeguard** mechanisms against transfer of energy capable of causing pain or injury include:

– attenuating the energy (reduces the value of the energy); or

– impeding the energy (slows the rate of energy transfer); or

– diverting the energy (changes the energy direction); or

– disconnecting, interrupting, or disabling the energy source; or

– enveloping the energy source (reduces the likelihood of the energy from escaping); or

– interposing a barrier between a body part and the energy source.

A **safeguard** can be applied to the equipment, to the local installation, to a person or can be a learned or directed behaviour (for example, resulting from an **instructional safeguard**) intended to reduce the likelihood of transfer of energy capable of causing pain or injury. A **safeguard** may be a single element or may be a set of elements.

Generally, this document uses ~~the~~ an order of preference for providing **safeguards** ~~is~~ based on the requirements given in ISO/IEC Guide 51 as follows:

– **equipment safeguards** are always useful, since they do not require any knowledge or actions by persons coming into contact with the equipment;

– **installation safeguards** are useful when a safety characteristic can only be provided after installation (for example, the equipment has to be bolted to the floor to provide stability);

– behavioural **safeguards** are useful when the equipment requires an energy source to be **accessible**.

In practice, **safeguard** selection accounts for the nature of the energy source, the intended user, the functional requirements of the equipment, and similar considerations.

0.5.2 Equipment safeguard

An **equipment safeguard** may be a **basic safeguard**, a **supplementary safeguard**, a **double safeguard**, or a **reinforced safeguard**.

0.5.3 Installation safeguard

Installation safeguards are not controlled by the equipment manufacturer, although in some cases, **installation safeguards** may be specified in the equipment installation instructions.

Generally, with respect to equipment, an **installation safeguard** is a **supplementary safeguard**.

NOTE For example, the ~~protective earthing~~ **supplementary safeguard** providing **protective earthing** is located partly in the equipment and partly in the installation. The ~~protective earthing~~ **supplementary safeguard** providing **protective earthing** is not effective until the equipment is connected to the **protective earthing** of the installation.

Requirements for **installation safeguards** are not addressed in this document. However, this document does assume some **installation safeguards**, such as **protective earthing**, are in place and are effective.

0.5.4 Personal safeguard

A **personal safeguard** may be a **basic safeguard**, a **supplementary safeguard**, or a **reinforced safeguard**.

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Requirements for **personal safeguards** are not addressed in this document. However, this document does assume that **personal safeguards** are available for use as specified by the manufacturer.

0.5.5 Behavioural safeguards

0.5.5.1 Introduction to behavioural safeguards

In the absence of an **equipment**, **installation**, or **personal safeguard**, a person may use a specific behaviour as a **safeguard** to avoid energy transfer and consequent injury. A behavioural **safeguard** is a voluntary or instructed behaviour intended to reduce the likelihood of transfer of energy to a body part.

Three kinds of behavioural **safeguards** are specified in this document. Each kind of behavioural **safeguard** is associated with a specific kind of person. An **instructional safeguard** is usually addressed to an **ordinary person**, but may also be addressed to an **instructed person** or a **skilled person**. A **precautionary safeguard** is used by an **instructed person**. A **skill safeguard** is used by a **skilled person**.

0.5.5.2 Instructional safeguard

An **instructional safeguard** is a means of providing information, describing the existence and location of an energy source capable of causing pain or injury, and is intended to invoke a specific behaviour on the part of a person to reduce the likelihood of transfer of energy to a body part (see Annex F).

An **instructional safeguard** may be a visual indicator (symbols or words or both) or an audible message, as applicable to the expected use of the product.

When accessing locations where the equipment needs to be energized to perform a service activity, an **instructional safeguard** may be considered acceptable protection to bypass an **equipment safeguard** such that the person is made aware of how to avoid contact with a class 2 or class 3 energy source.

If **equipment safeguards** would interfere with or prohibit the equipment function, an **instructional safeguard** may replace an **equipment safeguard**.

If exposure to an energy source capable of causing pain or injury is essential to the correct functioning of equipment, an **instructional safeguard** may be used to ensure protection of persons instead of another **safeguard**. Consideration should be given as to whether the **instructional safeguard** should require the use of a **personal safeguard**.

Provision of an **instructional safeguard** does not result in an **ordinary person** becoming an **instructed person** (see 0.5.5.3).

0.5.5.3 Precautionary safeguard (used by an instructed person)

A **precautionary safeguard** is the training and experience or supervision of an **instructed person** by a **skilled person** to use precautions to protect the **instructed person** against class 2 energy sources. **Precautionary safeguards** are not specifically prescribed in this document but are assumed to be effective when the term **instructed person** is used.

During equipment servicing, an **instructed person** may need to remove or defeat an **equipment safeguard**. In this case, an **instructed person** is expected to then apply precaution as a **safeguard** to avoid ~~injury~~ exposure to class 2 energy sources.

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0.5.5.4 Skill safeguard (used by a skilled person)

A **skill safeguard** is the education, training, knowledge and experience of the **skilled person** that is used to protect the **skilled person** against class 2 or class 3 energy sources. **Skill safeguards** are not specifically prescribed in this document but are assumed to be effective when the term **skilled person** is used.

During equipment servicing, a **skilled person** may need to remove or defeat an **equipment safeguard**. In this case, a **skilled person** is expected to then apply skill as a **safeguard** to avoid injury.

0.5.6 Safeguards during ordinary or instructed person service conditions

During **ordinary person** or **instructed person** service conditions, **safeguards** for such persons may be necessary. Such **safeguards** can be **equipment safeguards**, **personal safeguards**, or **instructional safeguards**.

0.5.7 Equipment safeguards during skilled person service conditions

During **skilled person** service conditions, **equipment safeguards** should be provided to protect against the effects of a body's involuntary reaction (for example, startle) that might cause unintentional contact with a class 3 energy source located outside the view of the **skilled person**.

NOTE This **safeguard** typically applies in large equipment, where the **skilled person** needs to partially or wholly enter between two or more class 3 energy source locations while servicing.

0.5.8 Examples of safeguard characteristics

Table 3 lists some examples of **safeguard** characteristics.

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Table 3 – Examples of safeguard characteristics

Safeguard	Basic safeguard	Supplementary safeguard	Reinforced safeguard
Equipment safeguard: a physical part of an equipment	Effective under **normal operating conditions**	Effective in the event of failure of the **basic safeguard**	Effective under **normal operating conditions** and in the event of a **single fault condition** elsewhere in the equipment
	Example: **basic insulation**	Example: **supplementary insulation**	Example: **reinforced insulation**
	Example: normal temperatures below ignition temperatures	Example: **fire enclosure**	Not applicable
Installation safeguard: a physical part of a man-made installation	Effective under **normal operating conditions**	Effective in the event of failure of an equipment **basic safeguard**	Effective under **normal operating conditions** and in the event of a **single fault condition** elsewhere in the equipment
	Example: wire size	Example: overcurrent protective device	Example: socket outlet
Personal safeguard: a physical device worn on the body	In the absence of any **equipment safeguard**, effective under **normal operating conditions**	Effective in the event of failure of an equipment **basic safeguard**	In the absence of any **equipment safeguard**, effective under **normal operating conditions** and in the event of a **single fault condition** elsewhere in the equipment
	Example: gloves	Example: insulating floor mat	Example: electrically-insulated glove for handling live conductors
Instructional safeguard: a voluntary or instructed behaviour intended to reduce the likelihood of transfer of energy to a body part	In the absence of any **equipment safeguard**, effective under **normal operating conditions**	Effective in the event of failure of an equipment **basic safeguard**	Only effective on an exceptional basis, when providing all appropriate **safeguards** would prevent the intended functioning of the equipment
	Example: **instructional safeguard** to disconnect telecommunication cable before opening the cover	Example: after opening a door, an **instructional safeguard** against hot parts	Example: **instructional safeguard** of hot parts in an office photocopier, or a continuous roll paper cutter on a commercial printer

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0.6 Electrically-caused pain or injury (electric shock)

0.6.1 Models for electrically-caused pain or injury

Electrically-caused pain or injury may occur when electrical energy capable of causing pain or injury is transferred to a body part (see Figure 3).

Electrical energy transfer occurs when there are two or more electrical contacts to the body:

– the first electrical contact is between a body part and a conductive part of the equipment;
– the second electrical contact is between another body part and
  - earth, or
  - another conductive part of the equipment.

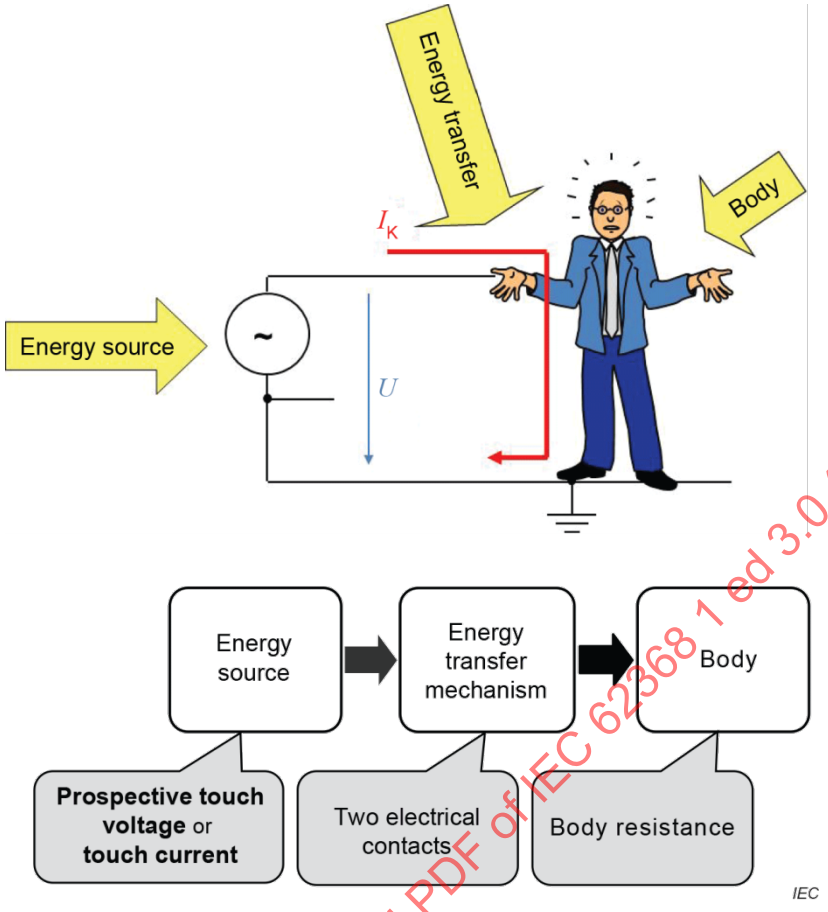


Figure 3 – Schematic and model for electrically-caused pain or injury

Depending on the magnitude, duration, wave shape, and frequency of the current, the effect on the human body varies from undetectable to detectable to painful to injurious.

0.6.2 Models for protection against electrically-caused pain or injury

~~Protection against electrically-caused pain or injury requires that~~ One or more **safeguards** ~~be~~ are interposed between an electrical energy source capable of causing pain or injury and a body part to protect against electrically-caused pain or injury (see Figure 4).

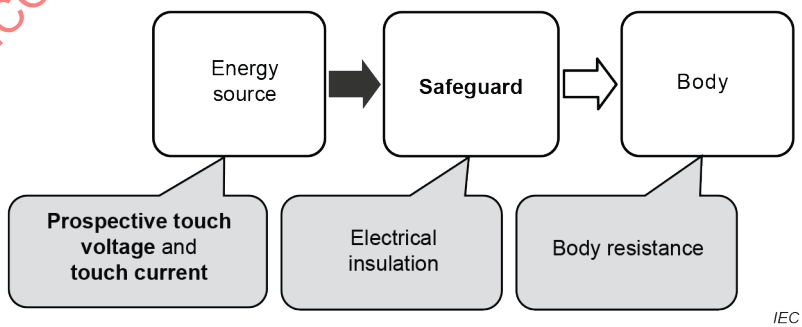


Figure 4 – Model for protection against electrically-caused pain or injury

Protection against electrically-caused pain is provided under **normal operating conditions** and **abnormal operating conditions**. For such protection ~~requires that~~, under **normal operating conditions** and **abnormal operating conditions**, a **basic safeguard** ~~be~~ is interposed between an electrical energy source capable of causing pain and an **ordinary person**.

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The most common **basic safeguard** against an electrical energy source capable of causing pain is electrical insulation (also known as **basic insulation**) interposed between the energy source and a body part.

Protection against electrically-caused injury is provided under **normal operating conditions**, **abnormal operating conditions**, and **single fault conditions**. For such protection ~~requires that~~, under **normal operating conditions** and **abnormal operating conditions**, both a **basic safeguard** and a **supplementary safeguard** ~~be~~ are interposed between an electrical energy source capable of causing injury and an **ordinary person** (see 4.3.2.4), or an **instructed person** (see 4.3.3.3). In the event of a failure of either **safeguard**, the other **safeguard** becomes effective. The **supplementary safeguard** against an electrical energy source capable of causing injury is placed between the **basic safeguard** and a body part. A **supplementary safeguard** may be additional electrical insulation (**supplementary insulation**) or a protectively earthed conductive barrier or other construction that performs the same function.

~~The most common~~ Another **safeguard** against an electrical energy source capable of causing injury is electrical insulation (also known as **double insulation** or **reinforced insulation**) placed between the energy source and a body part.

Likewise, a **reinforced safeguard** may be placed between an electrical energy source capable of causing injury and a body part.

0.7 Electrically-caused fire

0.7.1 Models for electrically-caused fire

Electrically-caused fire is due to conversion of electrical energy to thermal energy (see Figure 5), where the thermal energy heats a fuel material followed by ignition and combustion.

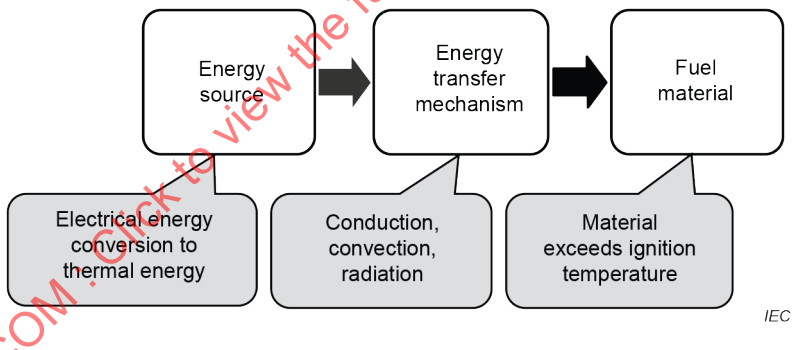


Figure 5 – Model for electrically-caused fire

Electrical energy is converted to thermal energy either in a resistance or in an arc and is transferred to a fuel material by conduction, convection, or radiation. As the fuel material heats, it chemically decomposes into gases, liquids and solids. When the gas is at its ignition temperature, the gas can be ignited by an ignition source. When the gas is at its spontaneous ignition temperature, the gas ignites by itself. Both result in fire.

0.7.2 Models for protection against electrically-caused fire

The **basic safeguard** against electrically-caused fire (see Figure 6) is that the temperature of a material, under **normal operating conditions** and **abnormal operating conditions**, does not cause the material to ignite.

The **supplementary safeguard** against electrically-caused fire reduces the likelihood of ignition or, in the case of ignition, reduces the likelihood of spread of fire.

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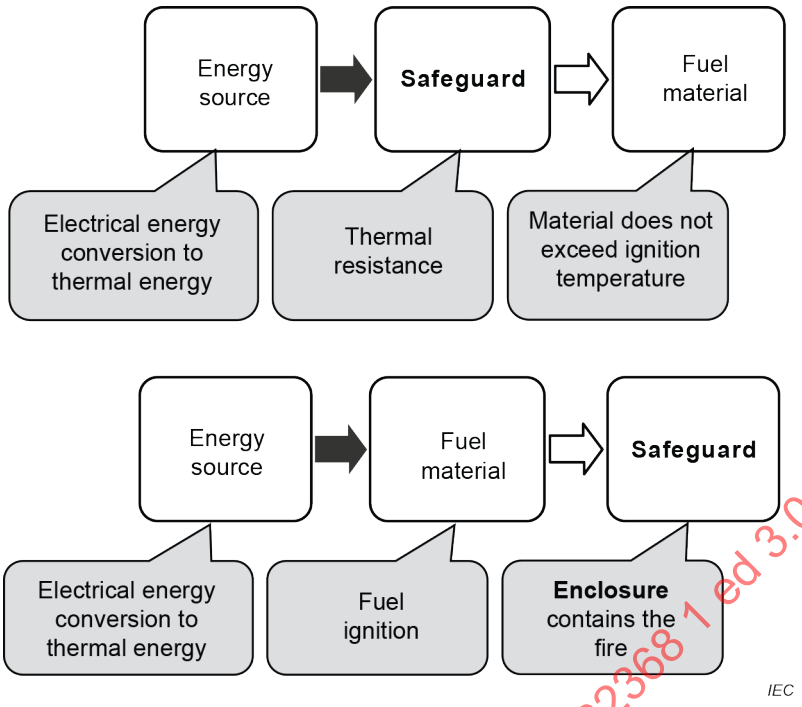


Figure 6 – Models for protection against fire

0.8 Injury caused by hazardous substances

Injury caused by **hazardous substances** is due to a chemical reaction with a body part. The extent of injury by a given substance depends on both the magnitude and duration of exposure and on the body part susceptibility to that substance.

The **basic safeguard** against injury caused by **hazardous substances** is containment of the material.

Supplementary safeguards against injury caused by **hazardous substances** may include:

– a second container or a spill-resistant container;
– containment trays;
– tamper-proof screws to prevent unauthorized access;
– **instructional safeguards**.

National and regional regulations govern the use of and exposure to **hazardous substances** used in equipment. These regulations do not enable a practical classification of **hazardous substances** in the manner in which other energy sources are classified in this document. Therefore, energy source classifications are not applied in Clause 7.

0.9 Mechanically-caused injury

Mechanically-caused injury is due to kinetic energy transfer to a body part when a collision occurs between a body part and an equipment part. The kinetic energy is a function of the relative motion between a body part and **accessible** parts of the equipment, including parts ejected from the equipment that collide with a body part.

Examples of kinetic energy sources are:

– body motion relative to sharp edges and corners;
– part motion due to rotating or other moving parts, including pinch points;
– part motion due to loosening, exploding, or imploding parts;

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– equipment motion due to instability;
– equipment motion due to wall, ceiling, or rack mounting means failure;
– equipment motion due to handle failure;
– part motion due to an exploding **battery**;
– equipment motion due to cart or stand instability or failure.

The **basic safeguard** against mechanically-caused injury is a function of the specific energy source. **Basic safeguards** may include:

– rounded edges and corners;
– an **enclosure** to prevent a moving part from being **accessible**;
– an **enclosure** to prevent expelling a moving part;
– a **safety interlock** to control access to an otherwise moving part;
– means to stop the motion of a moving part;
– means to stabilize the equipment;
– robust handles;
– robust mounting means;
– means to contain parts expelled during **explosion** or implosion.

The **supplementary safeguard** against mechanically-caused injury is a function of the specific energy source. **Supplementary safeguards** may include:

– **instructional safeguards**;
– instructions and training;
– additional **enclosures** or barriers;
– **safety interlocks**.

The **reinforced safeguard** against mechanically-caused injury is a function of the specific energy source. **Reinforced safeguards** may include:

– extra thick glass on the front of a CRT;
– rack slide-rails and means of support;
– **safety interlock**.

0.10 Thermally-caused injury (skin burn)

0.10.1 Models for thermally-caused injury

Thermally-caused injury may occur when thermal energy capable of causing injury is transferred to a body part (see Figure 7).

Thermal energy transfer occurs when a body touches a hot equipment part. The extent of injury depends on the temperature difference, the thermal mass of the object, rate of thermal energy transfer to the skin, and duration of contact.

The requirements in this document only address **safeguards** against thermal energy transfer by conduction. This document does not address **safeguards** against thermal energy transfer by convection or radiation.

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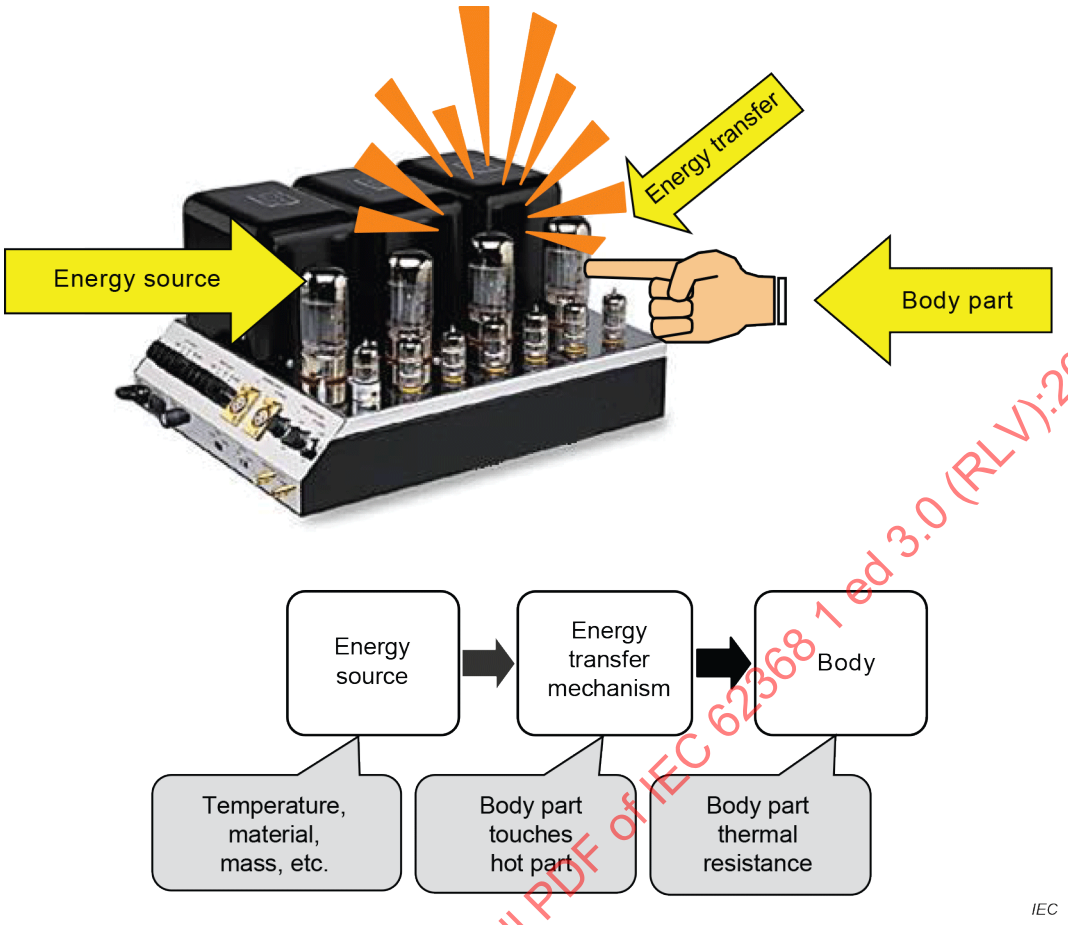


Figure 7 – Schematic and model for thermally-caused injury

Depending on the temperature, contact duration, material properties, and mass of the material, the perception of the human body varies from warmth to heat that may result in pain or injury (burn).

0.10.2 Models for protection against thermally-caused pain or injury

~~Protection against thermally-caused pain or injury requires that~~ One or more **safeguards** ~~be~~ are interposed between a thermal energy source capable of causing pain or injury and an **ordinary person** (see Figure 8).

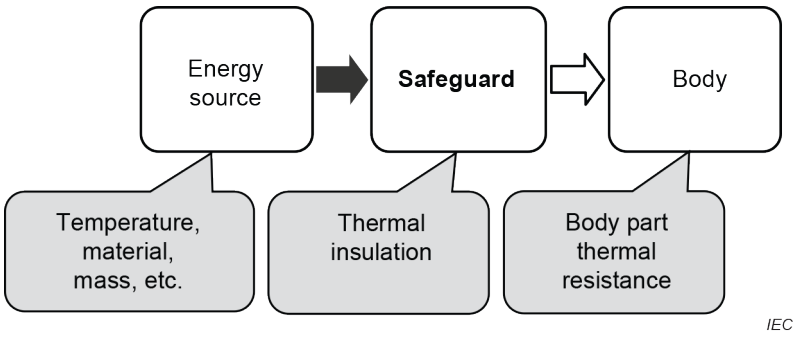


Figure 8 – Model for protection against thermally-caused injury

~~Protection against thermally-caused pain is required~~ Under **normal operating conditions** and **abnormal operating conditions**, protection is used against thermally-cause pain**.** For such

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protection ~~requires that~~ a **basic safeguard** ~~be~~ is interposed between a thermal energy source capable of causing pain and an **ordinary person**.

~~Protection against thermally-caused injury is required under **normal operating conditions**, **abnormal operating conditions** and **single fault conditions**.~~ Under **normal operating conditions**, **abnormal operating conditions** and **single fault conditions**, protection is used against thermally-caused injury. For such protection ~~requires that~~ a **basic safeguard** and a **supplementary safeguard** ~~be~~ are interposed between a thermal energy source capable of causing injury and an **ordinary person**.

The **basic safeguard** against a thermal energy source capable of causing pain or injury is thermal insulation placed between the energy source and a body part. In some cases, a **basic safeguard** against a thermal energy source capable of causing pain or injury may be an **instructional safeguard** identifying the hot parts and how to reduce the likelihood of injury. In some cases, a **basic safeguard** reduces the likelihood of a non-injurious thermal energy source from becoming a thermal energy source capable of causing pain or injury.

Examples of such **basic safeguards** are:

– control of electrical energy being converted to thermal energy (for example, a **thermostat**);
– heat sinking, etc.

The **supplementary safeguard** against a thermal energy source capable of causing injury is thermal insulation placed between the energy source and a body part. In some cases, a **supplementary safeguard** against a thermal energy source capable of causing pain or injury may be an **instructional safeguard** identifying the hot parts and how to reduce the likelihood of injury.

0.11 Radiation-caused injury

Radiation-caused injury within the scope of this document is generally attributed to one of the following energy transfer mechanisms:

– heating of a body organ caused by exposure to non-ionising radiation, such as the highly localised energy of a laser impinging on the retina~~, or heating a larger volume such as the energy from a high frequency wireless, electromagnetic fields, or high frequency transmitter~~; or
– auditory injury caused by over stimulation of the ear by excessive peaks or sustained loud sound, leading to physical or nerve damage; or
– X-radiation; or
– UV radiation.

Radiated energy is transferred by impingement of wave emission upon a body part.

The **basic safeguard** against radiation-caused injury is containment of the energy within an **enclosure** that is opaque to the radiated energy.

There are several **supplementary safeguards** against radiation-caused injury. The **supplementary safeguards** may include **safety interlocks** to disconnect power to the generator, tamper-proof screws to prevent unauthorized access, etc.

The **basic safeguard** against auditory injury is to limit the acoustic output of personal music players and their associated headphones and earphones.

Examples of **supplementary safeguards** against auditory pain and injury are the provision of warnings and information advising the user how to use the equipment correctly.

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AUDIO/VIDEO, INFORMATION AND COMMUNICATION TECHNOLOGY EQUIPMENT –

Part 1: Safety requirements

1 Scope

This part of IEC 62368 is applicable to the safety of electrical and electronic equipment within the field of audio, video, information and communication technology, and business and office machines with a **rated voltage** not exceeding 600 V. This document does not include requirements for performance or functional characteristics of equipment.

NOTE 1 Examples of equipment within the scope of this document are given in Annex A.

NOTE 2 A **rated voltage** of 600 V is considered to include equipment rated 400/690 V.

This document is also applicable to:

– components and subassemblies intended for incorporation in this equipment. Such components and subassemblies need not comply with every requirement of this document, provided that the complete equipment, incorporating such components and subassemblies, does comply;

– external power supply units intended to supply other equipment within the scope of this document;

– accessories intended to be used with equipment within the scope of this document;

– large equipment installed in **restricted access areas**. For equipment having large machinery aspects, additional requirements may apply; and

– equipment to be used in tropical regions.

~~This part of IEC 62368 does not apply to power supply systems which are not an integral part of the equipment, such as motor-generator sets, **battery** backup systems and distribution transformers.~~

~~This part of IEC 62328 specifies **safeguards** for **ordinary persons**, **instructed persons**, and **skilled persons**. Additional requirements may apply for equipment that is clearly designed or intended for use by children or specifically attractive to children.~~

~~This part of IEC 62368 does not apply to equipment to be used in wet areas. Additional requirements may apply.~~

~~Additional requirements for equipment intended for outdoor installation are given in IEC 60950-22.~~

This document also includes requirements for audio/video, information and communication technology equipment intended to be installed in an **outdoor location**. The requirements for **outdoor equipment** also apply, where relevant, to **outdoor enclosures** suitable for direct installation in the field and supplied for housing audio/video, information and communication technology equipment to be installed in an **outdoor location**. See Annex Y for specific construction requirements not covered elsewhere in this document.

Each installation may have particular requirements. In addition, requirements for protection of the **outdoor equipment** against the effects of direct lightning strikes are not covered by this document.

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NOTE 3 For information on this subject, see IEC 62305-1.

This document assumes a maximum altitude of 2 000 m unless otherwise specified by the manufacturer.

Additional requirements for equipment having the capability to supply DC power over commonly used communication cables, such as USB or Ethernet (PoE), are given in IEC 62368-3. IEC 62368-3 does not apply to:

– equipment supplying power using proprietary connectors; or
– equipment using a proprietary protocol for power selection.

This document specifies **safeguards** for **ordinary persons**, **instructed persons**, and **skilled persons**. Additional requirements may apply for equipment that is clearly designed or intended for use by children or specifically attractive to children.

NOTE ~~3~~ 4 In Australia, the work conducted by an **instructed person** or a **skilled person** may require formal licensing from regulatory authorities.

NOTE 5 In Germany, in many cases a person may only be regarded as an **instructed person** or a **skilled person** if certain legal requirements are fulfilled.

This document does not apply to:

– equipment with non-self-contained hazardous moving parts, such as robotic equipment; and

  NOTE 6 For requirements related to robotic equipment in an industrial environment, see IEC 60204-1, IEC 60204-11, ISO 10218-1 and ISO 10218-2.

– personal care robots, including mobile servant robots, physical assistant robots, and person carrier robots; and

  NOTE 7 For requirements related to personal care robots, see ISO 13482.

– power supply systems that are not an integral part of the equipment, such as motor-generator sets, **battery** backup systems and distribution transformers.

This document does not address:

– manufacturing processes except ~~safety testing~~ for **routine tests**;
– injurious effects of gases released by thermal decomposition or combustion;
– disposal processes;
– effects of transport (other than as specified in this document);
– effects of storage of materials, components, or the equipment itself;
– the likelihood of injury from particulate radiation such as alpha particles and beta particles;
– the likelihood of thermal injury due to radiated or convected thermal energy;
– the likelihood of injury due to flammable liquids;
– the use of the equipment in oxygen-enriched or **explosive** atmospheres;
– exposure to chemicals other than as specified in Clause 7;
– electrostatic discharge events;
– exposure to electromagnetic fields;
– environmental aspects; or
– requirements for functional safety, except for those related to **work cells**.

NOTE ~~4~~ 8 For specific functional and software safety requirements of electronic safety-related systems (for example, protective electronic circuits), see IEC 61508-1.

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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 60027-1, *Letter symbols to be used in electrical technology – Part 1: General*

IEC 60065, *Audio, video and similar electronic apparatus – Safety requirements*

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

IEC 60068-2-11, *Basic environmental testing procedures – Part 2-11: Tests – Test Ka: Salt mist*

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

IEC 60073, *Basic and safety principles for man-machine interface, marking and identification – Coding principles for indicators and actuators*

IEC 60076-14, *Power transformers – Part 14: Liquid-immersed power transformers using high-temperature insulation materials*

IEC TR 60083, *Plugs and socket-outlets for domestic and similar general use standardized in member countries of IEC*

IEC 60085, *Electrical insulation – Thermal evaluation and designation*

IEC 60086-4, *Primary batteries – Part 4: Safety of lithium batteries*

IEC 60086-5, *Primary batteries – Part 5: Safety of batteries with aqueous electrolyte*

IEC 60107-1:1997, *Methods of measurement on receivers for television broadcast transmissions – Part 1: General considerations – Measurements at radio and video frequencies*

IEC 60112, *Method for the determination of the proof and the comparative tracking indices of solid insulating materials*

IEC 60127 (all parts), *Miniature fuses*

IEC 60227-1, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 1: General requirements*

IEC 60227-2:~~2003~~ 1997, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 2: Test methods*
IEC 60227-2:1997/AMD1:2003

IEC 60245-1, *Rubber insulated cables – Rated voltages up to and including 450/750 V – Part 1: General requirements*

IEC 60296, *Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear*

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IEC 60309 (all parts), *Plugs, socket-outlets and couplers for industrial purposes*

IEC 60317 (all parts), *Specifications for particular types of winding wires*

IEC 60317-0-7:2017, *Specifications for particular types of winding wires – Part 0-7: General requirements – Fully insulated (FIW) zero-defect enamelled round copper wire*

IEC 60317-43, *Specifications for particular types of winding wires – Part 43: Aromatic polyimide tape wrapped round copper wire, class 240*

IEC 60317-56, *Specifications for particular types of winding wires – Part 56: Solderable fully insulated (FIW) zero-defect polyurethane enamelled round copper wire, class 180*

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

IEC 60320-1, *Appliance couplers for household and similar general purposes – Part 1: General requirements*

~~IEC 60320-2-2, *Appliance couplers for household and similar general purposes – Part 2-2: Interconnection couplers for household and similar equipment*~~

IEC 60332-1-2, *Tests on electric and optical fibre cables under fire conditions – Part 1-2: Test for vertical flame propagation for a single insulated wire or cable – Procedure for 1 kW pre-mixed flame*

IEC 60332-1-3, *Tests on electric and optical fibre cables under fire conditions – Part 1-3: Test for vertical flame propagation for a single insulated wire or cable – Procedure for determination of flaming droplets/particles*

IEC 60332-2-2, *Tests on electric and optical fibre cables under fire conditions – Part 2-2: Test for vertical flame propagation for a single small insulated wire or cable – Procedure for diffusion flame*

IEC 60384-14~~:2005~~, *Fixed capacitors for use in electronic equipment – Part 14: Sectional specification: Fixed capacitors for electromagnetic interference suppression and connection to the supply mains*

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

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

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

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

IEC 60691:~~2002~~ 2015, *Thermal-links – Requirements and application guide*

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

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

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IEC 60695-10-3, *Fire hazard testing – Part 10-3: Abnormal heat – Mould stress relief distortion test*

IEC 60695-11-5:~~2004~~ 2016, *Fire hazard testing – Part 11-5: Test flames – Needle-flame test method – Apparatus, confirmatory test arrangement and guidance*

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

IEC 60695-11-20:~~1999~~ 2015, *Fire hazard testing – Part 11-20: Test flames – 500 W flame test methods*

IEC TS 60695-11-21, *Fire hazard testing – Part 11-21: Test flames – 500 W vertical flame test method for tubular polymeric materials*

IEC 60728-11:~~2005~~ 2016, *Cable networks for television signals, sound signals and interactive services – Part 11: Safety*

IEC 60730 (all parts), *Automatic electrical controls for household and similar use*

IEC 60730-1:~~2010~~ 2013, *Automatic electrical controls ~~for household and similar use~~ – Part 1: General requirements*

IEC 60738-1:~~2009~~ 2006, *Thermistors – Directly heated positive temperature coefficient – Part 1: Generic specification*

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IEC 60998-1, *Connecting devices for low-voltage circuits for household and similar purposes – Part 1: General requirements*

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IEC 61434, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Guide to designation of current in alkaline secondary cell and battery standards*

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IEC 62133-1, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications – Part 1: Nickel systems*

IEC 62133-2, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for portable sealed secondary lithium cells, and for batteries made from them, for use in portable applications – Part 2: Lithium systems*

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IEC 62619, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for secondary lithium cells and batteries, for use in industrial applications*

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ISO 178, *Plastics – Determination of flexural properties*

ISO 179-1, *Plastics – Determination of Charpy impact properties – Part 1: Non-instrumented impact test*

ISO 180, *Plastics – Determination of Izod impact strength*

ISO 306, *Plastics – Thermoplastic materials – Determination of Vicat softening temperature (VST)*

ISO 527 (all parts), *Plastics – Determination of tensile properties*

ISO 871, *Plastics – Determination of ignition temperature using a hot-air furnace*

ISO 1798, *Flexible cellular polymeric materials – Determination of tensile strength and elongation at break*

ISO 1817:2015, *Rubber, vulcanized or thermoplastic – Determination of the effect of liquids*

ISO 2719, *Determination of flash point – Pensky-Martens closed cup method*

ISO 3231, *Paints and varnishes – Determination of resistance to humid atmospheres containing sulfur dioxide*

ISO 3679, *Determination of flash no-flash and flash point – Rapid equilibrium closed cup method*

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ISO 3864-2, *Graphical symbols – Safety colours and safety signs – Part 2: Design principles for product safety labels*

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ISO 4892-2~~:2006~~, *Plastics – Methods of exposure to laboratory light sources – Part 2: Xenon-arc lamps*

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EN 50332-3, *Sound system equipment: Headphones and earphones associated with personal music players – maximum sound pressure level measurement methodology – Part 3: Measurement method for sound dose management*

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3 Terms, definitions and abbreviated terms

3.1 Energy source abbreviations

Abbreviation	Description	
ES	Electrical energy source	see 5.2
ES1	Electrical energy source class 1	
ES2	Electrical energy source class 2	
ES3	Electrical energy source class 3	
MS	Mechanical energy source	see 8.2
MS1	Mechanical energy source class 1	
MS2	Mechanical energy source class 2	
MS3	Mechanical energy source class 3	
PS	Power source	see 6.2
PS1	Power source class 1	
PS2	Power source class 2	
PS3	Power source class 3	
RS	Radiation energy source	see 10.2
RS1	Radiation energy source class 1	
RS2	Radiation energy source class 2	
RS3	Radiation energy source class 3	
TS	Thermal energy source	see 9.2
TS1	Thermal energy source class 1	
TS2	Thermal energy source class 2	
TS3	Thermal energy source class 3	

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3.2 Other abbreviations

Abbreviation	Description
CD	compact disc
CD ROM	compact disc read-only memory
CRT	cathode ray tube
CSD	calculated sound dose
CTI	comparative tracking index
DVD	digital versatile disc
E	sound exposure
EIS	electrical insulation system
EUT	equipment under test
FIW	fully insulated winding wire
GDT	gas discharge tube
IC	integrated circuit
ICX	integrated circuit with X-capacitor function
IR	infrared
LED	light emitting diode
LEL	lower explosion limit
LFC	liquid filled component
LPS	limited power source
MEL	momentary exposure level
MOV	metal oxide varistor
NEMA	National Electrical Manufacturers Association
NiCd	nickel cadmium
PIS	potential ignition source
PMP	personal music player
PoE	power over Ethernet
PPE	personal protective equipment
PTC	positive temperature coefficient
PTI	proof tracking index
RC	resistor-capacitor
RG	risk group
Sb	antimony
SEL	sound exposure level
SPD	surge protective device
SRME	slide rail mounted equipment
TSS	thyristor surge suppressor
UPS	uninterruptible power supply
USB	universal serial bus
UV	ultraviolet
VDR	voltage dependent resistor
VRLA	valve regulated lead acid

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3.3 Terms and definitions

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

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

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

For the convenience of the user, the defined terms are listed below in alphabetical order indicating the number of the defined term.

Where the words “voltage” and “current” or their abbreviations are used, they are RMS values unless otherwise specified.

5VA class material	3.3.4.2.1
5VB class material	3.3.4.2.2
abnormal operating condition	3.3.7.1
accessible	3.3.6.1
arcing PIS	3.3.9.2
backfeed	3.3.6.2
backfeed safeguard	3.3.11.1
basic insulation	3.3.5.1
basic safeguard	3.3.11.2
battery	3.3.17.1
calculated sound dose, CSD	3.3.19.1
cell	3.3.17.2
cheesecloth	3.3.6.3
class I equipment	3.3.15.1
class II construction	3.3.15.2
class II equipment	3.3.15.3
class III equipment	3.3.15.4
clearance	3.3.12.1
coin / button cell battery	3.3.17.3
combustible material	3.3.4.1
consumable material	3.3.16.1
creepage distance	3.3.12.2
DC voltage	3.3.14.1
digital signal level relative to full scale, dBFS	3.3.19.5
direct plug-in equipment	3.3.3.1
disconnect device	3.3.6.4
double insulation	3.3.5.2
double safeguard	3.3.11.3
electrical enclosure	3.3.2.1
enclosure	3.3.2.2
equipment safeguard	3.3.11.4

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explosion	3.3.16.2
explosive	3.3.16.3
external circuit	3.3.1.1
fire enclosure	3.3.2.3
fixed equipment	3.3.3.2
fully insulated winding wire, FIW	3.3.18.1
functional earthing	3.3.6.5
functional insulation	3.3.5.3
grade of FIW	3.3.18.2
hand-held equipment	3.3.3.3
hazardous substance	3.3.16.4
HB40 class material	3.3.4.2.3
HB75 class material	3.3.4.2.4
HBF class foamed material	3.3.4.2.5
HF-1 class foamed material	3.3.4.2.6
HF-2 class foamed material	3.3.4.2.7
highest specified charging temperature	3.3.17.4
installation safeguard	3.3.11.5
instructed person	3.3.8.1
instructional safeguard	3.3.11.6
insulating liquid	3.3.5.4
intermittent operation	3.3.7.2
lowest specified charging temperature	3.3.17.5
mains	3.3.1.2
mains transient voltage	3.3.14.2
material flammability class	3.3.4.2
maximum specified charging current	3.3.17.6
maximum specified charging voltage	3.3.17.7
mechanical enclosure	3.3.2.4
momentary exposure level, MEL	3.3.19.2
movable equipment	3.3.3.4
non-clipped output power	3.3.7.3
non-detachable power supply cord	3.3.6.6
normal operating condition	3.3.7.4
ordinary person	3.3.8.2
~~overload condition~~	~~3.3.7.5~~
outdoor enclosure	3.3.2.5
outdoor equipment	3.3.3.5
outdoor location	3.3.6.7
peak response frequency	3.3.7.5
~~peak working voltage~~	~~3.3.14.3~~
permanently connected equipment	3.3.3.6
personal safeguard	3.3.11.7

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pluggable, type A equipment	3.3.3.7
pluggable, type B equipment	3.3.3.8
pollution degree	3.3.6.8
potential ignition source, PIS	3.3.9.1
precautionary safeguard	3.3.11.8
professional equipment	3.3.3.9
prospective touch voltage	3.3.14.3
protective bonding conductor	3.3.11.9
protective conductor current	3.3.14.4
protective conductor	3.3.11.10
protective current rating	3.3.10.6
protective earthing	3.3.11.11
protective earthing conductor	3.3.11.12
rated current	3.3.10.1
rated frequency	3.3.10.2
rated load impedance	3.3.7.6
rated power	3.3.10.3
rated voltage range	3.3.10.5
rated voltage	3.3.10.4
reasonably foreseeable misuse	3.3.7.7
reinforced insulation	3.3.5.5
reinforced safeguard	3.3.11.13
required withstand voltage	3.3.14.5
resistive PIS	3.3.9.3
restricted access area	3.3.6.9
RMS working voltage	3.3.14.6
routine test	3.3.6.10
safeguard	3.3.11.14
safety interlock	3.3.11.15
sampling test	3.3.6.11
secondary lithium battery	3.3.17.8
short-time operation	3.3.7.8
single fault condition	3.3.7.9
skill safeguard	3.3.11.16
skilled person	3.3.8.3
solid insulation	3.3.5.6
sound exposure, E	3.3.19.3
sound exposure level, SEL	3.3.19.4
stationary equipment	3.3.3.10
stored energy mode	3.3.6.12
supplementary insulation	3.3.5.7
supplementary safeguard	3.3.11.17
temperature limiter	3.3.13.1

IECNORM.COM : Click to view the full PDF of IEC 62368 1 ed 3.0 (RLV):2018

temporary overvoltage	3.3.14.7
thermal cut-off	3.3.13.2
thermostat	3.3.13.3
tool	3.3.6.13
touch current	3.3.6.14
transportable equipment	3.3.3.11
type test	3.3.6.15
V-0 class material	3.3.4.2.8
V-1 class material	3.3.4.2.9
V-2 class material	3.3.4.2.10
VTM-0 class material	3.3.4.2.11
VTM-1 class material	3.3.4.2.12
VTM-2 class material	3.3.4.2.13
wireless power transmitter	3.3.3.12
work cell	3.3.6.16
working voltage	3.3.14.8
wrapping tissue	3.3.6.17

3.3.1 Circuit terms

3.3.1.1
external circuit
electrical circuit that is external to the equipment and is not **mains**

Note 1 to entry: An **external circuit** is classified as ES1, ES2 or ES3, and PS1, PS2, or PS3.

3.3.1.2
mains
AC or DC power distribution system (external to the equipment) that supplies operating power to the equipment and is PS3

Note 1 to entry: **Mains** include public or private utilities and, unless otherwise specified in this document, equivalent sources such as motor-driven generators and uninterruptible power supplies.

3.3.2 Enclosure terms

3.3.2.1
electrical enclosure
enclosure intended as a **safeguard** against electrically-caused injury

[SOURCE: IEC 60050-195:1998, 195-06-13, modified – the term **safeguard** has been used]

3.3.2.2
enclosure
housing affording the type and degree of protection suitable for the intended application

[SOURCE: IEC 60050-195:1998, 195-02-35]

3.3.2.3
fire enclosure
enclosure intended as a **safeguard** against the spread of fire from within the **enclosure** to outside the **enclosure**

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3.3.2.4
mechanical enclosure
enclosure intended as a **safeguard** against mechanically-caused pain and injury

3.3.2.5
outdoor enclosure
enclosure that is intended to provide protection from specific conditions in an **outdoor location**

Note 1 to entry: An **outdoor enclosure** can also perform the functions of another **enclosure**, for example: a **fire enclosure**; an **electrical enclosure**; a **mechanical enclosure**.

Note 2 to entry: A separate cabinet or housing into which the equipment is placed can provide the function of an **outdoor enclosure**.

3.3.3 Equipment terms

3.3.3.1
direct plug-in equipment
equipment in which the **mains** plug forms an integral part of the equipment **enclosure**

3.3.3.2
fixed equipment
equipment that is specified in the installation instructions to only be secured in place by a means defined by the manufacturer

Note 1 to entry: Equipment that has a screw hole or other means to secure the equipment by an **ordinary person**, such as for securement to a table or for earthquake protection, is not considered to be **fixed equipment**.

Note 2 to entry: Typically, **fixed equipment** will be wall, ceiling or floor mounted.

3.3.3.3
hand-held equipment
movable equipment, or a part of any kind of equipment, that is intended to be held in the hand during normal use

3.3.3.4
movable equipment
equipment that is either:

– 18 kg or less in mass and is not **fixed** ~~in place~~ **equipment**; or
– provided with wheels, casters, or other means to facilitate movement by an **ordinary person** as required to perform its intended use

3.3.3.5
outdoor equipment
equipment that is installed or exposed in an **outdoor location**, specified by the manufacturer to comply wholly or in part under specific conditions

Note 1 to entry: **Transportable equipment**, for example, a laptop or notebook computer, or a telephone, is not **outdoor equipment** unless specified by the manufacturer for continuous use in an **outdoor location**.

3.3.3.6
permanently connected equipment
equipment that can only be electrically connected to or disconnected from the **mains** by the use of a **tool**

3.3.3.7
pluggable equipment type A
equipment that is intended for connection to the **mains** via a non-industrial plug and socket-outlet or via a non-industrial appliance coupler, or both

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Note 1 to entry: Examples are plugs and socket-outlets covered by standards such as IEC TR 60083 and IEC 60320-1.

3.3.3.8
pluggable equipment type B
equipment that is intended for connection to the **mains** via an industrial plug and socket-outlet or via an industrial appliance coupler, or both

Note 1 to entry: Examples are plugs and socket-outlets covered by standards such as IEC 60309-1.

3.3.3.9
professional equipment
equipment for use in trades, professions or industries and which is not intended for sale to the general public

[SOURCE: IEC 60050-161:1990, 161-05-05]

3.3.3.10
stationary equipment

– **fixed equipment**, or
– **permanently connected equipment**, or
– equipment that, due to its physical characteristics, is normally not moved

Note 1 to entry: **Stationary equipment** is neither **movable equipment** nor **transportable equipment**.

3.3.3.11
transportable equipment
equipment that is intended to be routinely carried

Note 1 to entry: Examples include notebook computers, CD players and portable accessories, including their external power supplies.

3.3.3.12
wireless power transmitter
equipment that uses electromagnetic fields to transfer electrical power for charging **battery** operated hand-held devices

3.3.4 Flammability terms

3.3.4.1
combustible material
~~organic~~ material that is capable of ~~combustion~~ being ignited or burned

Note 1 to entry: All thermoplastic materials are considered capable of being ~~combusted~~ ignited or burned regardless of the **material flammability class**.

3.3.4.2
material flammability class
recognition of the burning behaviour of materials and their ability to extinguish if ignited

Note 1 to entry: Materials are classified when tested in accordance with IEC 60695-11-10, IEC 60695-11-20, ISO 9772 or ISO 9773.

3.3.4.2.1
5VA class material
material tested in the thinnest significant thickness used and classified 5VA according to IEC 60695-11-20

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3.3.4.2.2
5VB class material
material tested in the thinnest significant thickness used and classified 5VB according to IEC 60695-11-20

3.3.4.2.3
HB40 class material
material tested in the thinnest significant thickness used and classified HB40 according to IEC 60695-11-10

3.3.4.2.4
HB75 class material
material tested in the thinnest significant thickness used and classified HB75 according to IEC 60695-11-10

3.3.4.2.5
HBF class foamed material
foamed material tested in the thinnest significant thickness used and classified HBF according to ISO 9772

3.3.4.2.6
HF-1 class foamed material
foamed material tested in the thinnest significant thickness used and classified HF-1 according to ISO 9772

3.3.4.2.7
HF-2 class foamed material
foamed material tested in the thinnest significant thickness used and classified HF-2 according to ISO 9772

3.3.4.2.8
V-0 class material
material tested in the thinnest significant thickness used and classified V-0 according to IEC 60695-11-10

3.3.4.2.9
V-1 class material
material tested in the thinnest significant thickness used and classified V-1 according to IEC 60695-11-10

3.3.4.2.10
V-2 class material
material tested in the thinnest significant thickness used and classified V-2 according to IEC 60695-11-10

3.3.4.2.11
VTM-0 class material
material tested in the thinnest significant thickness used and classified VTM-0 according to ISO 9773

3.3.4.2.12
VTM-1 class material
material tested in the thinnest significant thickness used and classified VTM-1 according to ISO 9773

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3.3.4.2.13
VTM-2 class material
material tested in the thinnest significant thickness used and classified VTM-2 according to ISO 9773

3.3.5 Electrical insulation

3.3.5.1
basic insulation
insulation to provide a **basic safeguard** against electric shock

Note 1 to entry: This concept does not apply to insulation used exclusively for functional purposes.

3.3.5.2
double insulation
insulation comprising both **basic insulation** and **supplementary insulation**

[SOURCE: IEC 60050-195~~, Amendment 1:2001~~1998, 195-06-08]

3.3.5.3
functional insulation
insulation between conductive parts which is necessary only for the proper functioning of the equipment

3.3.5.4
insulating liquid
insulating material consisting entirely of a liquid

[SOURCE: IEC 60050-212:2010, 212-11-04]

3.3.5.5
reinforced insulation
single insulation system that provides a degree of protection against electric shock equivalent to **double insulation**

3.3.5.6
solid insulation
~~solid insulating material placed between two conductive parts or between a conductive part and a body part~~

insulation consisting entirely of solid material

[SOURCE: IEC 60050-212:2010, 212-11-02]

3.3.5.7
supplementary insulation
independent insulation applied in addition to **basic insulation** to provide a **supplementary safeguard** for fault protection against electric shock

3.3.6 Miscellaneous

3.3.6.1
accessible
touchable by a body part

Note 1 to entry: A body part is represented by one or more of the probes specified in Annex V, as applicable.

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3.3.6.2
backfeed
condition in which a voltage or energy available within a **battery** backed up supply is fed back to any of the input terminals, either directly or by a leakage path while operating in the **stored energy mode** and with **mains** power not available

3.3.6.3
cheesecloth
bleached cotton cloth of approximately 40 g/m^2

Note 1 to entry: **Cheesecloth** is a coarse, loosely woven cotton gauze, originally used for wrapping cheese.

3.3.6.4
disconnect device
means to electrically disconnect equipment from the **mains** that, in the open position, complies with the requirements specified for isolation

3.3.6.5
functional earthing
earthing a point or points in a system or in an installation or in equipment, for purposes other than electrical safety

[SOURCE: IEC 60050-195:1998/AMD1:2001, 195-01-13]

3.3.6.6
non-detachable power supply cord
flexible supply cord affixed to or assembled ~~with~~ to the equipment and that cannot be removed from the equipment without the use of **tools**

3.3.6.7
outdoor location
location for equipment where protection from the weather and other outdoor influences provided by a building or other structure is limited or non-existent

3.3.6.8
pollution degree
numeral characterizing the expected pollution of the micro-environment

[SOURCE: IEC 60050-581:2008, 581-21-07]

3.3.6.9
restricted access area
area **accessible** only to **skilled persons** and to **instructed persons** with the proper authorization

3.3.6.10
routine test
test to which each individual device is subjected during or after manufacture to ascertain whether it complies with certain criteria

[SOURCE: IEC 60664-1:2007, 3.19.2]

3.3.6.11
sampling test
test on a number of devices taken at random from a batch

[SOURCE: IEC 60664-1:2007, 3.19.3]

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3.3.6.12
stored energy mode
stable mode of operation that a **battery** backed up supply attains under specified conditions

Note 1 to entry: In accordance with IEC 62040-1:2017, the specified conditions are as follows:

– AC input power is disconnected or is out of required tolerance;

– operating and output power is supplied by the energy storage device;

– the load is within the specified rating of the **battery** backed up supply.

3.3.6.13
tool
object that can be used to operate a screw, latch or similar fixing means

Note 1 to entry: Examples of **tools** include coins, tableware, screwdrivers, pliers, etc.

3.3.6.14
touch current
electric current through a human body when body parts touch two or more **accessible** parts or one **accessible** part and earth

3.3.6.15
type test
test on a representative sample with the objective of determining if, as designed and manufactured, it can meet the requirements of this document

3.3.6.16
work cell
space within the equipment of such size that a person can enter completely or partially (for example, entire limb or head) for servicing or operating the equipment and where mechanical hazards may be present

Note 1 to entry: A **work cell** can contain more than one compartment. A compartment can be used for either operational or service purposes.

Note 2 to entry: The equipment containing the **work cell** is typically installed within a **restricted access area**.

3.3.6.17
wrapping tissue
tissue between 12 g/m^2 and 30 g/m^2

Note 1 to entry: The **wrapping tissue** is soft, thin, usually translucent paper used for wrapping delicate articles.

3.3.7 Operating and fault conditions

3.3.7.1
abnormal operating condition
temporary operating condition that is not a **normal operating condition** and is not a **single fault condition** of the equipment itself

Note 1 to entry: **Abnormal operating conditions** are specified in Clause B.3.

Note 2 to entry: An **abnormal operating condition** may be introduced by the equipment or by a person.

Note 3 to entry: An **abnormal operating condition** may result in a failure of a component, a device or a **safeguard**.

3.3.7.2
intermittent operation
operation in a series of cycles, each composed of a period of operation followed by a period with the equipment switched off or running idle

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3.3.7.3
non-clipped output power
sine wave power dissipated in the **rated load impedance**, measured at 1 000 Hz at the onset of clipping on either one or both peaks

3.3.7.4
normal operating condition
mode of operation that represents as closely as possible the range of normal use that can reasonably be expected

Note 1 to entry: Unless otherwise ~~stated~~ specified, the most severe conditions of normal use are the most unfavourable default values as specified in Clause B.2.

Note 2 to entry: **Reasonably foreseeable misuse** is not covered by **normal operating conditions**. Instead, it is covered by **abnormal operating conditions**.

~~**3.3.7.5**~~
~~**overload condition**~~
~~**abnormal operating condition** or **single fault condition** where the load stresses the equipment or circuit beyond **normal operating conditions**, but does not, immediately, result in a non-operating state~~

3.3.7.5
peak response frequency
test frequency that produces the maximum output power measured at the **rated load impedance**

Note 1 to entry: The frequency applied should be within the amplifier/transducer's intended operating range.

3.3.7.6
rated load impedance
impedance or resistance, as declared by the manufacturer, by which an output circuit should be terminated

3.3.7.7
reasonably foreseeable misuse
use of a product, process or service in a way not intended by the supplier, but which ~~may~~ can result from readily predictable human behaviour

Note 1 to entry: **Reasonably foreseeable misuse** is considered to be a form of **abnormal operating conditions**.

[SOURCE: ISO/IEC Guide 51:~~1999~~ 2014, ~~3.14, modified – Note 1 to entry has been added~~ 3.7, modified – In the definition, "product or system" has been replaced by "product, process or service". The Notes to entry have been replaced]

3.3.7.8
short-time operation
operation under **normal operating conditions** for a specified period, starting when the equipment is cold, the intervals after each period of operation being sufficient to allow the equipment to cool down to room temperature

3.3.7.9
single fault condition
condition of equipment with a fault under **normal operating condition** of a single **safeguard** (but not a **reinforced safeguard**) or of a single component or a device

Note 1 to entry: **Single fault conditions** are specified in Clause B.4.

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3.3.8 Persons

3.3.8.1
instructed person
person instructed or supervised by a **skilled person** as to energy sources and who can responsibly use **equipment safeguards** and **precautionary safeguards** with respect to those energy sources

Note 1 to entry: Supervised, as used in the definition, means having the direction and oversight of the performance of others.

Note 2 to entry: In Germany, in many cases, a person may only be regarded as an **instructed person** if certain legal requirements are fulfilled.

3.3.8.2
ordinary person
person who is neither a **skilled person** nor an **instructed person**

[SOURCE: IEC 60050-826:2004, 826-18-03]

3.3.8.3
skilled person
person with relevant education or experience to enable him or her to identify hazards and to take appropriate actions to reduce the risks of injury to themselves and others

Note 1 to entry: In Germany, in many cases, a person may only be regarded as an **skilled person** if certain legal requirements are fulfilled.

[SOURCE: IEC 60050-826:2004, 826-18-01, modified – The definition has been made applicable to all types of hazards.]

3.3.9 Potential ignition sources

3.3.9.1
potential ignition source
PIS
location where electrical energy can cause ignition

3.3.9.2
arcing PIS
~~location~~ **PIS** where an arc may occur due to the opening of a conductor or a contact

Note 1 to entry: An electronic protection circuit or additional constructional measures may be used to prevent a location from becoming an **arcing PIS**.

Note 2 to entry: A faulty contact or interruption in an electric connection that may occur in conductive patterns on printed boards is considered to be within the scope of this definition.

3.3.9.3
resistive PIS
~~location~~ **PIS** where a component may ignite due to excessive power dissipation

Note 1 to entry: An electronic protection circuit or additional constructional measures may be used to prevent a location from becoming a **resistive PIS**.

3.3.10 Ratings

3.3.10.1
rated current
input current of the equipment, as declared by the manufacturer, at **normal operating conditions**

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3.3.10.2
rated frequency
supply frequency or frequency range as declared by the manufacturer

3.3.10.3
rated power
input power of the equipment, as declared by the manufacturer, at **normal operating conditions**

3.3.10.4
rated voltage
value of voltage assigned by the manufacturer to a component, device or equipment and to which operation and performance characteristics are referred

Note 1 to entry: Equipment may have more than one **rated voltage** value or may have a **rated voltage range**.

[SOURCE: IEC 60664-1:2007, 3.9]

3.3.10.5
rated voltage range
supply voltage range, as declared by the manufacturer, expressed by its lower and upper **rated voltages**

3.3.10.6
protective current rating
current rating of an overcurrent protective device that is in the building installation or in the equipment to protect a circuit

3.3.11 Safeguards

3.3.11.1
backfeed safeguard
control scheme that reduces the risk of electric shock due to backfeed

3.3.11.2
basic safeguard
safeguard that provides protection under **normal operating conditions** and under **abnormal operating conditions** whenever an energy source capable of causing pain or injury is present in the equipment

3.3.11.3
double safeguard
safeguard comprising both a **basic safeguard** and a **supplementary safeguard**

3.3.11.4
equipment safeguard
safeguard that is a physical part of the equipment

3.3.11.5
installation safeguard
safeguard that is a physical part of a man-made installation

3.3.11.6
instructional safeguard
instruction invoking specified behaviour

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3.3.11.7
personal safeguard
personal protective equipment that is worn on the body and that reduces exposure to an energy source

Note 1 to entry: ~~Personal protective equipment (PPE) is a form of a **personal safeguard**.~~ Examples are shields, goggles, gloves, aprons, face masks or breathing apparatus.

3.3.11.8
precautionary safeguard
instructed person behaviour to avoid contact with or exposure to a class 2 energy source based on supervision or instructions given by a **skilled person**

3.3.11.9
protective bonding conductor
protective conductor in the equipment provided for protective equipotential-bonding of parts required to be earthed for safety purposes

Note 1 to entry: A **protective bonding conductor** is internal in the equipment.

3.3.11.10
protective conductor
conductor provided for the purposes of safety (for example, protection against electric shock)

Note 1 to entry: A **protective conductor** is either a **protective earthing conductor** or a **protective bonding conductor**.

[SOURCE: IEC 60050-195:1998~~/AMD1:2001~~, 195-02-09]

3.3.11.11
protective earthing
earthing a point or points in a system or in an installation or in equipment for purposes of electrical safety

[SOURCE: IEC 60050-195:1998/AMD1:2001, 195-01-11]

3.3.11.12
protective earthing conductor
protective conductor connecting a main **protective earthing** terminal in the equipment to an earth point in the building installation for **protective earthing**

3.3.11.13
reinforced safeguard
single **safeguard** that is ~~operational~~ effective under:

– **normal operating conditions**;
– **abnormal operating conditions**; and
– **single fault conditions**

3.3.11.14
safeguard
physical part or system or instruction specifically provided to reduce the likelihood of pain or injury, or, for fire, to reduce the likelihood of ignition or spread of fire

Note 1 to entry: See 0.5 for further explanation of a **safeguard**.

3.3.11.15
safety interlock
means to automatically change an energy source to a lower class energy source prior to the potential for transfer of the higher energy to a body part

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Note 1 to entry: A **safety interlock** encompasses the system of components and circuits that are directly involved in the **safeguard** function, including electro-mechanical devices, conductors on printed boards, wiring and their terminations, etc., as applicable.

3.3.11.16
skill safeguard
skilled person behaviour to avoid contact with or exposure to a class 2 or class 3 energy source based on education and experience

3.3.11.17
supplementary safeguard
safeguard applied in addition to the **basic safeguard** that is or becomes operational in the event of failure of the **basic safeguard**

3.3.12 Spacings

3.3.12.1
clearance
shortest distance in air between two conductive parts

[SOURCE: IEC 60664-1:2007, 3.2]

3.3.12.2
creepage distance
shortest distance along the surface of an insulating material between two conductive parts

[SOURCE: IEC 60664-1:2007, 3.3, modified – In the definition, “solid” has been deleted.]

3.3.13 Temperature controls

3.3.13.1
temperature limiter
device for limiting the temperature of a system, either below or above a particular value, by controlling, either directly or indirectly, the flow of thermal energy into or out of the system

Note 1 to entry: A **temperature limiter** may be of the automatic reset or of the manual reset type.

3.3.13.2
thermal cut-off
device for limiting the temperature of a system, under **single fault conditions**, by controlling, either directly or indirectly, the flow of thermal energy into or out of the system

3.3.13.3
thermostat
device for maintaining the temperature of a system within a range by controlling, either directly or indirectly, the flow of thermal energy into or out of the system

3.3.14 Voltages and currents

3.3.14.1
DC voltage
voltage having a peak-to-peak ripple not exceeding 10 % of the average value

Note 1 to entry: Where peak-to-peak ripple exceeds 10 % of the average value, the requirements related to peak voltage are applicable.

3.3.14.2
mains transient voltage
highest peak voltage expected at the **mains** input to the equipment arising from external transients

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~~**3.3.14.3**~~
~~**peak working voltage**~~
~~peak value of the **working voltage**, including any d.c. component and any repetitive peak impulses generated in the equipment~~

3.3.14.3
prospective touch voltage
voltage between simultaneously **accessible** conductive parts or between one **accessible** conductive part and earth when those conductive parts are not being touched

[SOURCE: IEC 60050-195:1998, 195-05-09, modified – In the definition, "or between one **accessible** conductive part and earth" has been added.]

3.3.14.4
protective conductor current
current flowing through the **protective earthing conductor** under **normal operating conditions**

Note 1 to entry: **Protective conductor current** was previously included in the term "leakage current".

3.3.14.5
required withstand voltage
peak voltage that the insulation under consideration is required to withstand

3.3.14.6
RMS working voltage
true RMS value of the **working voltage**

Note 1 to entry: True RMS ~~measurement~~ value of the **working voltage** includes any DC component of the waveform.

Note 2 to entry: The resultant RMS value of a waveform having an AC RMS voltage A and a DC ~~offset~~ component voltage B is given by the following formula:

$$\text{RMS value} = (A^2 + B^2)^{1/2}$$

3.3.14.7
temporary overvoltage
overvoltage at **mains** power frequency of relatively long duration

3.3.14.8
working voltage
~~highest~~ voltage across any particular insulation ~~that can occur when~~ while the equipment is supplied at **rated voltage** or any voltage in the **rated voltage range** under **normal operating conditions**

Note 1 to entry: External transients are disregarded.

Note 2 to entry: Recurring peak voltages are disregarded.

3.3.15 Classes of equipment with respect to protection from electric shock

3.3.15.1
class I equipment
~~equipment in which protection against electric shock does not rely on **basic insulation** only, but that includes a **supplementary safeguard** in such a way that means are provided for the connection of **accessible** conductive parts to the **protective earthing conductor** in the fixed wiring of the installation~~

~~Note 1 to entry: For equipment intended for use with a flexible cord or cable, this provision includes a **protective conductor** as part of the flexible cord or cable.~~

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equipment with **basic insulation** used as a **basic safeguard**, and with protective bonding and **protective earthing** used as a **supplementary safeguard**

Note ~~2~~1 to entry: **Class I equipment** may be provided with **class II construction**.

[SOURCE: IEC 60050-851:2008, 851-15-10, modified – The definition has been adapted to the **safeguard** principle.]

3.3.15.2
class II construction
part of an equipment for which protection against electric shock relies upon **double insulation** or **reinforced insulation**

3.3.15.3
class II equipment
equipment in which protection against electric shock does not rely on **basic insulation** only, but in which a **supplementary safeguard** is provided, there being no provision for **protective earthing** or reliance upon installation conditions

3.3.15.4
class III equipment
equipment in which protection against electric shock relies upon supply from ES1 and in which ES3 is not generated

3.3.16 Chemical terms

3.3.16.1
consumable material
material that is used by the equipment in performing its intended function, and intended to be periodically or occasionally replaced or replenished, including any material that has a life expectancy less than that of the equipment

Note 1 to entry: Air filters are not considered to be **consumable materials**.

3.3.16.2
explosion
chemical reaction of any chemical compound or mechanical mixture that, when initiated, undergoes a very rapid combustion or decomposition, releasing large volumes of highly heated gases that exert pressure on the surrounding medium

Note 1 to entry: **Explosion** can also be a mechanical reaction in which failure of the container causes sudden release of pressure, and the contents, from within a pressure vessel. Depending on the rate of energy release, an **explosion** can be categorized as a deflagration, a detonation or pressure rupture.

3.3.16.3
explosive
substance or mixture of substances that can undergo a rapid chemical change with or without an outside source of oxygen, generating large quantities of energy generally accompanied by hot gases

3.3.16.4
hazardous substance
substance that has the potential for adversely impacting human health

Note 1 to entry: The criteria for determining whether a substance is classified as hazardous are usually defined by law or regulation.

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3.3.17 Batteries

3.3.17.1
battery
assembly of one or more **cells** ready for use as a source of electrical energy characterized by its voltage, size, terminal arrangement, capacity and rate capability

Note 1 to entry: The term **battery** pack is considered to be a **battery**.

3.3.17.2
cell
basic manufactured unit providing a source of electrical energy by direct conversion of chemical energy, that consists of electrodes, separators, electrolyte, container and terminals

3.3.17.3
coin / button cell battery
small, single **cell battery** having a diameter greater than its height

3.3.17.4
highest specified charging temperature
highest temperature specified by the manufacturer at a site on each individual **cell** comprising the **battery** during charging of a secondary **battery**

Note 1 to entry: It is usually assumed that the end-product manufacturer is responsible to specify the safety-sensitive temperature, voltage or current of the **battery**, based on the specifications provided by **battery** supplier.

3.3.17.5
lowest specified charging temperature
lowest temperature ~~as declared~~ specified by the manufacturer at a site on each individual **cell** comprising the **battery** during charging of a secondary **battery**

Note 1 to entry: It is usually assumed that the end-product manufacturer is responsible to specify the safety sensitive temperature, voltage or current of the **battery**, based on the specifications provided by **battery** supplier.

3.3.17.6
maximum specified charging current
highest charging current ~~as declared~~ specified by the manufacturer during charging of a secondary **battery**

3.3.17.7
maximum specified charging voltage
highest charging voltage ~~as declared~~ specified by the manufacturer during charging of a secondary **battery**

3.3.17.8
secondary lithium battery
battery that

– incorporates one or more secondary lithium **cells**, and
– has a housing and a terminal arrangement, and
– may have electronic control devices, and
– ~~that~~ is ready for use

Note 1 to entry: Examples of a **secondary lithium battery** include a rechargeable lithium-ion **battery**, a rechargeable lithium-polymer **battery** and a rechargeable lithium manganese **battery**.

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3.3.18 FIW terms

3.3.18.1
fully insulated winding wire
FIW
polyurethane enamelled round copper wire, class 180

Note 1 to entry: The insulating properties are in accordance with IEC 60317-0-7, IEC 60317-56 and IEC 60851-5:2008. These standards also refer to this type of wire as “zero-defect wire”, which they define as “winding wire that exhibits no electrical discontinuities when tested under specific conditions”.

Note 2 to entry: The term “zero-defect wire” is commonly used to refer to **FIW**.

3.3.18.2
grade of FIW
range of overall diameter of a wire (FIW3 to FIW9)

3.3.19 Sound exposure

3.3.19.1
calculated sound dose
CSD
one week rolling estimate of **sound exposure** expressed as a percentage of the maximum regarded as safe

Note 1 to entry: See B.4 of EN 50332-3:2017 for additional information.

3.3.19.2
momentary exposure level
MEL
metric for estimating 1 s **sound exposure** level from a specific test signal applied to both channels, based on EN 50332-1:2013, 4.2

Note 1 to entry: MEL is measured in dB(A).

Note 2 to entry: See B.3 of EN 50332-3:2017 for additional information.

3.3.19.3
sound exposure
E
A-weighted sound pressure (p) squared and integrated over a stated period of time, T

$$E = \int_0^T p(t)^2 \, \mathrm{d}t$$

Note 1 to entry: The SI unit is Pa^2 s.

3.3.19.4
sound exposure level
SEL
logarithmic measure of **sound exposure** relative to a reference value, E_0

$$\mathrm{SEL} = 10 \log_{10} \left(\frac{E}{E_0} \right)$$

Note 1 to entry: SEL is measured in dB(A).

Note 2 to entry: The reference value E_0 is typically the 1 kHz threshold of hearing in humans.

Note 3 to entry: See B.4 of EN 50332-3:2017 for additional information.

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3.3.19.5
digital signal level relative to full scale
dBFS
level of a DC-free 997 Hz sine wave whose undithered positive peak value is positive digital full scale, leaving the code corresponding to negative digital full scale unused

Note 1 to entry: Levels reported in dBFS are always RMS.

Note 2 to entry: It is invalid to use dBFS for non-RMS levels. Because the definition of full scale is based on a sine wave, the level of signals with a crest factor lower than that of a sine wave may exceed 0 dBFS. In particular, square-wave signals may reach +3,01 dBFS.

4 General requirements

4.1 General

4.1.1 Application of requirements and acceptance of materials, components and subassemblies

Requirements are specified in the relevant clauses and, where referenced in those clauses, in the relevant annexes.

Where compliance of materials, components or subassemblies is demonstrated by inspection, such compliance may be by review of published data or previous test results.

Internal and external components and subassemblies that comply with IEC 60950-1 or IEC 60065 are acceptable as part of equipment covered by this document without further evaluation other than to give consideration to the appropriate use of the component or subassembly in the end-product.

NOTE The paragraph above will be deleted in ~~edition 3~~ the next revision of this document, subject to a vote of National Committees at the time. It is added here to provide a smooth transition from the latest editions of IEC 60950-1 and IEC 60065 to this document.

4.1.2 Use of components

Where the component, or a characteristic of a component, is a **safeguard** or a part of a **safeguard**, components shall comply with the requirements of this document or, where specified in a requirements clause, with the safety aspects of the relevant IEC component standards.

NOTE 1 An IEC component standard is considered relevant only if the component in question clearly falls within its scope.

NOTE 2 The applicable test for compliance with a component standard is, in general, conducted separately.

Where use of an IEC component standard is permitted above, evaluation and testing of components shall be conducted as follows:

– a component shall be checked for correct application and use in accordance with its rating;

– a component that has been demonstrated to comply with a standard harmonized with the relevant IEC component standard shall be subjected to the applicable tests of this document, as part of the equipment, with the exception of those tests that are part of the relevant IEC component standard;

– a component that has not been demonstrated to comply with a relevant standard as above shall be subjected to the applicable tests of this document, as part of the equipment, and to the applicable tests of the component standard, under the conditions occurring in the equipment; and

– where components are used in circuits not in accordance with their specified ratings, the components shall be tested under the conditions occurring in the equipment. The number

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of samples required for test is, in general, the same as required by an equivalent standard.

Compliance is checked by inspection and by the relevant data or tests.

4.1.3 Equipment design and construction

Equipment shall be so designed and constructed that, under **normal operating conditions** as specified in Clause B.2, **abnormal operating conditions** as specified in Clause B.3, and **single fault conditions** as specified in Clause B.4, **safeguards** are provided to reduce the likelihood of injury or, in the case of fire, property damage.

Parts of equipment that could cause injury shall not be **accessible**, and **accessible** parts shall not cause an injury.

~~For an **ordinary person** or an **instructed person**, the adjustment of a control shall not defeat an **equipment safeguard**.~~

Compliance is checked by inspection and by the relevant tests.

4.1.4 Equipment installation

Except as given in 4.1.6, equipment evaluation according to this document shall take into account manufacturer's instructions with regard to installation, relocation, servicing and operation, as applicable.

Outdoor enclosures providing a **safeguard** function shall comply with Annex Y. **Outdoor equipment** and **outdoor enclosures** shall be suitable for use at any temperature in the range specified by the manufacturer. If not specified by the manufacturer, the range shall be taken as:

– minimum ambient temperature: –33 °C;

– maximum ambient temperature: +40 °C.

Compliance is checked by inspection and by evaluation of the data provided by the manufacturer.

NOTE 1 The temperature values are based on IEC 60721-3-4, Class 4K2. These temperatures do not take into account severe environments (for example, extremely cold or extremely warm), nor do they include provision for heating by radiation from the sun (solar loading).

NOTE 2 Attention is drawn to IEC 61587-1 for additional information on performance levels C1, C2 and C3.

4.1.5 Constructions and components not specifically covered

Where the equipment involves technologies, components and materials or methods of construction not specifically covered in this document, the equipment shall provide **safeguards** not less than that generally afforded by this document and the principles of safety contained herein.

The need for additional detailed requirements to cope with a new situation should be brought promptly to the attention of the appropriate committee.

4.1.6 Orientation during transport and use

Where it is clear that the orientation of use of equipment is likely to have a significant effect on the application of the requirements or the results of tests, all orientations of use specified in the installation or user instructions shall be taken into account. However, if equipment has means for fixing in place by an **ordinary person**, such as the provision of screw holes for direct attachment to a mounting surface or through the use of brackets or the like, either

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provided with the equipment or readily available in the market, all likely positions of orientation of the equipment shall be taken into account, including the possibility of mounting to a non-vertical surface regardless of the installation or user instructions that are provided by the manufacturer.

In addition, for **transportable equipment**, all orientations of transport shall be taken into account.

4.1.7 Choice of criteria

Where this document indicates a choice between different criteria for compliance, or between different methods or conditions of test, the choice is specified by the manufacturer.

4.1.8 ~~Conductive liquids~~ Liquids and liquid filled components (LFC)

~~For the electrical requirements of this standard, conductive liquids shall be treated as conductive parts.~~

Unless specified as an **insulating liquid**, liquids shall be treated as electrically conductive materials.

Constructions and test requirements for pressurized LFCs used inside the equipment where an injury can occur within the meaning of this document due to leaks of the liquid in the LFC shall comply with Clause G.15. However, Clause G.15 does not apply to the following:

– an LFC that is sealed but open to the atmosphere in the equipment; or

– components containing small amounts of liquids not likely to cause any injury (for example, liquid crystal displays, electrolytic capacitors, liquid cooling heat pipes, etc.); or

– wet **cell batteries** (for wet **cell batteries**, see Annex M); or

– an LFC and its associated parts that comply with P.3.3; or

– equipment with more than 1 l of liquid.

4.1.9 Electrical measuring instruments

Electrical measuring instruments shall have ~~adequate~~ sufficient bandwidth to provide accurate readings, taking into account all components (DC, **mains** frequency, high frequency and harmonic content) of the parameter being measured.

If an RMS value is measured, care shall be taken that the measuring instrument gives a true RMS reading of non-sinusoidal waveforms as well as sinusoidal waveforms.

Measurements ~~are~~ shall be made with a meter whose input impedance has a negligible influence on the measurement.

4.1.10 Temperature measurements

Unless ~~stated~~ otherwise specified, where the result of a test is likely to depend upon the ambient temperature, the manufacturer's specified ambient temperature range of the equipment (T_{ma}) shall be taken into account. When performing the test at a specific ambient temperature (T_{amb}), extrapolation (above and below) the results of the test may be used to consider the impact of T_{ma} on the result. Components and subassemblies may be considered separately from the equipment if the test results and extrapolation is representative of the whole equipment being so tested. Relevant test data and manufacturer's specifications may be examined in order to determine the effect of temperature variability on a component or subassembly (see B.1.5).

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4.1.11 Steady state conditions

Steady state conditions are conditions when temperature stability is considered to exist (see B.1.5).

4.1.12 Hierarchy of safeguards

Safeguards that are required for **ordinary persons** are acceptable, but may not be required, for **instructed persons** and **skilled persons**. Likewise, **safeguards** that are required for **instructed persons** are acceptable, but may not be required, for **skilled persons**.

A **reinforced safeguard** may be used in place of a **basic safeguard** or a **supplementary safeguard** or a **double safeguard**. A **double safeguard** may be used in place of a **reinforced safeguard**.

Safeguards, other than **equipment safeguards**, ~~may be~~ are specified in specific clauses ~~(for example, see 8.4.1, 8.5.1 and Table 38)~~.

4.1.13 Examples mentioned in this document

Where examples are given in this document, other examples, situations, and solutions are not excluded.

4.1.14 Tests on parts or samples separate from the end-product

If a test is conducted on a part or sample separate from the end-product, the test shall be conducted as if the part or sample was in the end-product.

4.1.15 Markings and instructions

Equipment that is required by this document to:

– bear markings; or

– be provided with instructions; or

– be provided with **instructional safeguards**

shall meet the relevant requirements of Annex F.

Compliance is checked by inspection.

NOTE In Finland, Norway and Sweden, **class I pluggable equipment type A** intended for connection to other equipment or a network shall, if safety relies on connection to reliable earthing or if surge suppressors are connected between the network terminals and **accessible** parts, have a marking stating that the equipment must be connected to an earthed **mains** socket-outlet.

4.2 Energy source classifications

4.2.1 Class 1 energy source

Unless otherwise specified, a class 1 source is an energy source with levels not exceeding class 1 limits under:

– **normal operating conditions**; and

– **abnormal operating conditions** that do not lead to a **single fault condition**; and

– **single fault conditions** that do not result in class 2 limits being exceeded.

~~Under **normal operating conditions** and **abnormal operating conditions**, the energy in a class 1 source, in contact with a body part, may be detectable, but is not painful nor is it likely to cause an injury. For fire, the energy in a class 1 source is not likely to cause ignition.~~

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~~Under **single fault conditions**, a class 1 energy source, under contact with a body part, may be painful, but is not likely to cause injury.~~

A **protective conductor** is a class 1 electrical energy source.

4.2.2 Class 2 energy source

Unless otherwise specified, a class 2 source is an energy source with levels exceeding class 1 limits and not exceeding class 2 limits under **normal operating conditions**, **abnormal operating conditions**, or **single fault conditions**. ~~The energy in a class 2 source, under contact with a body part, may be painful, but is not likely to cause an injury. For fire, the energy in a class 2 source can cause ignition under some conditions.~~

4.2.3 Class 3 energy source

A class 3 source is an energy source with levels exceeding class 2 limits under **normal operating conditions**, **abnormal operating conditions**, or **single fault conditions**, or any energy source declared to be a class 3 source, as given in 4.2.4. ~~The energy in a class 3 source, under contact with a body part, is capable of causing injury. For fire, the energy in a class 3 source may cause ignition and the spread of flame where fuel is available.~~

A neutral conductor is a class 3 electrical energy source.

4.2.4 Energy source classification by declaration

The manufacturer may declare:

– a class 1 energy source to be either a class 2 energy source or a class 3 energy source;

– a class 2 energy source to be a class 3 energy source.

~~A neutral conductor is considered to be a class 3 electrical energy source.~~

~~A **protective conductor** is considered to be a class 1 electrical energy source.~~

4.3 Protection against energy sources

4.3.1 General

The terms “persons”, “body”, and “body parts” are represented by the probes of Annex V.

4.3.2 Safeguards for protection of an ordinary person

4.3.2.1 Safeguards between a class 1 energy source and an ordinary person

No **safeguards** are required between a class 1 energy source and an **ordinary person** (see Figure 9). Consequently, a class 1 energy source may be **accessible** to an **ordinary person**.

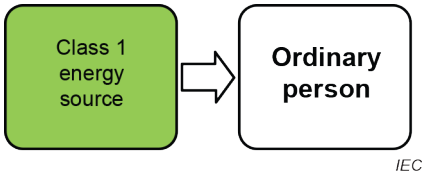


Figure 9 – Model for protection of an ordinary person against a class 1 energy source

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4.3.2.2 Safeguards between a class 2 energy source and an ordinary person

At least one **basic safeguard** is required between a class 2 energy source and an **ordinary person** (see Figure 10).

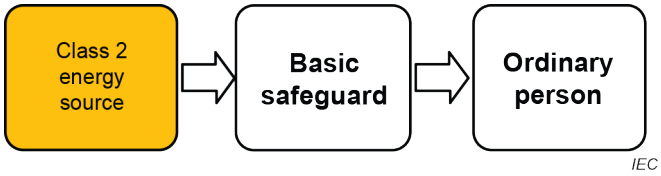


Figure 10 – Model for protection of an ordinary person against a class 2 energy source

4.3.2.3 Safeguards between a class 2 energy source and an ordinary person during ordinary person servicing conditions

If **ordinary person** servicing conditions require a **basic safeguard** to be removed or defeated, an **instructional safeguard** as described in Clause F.5 shall be provided and located in such a way that an **ordinary person** will see the instruction prior to removing or defeating the **basic safeguard** (see Figure 11).

The **instructional safeguard** (see Clause F.5) shall include all of the following:

– identify parts and locations of the class 2 energy source;

– specify actions that will protect persons from that energy source; and

– specify actions to reinstate or restore the **basic safeguard**.

If **ordinary person** servicing conditions require a **basic safeguard** to be removed or defeated, and where the equipment is intended for use in the home, an **instructional safeguard** (see Clause F.5), directed towards adults, shall warn against removing or defeating the **basic safeguard** by children.

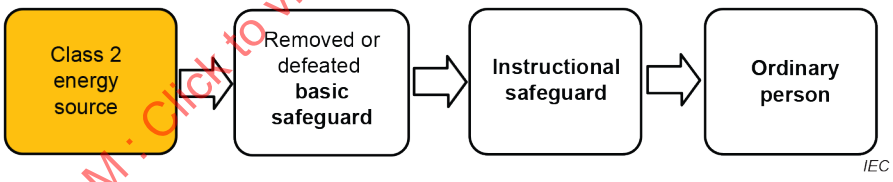


Figure 11 – Model for protection of an ordinary person against a class 2 energy source during ordinary person servicing conditions

4.3.2.4 Safeguards between a class 3 energy source and an ordinary person

Unless otherwise specified,

– an **equipment basic safeguard** and an **equipment supplementary safeguard** (together forming a **double safeguard**); or

– a **reinforced safeguard**

is required between a class 3 energy source and an **ordinary person** (see Figure 12).

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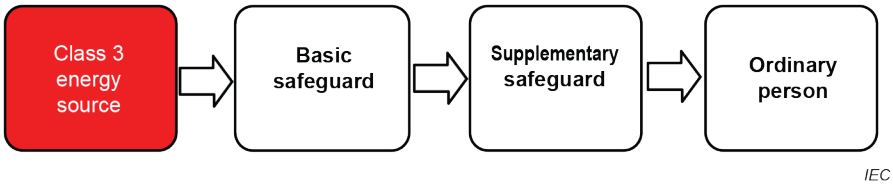


Figure 12 – Model for protection of an ordinary person against a class 3 energy source

4.3.3 Safeguards for protection of an instructed person

4.3.3.1 Safeguards between a class 1 energy source and an instructed person

No **safeguards** are required between a class 1 energy source and an **instructed person** (see Figure 13).

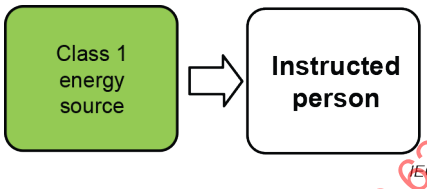


Figure 13 – Model for protection of an instructed person against a class 1 energy source

4.3.3.2 Safeguards between a class 2 energy source and an instructed person

An **instructed person** uses a **precautionary safeguard** (see Figure 14). No additional **safeguards** are required between a class 2 energy source and an **instructed person**. Consequently, a class 2 energy source may be **accessible** to an **instructed person**.



Figure 14 – Model for protection of an instructed person against a class 2 energy source

4.3.3.3 Safeguards between a class 3 energy source and an instructed person

Unless otherwise specified,

– an **equipment basic safeguard** and an **equipment supplementary safeguard** (together forming a **double safeguard**); or

– a **reinforced safeguard**

is required between a class 3 energy source and an **instructed person** (see Figure 15).

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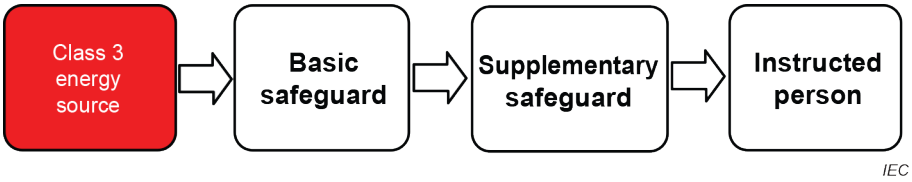


Figure 15 – Model for protection of an instructed person against a class 3 energy source

4.3.4 Safeguards for protection of a skilled person

4.3.4.1 Safeguards between a class 1 energy source and a skilled person

No **safeguard** is required between a class 1 energy source and a **skilled person**. Consequently, a class 1 energy source may be **accessible** to a **skilled person** (see Figure 16).

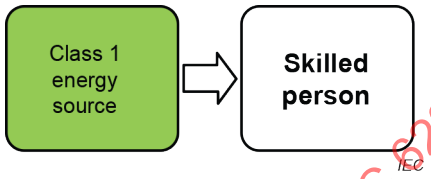


Figure 16 – Model for protection of a skilled person against a class 1 energy source

4.3.4.2 Safeguards between a class 2 energy source and a skilled person

A **skilled person** uses a **skill safeguard** (see Figure 17). No additional **safeguards** are required between a class 2 energy source and a **skilled person**. Consequently, a class 2 energy source may be **accessible** to a **skilled person**.

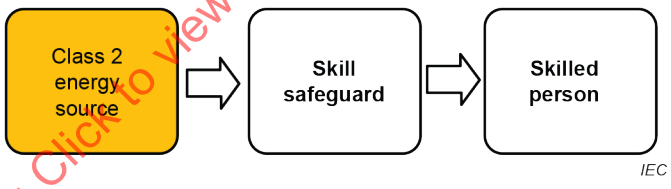


Figure 17 – Model for protection of a skilled person against a class 2 energy source

4.3.4.3 Safeguards between a class 3 energy source and a skilled person

A **skilled person** uses a **skill safeguard** (see Figure 18). Unless otherwise specified (for example, see 8.5.4), no additional **safeguards** are required between a class 3 energy source and a **skilled person**. Consequently, a class 3 energy source may be **accessible** to a **skilled person**.

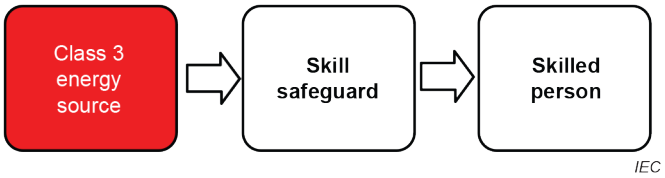


Figure 18 – Model for protection of a skilled person against a class 3 energy source

During equipment servicing conditions on a class 3 energy source, a **safeguard** intended to reduce the likelihood of injury due to an involuntary reaction is required between:

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– another class 3 energy source, not undergoing service and in the same vicinity as the class 3 energy source being serviced; and
– a **skilled person** (see 0.5.7 and Figure 19).

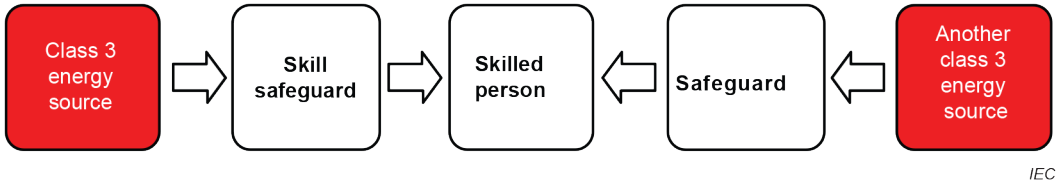


Figure 19 – Model for protection of a skilled person against class 3 energy sources during equipment servicing conditions

4.3.5 Safeguards in a restricted access area

Certain equipment is intended for installation exclusively in **restricted access areas**. Such equipment shall have **safeguards** as required in 4.3.3 for **instructed persons** and 4.3.4 for **skilled persons**.

4.4 Safeguards

4.4.1 Equivalent materials or components

Where this document specifies a particular **safeguard** parameter, such as thermal class of insulation or **material flammability class,** a **safeguard** with a better parameter may be used.

NOTE For a hierarchy of the **material flammability classes** see Table S.1, Table S.2 and Table S.3.

4.4.2 Composition of a safeguard

A **safeguard** may be comprised of one or more elements.

~~#### 4.4.3 Accessible parts of a safeguard~~

~~Where a solid **safeguard** is **accessible** to an **ordinary person** or to an **instructed person**, only the side of the **safeguard** opposite to the energy source may be **accessible**.~~

4.4.3 Safeguard robustness

4.4.3.1 General

Where a solid **safeguard** (for example, an **enclosure**, barrier, **solid insulation**, earthed metal, glass, etc.) is **accessible** to an **ordinary person** or to an **instructed person**, the **safeguard** shall comply with the relevant robustness tests as specified in 4.4.3.2 to 4.4.3.10.

~~A solid **safeguard** that is not **accessible** shall comply with the stress relief test of Clause T.8.~~

For a **safeguard** that is **accessible** after opening an external **enclosure**, see 4.4.3.5.

Requirements for:

– adhesion of metallized coatings; and
– adhesives securing parts serving as **safeguards**; and
– parts that may defeat a **safeguard** if an adhesive fails

are specified in Clause P.4.

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4.4.3.2 Steady force tests

An **enclosure** or barrier that is **accessible** and that is used as a **safeguard** of:

– **transportable equipment**; and
– **hand-held equipment**; and
– **direct plug-in equipment**

shall be subjected to the steady force test of Clause T.4.

A **safeguard** that is **accessible** and that only acts as a **fire enclosure** or fire barrier shall be subjected to the steady force test of Clause T.3.

~~For all other equipment, an~~ All other **enclosures** or barriers that ~~is~~ are **accessible** and that ~~is~~ are used as a **safeguard** shall be subjected to the steady force test of Clause T.5. There are no requirements for the bottom of equipment having a mass of more than 18 kg unless the user instructions permit an orientation in which the bottom of the **enclosure** becomes the top or a side of the equipment.

This subclause does not apply to glass. Requirements for glass are given in 4.4.3.6.

4.4.3.3 Drop tests

The following equipment shall be subjected to the drop test of Clause T.7:

– **hand-held equipment**;
– **direct plug-in equipment**;
– **transportable equipment**;
– **movable equipment** requiring lifting or handling by an **ordinary person** as part of its intended use, including routine relocation;

NOTE An example of such equipment is a paper shredder that rests on a waste container that requires removal of the paper shredder to empty the container.

– desk ~~-top or table~~-top equipment having a mass of 7 kg or less that is intended for use with any one of the following:
  • a cord-connected telephone handset; or
  • another cord-connected hand-held accessory with an acoustic function; or
  • a headset.

4.4.3.4 Impact tests

All equipment, other than that specified in 4.4.3.3, shall be subjected to the impact test of Clause T.6.

The impact test of Clause T.6 is not applied to the following:

– the bottom of an **enclosure**, except if the user instructions permit an orientation in which the bottom of the **enclosure** becomes the top or a side of the equipment;
– glass;

NOTE Impact tests for glass are in 4.4.3.6.

– the surface of the **enclosure** of **stationary equipment**, including equipment for building-in, that is
  • not **accessible**; or
  • protected after installation.

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4.4.3.5 Internal accessible safeguard tests

An internal solid **safeguard** that is **accessible** to an **ordinary person** after opening an external **enclosure** and whose failure would allow class 2 or class 3 energy sources to be **accessible** shall be subjected to the steady force test of Clause T.3.

4.4.3.6 Glass impact tests

The requirements below are applicable to all parts made of glass, with the exception of:

– platen glass used on copiers, scanners and the like, ~~provided that the glass complies with 4.4.4.5 and is covered during normal use~~ where the glass has been subjected to the steady force test of Clause T.3 and is provided with a cover or device to protect the platen glass; and

– CRTs: Requirements for CRTs are given in Annex U; and

– glass that is laminated or has a construction such that glass particles do not separate from each other if the glass is broken~~; and~~.

NOTE Laminated glass includes constructions such as plastic film affixed to a single side of a glass.

~~– a **safeguard** that is **accessible** and that acts as a **fire enclosure** only.~~

Glass that is **accessible** to an **ordinary person** or to an **instructed person**:

– having a surface area exceeding 0,1 m^2; or

– having a major dimension exceeding 450 mm; or

– that prevents access to class 3 energy sources other than PS3

shall be subjected to the glass impact test of Clause T.9.

4.4.3.7 Glass fixation test

Laminated glass used as a **safeguard** that prevents access to class 3 energy sources other than PS3 shall be subjected to the following fixation tests:

– a glass impact test as given in Clause T.9 with an impact of 1 J applied three times; and

– a push/pull test with 10 N applied in the centre of the glass in the least favourable direction.

NOTE To perform the test, any suitable method can be used, such as using suction handles or gluing a support to the glass.

4.4.3.8 Thermoplastic material tests

If a **safeguard** is of moulded or formed thermoplastic material, the **safeguard** shall be so constructed that any shrinkage or distortion of the material due to release of internal stresses shall not defeat its **safeguard** function. The thermoplastic material shall be subjected to the stress relief test of Clause T.8.

4.4.3.9 Air comprising a safeguard

Where a **safeguard** is comprised of air (for example, a **clearance**), a barrier or **enclosure** shall prevent displacement of the air by a body part or a conductive part. The barrier or **enclosure** shall comply with the mechanical strength test specified in Annex T, as applicable.

4.4.3.10 Compliance criteria

During and after the tests:

– *except for PS3, class 3 energy sources shall not become **accessible** to an **ordinary person** or to an **instructed person**; and*

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– *glass shall:*
  - *not break or crack; or*
  - *not expel pieces of glass greater than 30 g in mass or greater than 50 mm in any dimension; or*
  - *pass the fragmentation test of Clause T.10 on a separate test sample; and*
– *all other **safeguards** shall remain effective.*

4.4.4 Displacement of a safeguard by an insulating liquid

If an **insulating liquid** displaces air comprising a **safeguard**:

– the requirements of 5.4.12 and 6.4.9 apply to the **insulating liquid**; and
– the requirements of 5.4.2 and 5.4.3 apply to the equipment both with and without the **insulating liquid** present.

Partial or total loss of the **insulating liquid** shall be considered an **abnormal operating condition** of the equipment.

If the power supplied to parts immersed in **insulating liquid** is disconnected in the event of partial or total loss of the **insulating liquid**, the requirements of 6.4.2 to 6.4.8 do not apply for the immersed parts. An example of such a disconnect system is a float switch system complying with Annex K.

NOTE The use of **insulating liquids** to replace a **basic insulation**, a **supplementary insulation** or a **reinforced insulation** is not covered by the requirements of this document.

4.4.5 Safety interlocks

Unless otherwise specified, if a **safety interlock** is used as a **safeguard** for protection against:

– a class 2 or a class 3 energy source for an **ordinary person**; or
– a class 3 energy source for an **instructed person**,

the **safety interlock** shall comply with Annex K.

4.5 Explosion

4.5.1 General

Explosion can be caused by:

– chemical reaction;
– mechanical deformation of a sealed container;
– rapid combustion or decomposition, producing a large volume of hot gas;
– high pressure; or
– high temperature.

NOTE 1 Depending on the energy rate, **explosion** can be categorized as a deflagration, a detonation, or pressure rupture.

NOTE 2 An ultracapacitor (for example, a double layer capacitor) is a high energy source and can explode following overcharging and high temperature.

For requirements regarding **explosion** of **batteries**, see Annex M.

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4.5.2 Requirements

During **normal operating conditions** and **abnormal operating conditions**, an **explosion** shall not occur.

If an **explosion** occurs during **single fault conditions**, it shall not cause ~~harm~~ injury and the equipment shall comply with the relevant parts of this document.

Compliance is checked by inspection and tests as specified in Clause B.2, Clause B.3 and Clause B.4.

4.6 Fixing of conductors

4.6.1 Requirements

Conductors shall be such that displacement cannot defeat a **safeguard**, such as reducing **clearances** or **creepage distances** below the values specified in 5.4.2 and 5.4.3.

The fixing of the conductors shall be such that, if a conductor becomes loose or detached, the conductor cannot defeat a **safeguard**, such as reducing **clearances** or **creepage distances** below the values specified in 5.4.2 and 5.4.3.

For the purpose of these requirements, it is assumed that:

– two independent fixings will not become loose or detached at the same time; and

– parts fixed by means of screws or nuts provided with self-locking washers or other means of locking are not liable to become loose or detached.

NOTE Spring washers and the like can provide satisfactory locking.

4.6.2 Compliance criteria

Compliance is checked by inspection, by measurement or, in case of doubt, by ~~applying a force of 10 N~~ the test of Clause T.2 applied in the most unfavourable direction.

EXAMPLE Constructions regarded as meeting the requirements include:

– close-fitting tubing (for example, a heat shrink or rubber sleeve), applied over the wire and its termination;

– conductors connected by soldering and held in place near to the termination, independently of the soldered connection;

– conductors connected by soldering and securely hooked in before soldering, provided that the hole through which the conductor is passed is not unduly large;

– conductors connected to screw terminals, with an additional fixing near to the terminal that clamps, in the case of stranded conductors, the insulation and not only the conductors;

– conductors connected to screw terminals and provided with terminators that are unlikely to become free (for example, ring lugs crimped onto the conductors),however, the pivoting of such terminators is considered; or

– short rigid conductors that remain in position when the terminal screw is loosened.

4.7 Equipment for direct insertion into mains socket-outlets

4.7.1 General

Equipment incorporating integral pins for insertion into **mains** socket-outlets shall not impose undue torque on the socket-outlet. The means for retaining the pins shall withstand the forces to which the pins are likely to be subjected in normal use.

4.7.2 Requirements

The **mains** plug part shall comply with the relevant standard for the **mains** plug.

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The equipment is inserted, as in normal use, into a fixed socket-outlet of a configuration as intended by the manufacturer, which is pivoted about a horizontal axis intersecting the centre lines of the contacts at a distance of 8 mm behind the engagement face of the socket outlet parallel to the engagement face.

4.7.3 Compliance criteria

Compliance is checked by inspection and, the additional torque that has to be applied to the socket-outlet to maintain the engagement face in the vertical plane shall not exceed 0,25 Nm. The torque to keep the socket-outlet itself in the vertical plane is not included in this value.

NOTE 1 In Australia and New Zealand, compliance is checked in accordance with AS/NZS 3112.

NOTE 2 In the United Kingdom, the torque test is performed using a socket-outlet complying with BS 1363, and the plug part shall be assessed to the relevant clauses of BS 1363.

4.8 ~~Products~~ Equipment containing ~~lithium~~ coin / button cell batteries

4.8.1 General

These requirements apply to equipment, including remote controls, that:

– are likely to be **accessible** to children~~, taking into account information given by the manufacturer~~; and

– include ~~lithium~~ **coin / button cell batteries** with a diameter of 32 mm or less.

These requirements do not apply to:

– **professional equipment**;

~~NOTE Professional equipment is equipment sold through special sales channels. All equipment sold through normal electronics stores are considered not to be professional equipment.~~

– equipment for use in locations where it is unlikely that children will be present; or

– equipment containing ~~lithium~~ **coin / button cell batteries** that are soldered in place.

4.8.2 Instructional safeguard

Equipment containing one or more ~~lithium~~ **coin / button cell batteries** shall have an **instructional safeguard** in accordance with Clause F.5.

The **instructional safeguard** is not required where these **batteries** are not intended to be replaced or are only **accessible** after damaging the equipment.

The elements of the **instructional safeguard** shall be as follows:

– element 1a: not available

– element 2: “Do not ingest battery, Chemical Burn Hazard” or equivalent wording

– element 3: the following or equivalent text

[The remote control supplied with] This product contains a coin / button cell battery. If the coin / button cell battery is swallowed, it can cause severe internal burns in just 2 hours and can lead to death.

– element 4: the following or equivalent text

Keep new and used batteries away from children.

If the battery compartment does not close securely, stop using the product and keep it away from children.

If you think batteries might have been swallowed or placed inside any part of the body, seek immediate medical attention.

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4.8.3 Construction

Equipment having a **battery** compartment door / cover shall be designed to reduce the possibility of children removing the **battery** by one of the following methods:

– a **tool**, such as a screwdriver or coin, is required to open the **battery** compartment, in which case a minimum torque of 0,5 Nm and a minimum angle of 90 degrees of rotation shall be required to open the compartment; or

– the **battery** compartment door / cover requires the application of a minimum of two independent and simultaneous movements to open by hand.

4.8.4 Tests

4.8.4.1 Test sequence

One sample shall be subjected to the applicable tests of 4.8.4.2 to 4.8.4.6. If applicable, the test in 4.8.4.2 shall be conducted first.

4.8.4.2 Stress relief test

*If the **battery** compartment utilizes moulded or formed thermoplastic materials, the sample consisting of the complete equipment, or of the complete **enclosure** together with any supporting framework, is tested according to the stress relief test of Clause T.8.*

*During the test, the **battery** may be removed.*

4.8.4.3 Battery replacement test

*For equipment with a **battery** compartment door / cover, the **battery** compartment shall be opened and closed and the **battery** removed and replaced ten times to simulate normal replacement according to the manufacturer's instructions.*

*If the **battery** compartment door / cover is secured by one or more screws, the screws are loosened and then tightened applying a continuous linear torque according to Table 37, using a suitable screwdriver, spanner or key. The screws are to be completely removed and reinserted each time.*

4.8.4.4 Drop test

*Portable equipment having a mass of 7 kg or less are subjected to three drops from a height of 1 m onto a horizontal surface in positions likely to produce the maximum force on the **battery** compartment in accordance with Clause T.7.*

If the equipment is a remote control, it shall be subjected to ten drops.

4.8.4.5 Impact test

*The **battery** compartment door / cover shall be subjected to three impacts in a direction perpendicular to the **battery** compartment door / cover according to the test method of Clause T.6 with a force of:*

– *0,5 J (102 mm ± 10 mm height) for glasses for watching, for example, 3 dimensional television; or*

– *2 J (408 mm ± 10 mm height) for all other doors / covers.*

4.8.4.6 Crush test

Hand held remote control devices are to be supported by a fixed rigid supporting surface in a position likely to produce the most adverse results as long as the position can be self-supported. A crushing force of 330 N ± 5 N is applied to the exposed top and back surfaces of

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remote control devices placed in a stable condition by a flat surface measuring approximately 100 mm by 250 mm for a period of 10 s.

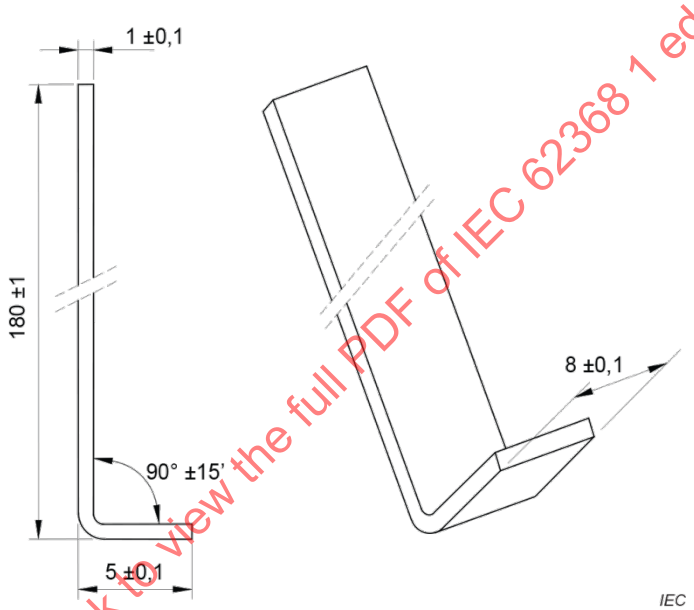
4.8.5 Compliance criteria

*Compliance is checked by applying a force of 30 N ± 1 N for 10 s to the **battery** compartment door / cover by ~~a rigid test finger according to~~ the straight unjointed version of the test probe of Figure V.~~2~~1 at the most unfavourable place and in the most unfavourable direction. The force shall be applied in one direction at a time.*

*The **battery** compartment door / cover shall remain functional, and:*

- *the **battery** shall not become **accessible**; or*
- *it shall not be possible remove the **battery** from the product with the test hook of Figure 20 using a force of approximately 20 N.*

Dimensions in millimetres



Material: steel

Figure 20 – Test hook

4.9 Likelihood of fire or shock due to entry of conductive objects

Where the entry of a conductive object from outside the equipment or from another part of the equipment can result in:

- bridging within ~~PS2,~~ PS3 and ES3 circuits; or
- bridging an ES3 circuit to **accessible**, unearthed conductive parts,

top and side openings above ~~PS2,~~ PS3 and ES3 circuits shall:

- be located more than 1,8 m above the floor; or
- comply with Annex P.

Compliance is checked by inspection or according to Annex P.

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4.10 Components requirements

4.10.1 Disconnect device

Equipment connected to the **mains** shall be provided with a **disconnect device** in accordance with Annex L.

4.10.2 Switches and relays

Switches and relays located in a PS3 circuit or used as a **safeguard** shall comply with Clause G.1 or Clause G.2 respectively.

5 Electrically-caused injury

5.1 General

To reduce the likelihood of painful effects and injury due to electric current passing through the human body, equipment shall be provided with the **safeguards** specified in Clause 5.

5.2 Classification and limits of electrical energy sources

5.2.1 Electrical energy source classifications

5.2.1.1 ES1

ES1 is a class 1 electrical energy source with current or voltage levels:

– not exceeding ES1 limits under
  - **normal operating conditions**, and
  - **abnormal operating conditions**, and
  - **single fault conditions** of a component, device or insulation not serving as a **safeguard**; and
– not exceeding ES2 limits under **single fault conditions** of a **basic safeguard** or of a **supplementary safeguard**.

NOTE For accessibility requirements, see 5.3.1.

5.2.1.2 ES2

ES2 is a class 2 electrical energy source where:

– both the ~~prospective touch~~ voltage and the ~~touch~~ current exceed the limits for ES1; and
– under
  - **normal operating conditions**, and
  - **abnormal operating conditions**, and
  - **single fault conditions**,

either the ~~prospective touch~~ voltage or the ~~touch~~ current does not exceed the limit for ES2.

NOTE For accessibility requirements, see 5.3.1.

5.2.1.3 ES3

ES3 is a class 3 electrical energy source where both the ~~prospective touch~~ voltage and ~~touch~~ current exceed the limit for ES2.

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5.2.2 Electrical energy source ES1 and ES2 limits

5.2.2.1 General

The limits specified in 5.2.2 are with respect to earth or with respect to an **accessible** part.

~~NOTE Throughout 5.2.2, the term "voltage" is taken to mean "**prospective touch voltage**." Likewise, the term "current" is taken to mean "**touch current**."~~

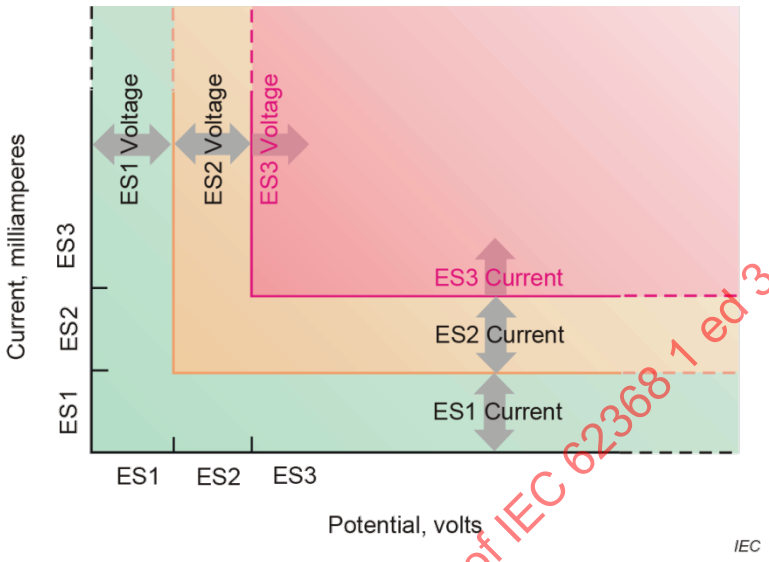


Figure 21 – Illustration showing ES limits for voltage and current

For any voltage up to the voltage limit, there is no limit for the current. Likewise for any current up to the current limit, there is no limit for the voltage, see Figure 21.

5.2.2.2 Steady state voltage and current limits

An electrical energy source class is determined from both the voltage and the current under **normal operating conditions**, **abnormal operating conditions**, and **single fault conditions** (see Table 4).

The values are the maximum that can be delivered by the source. Steady state is considered established when the voltage or current values persist for 2 s or longer, otherwise the limits of 5.2.2.3, 5.2.2.4 or 5.2.2.5 apply, as appropriate.

NOTE In Denmark, a warning (marking **safeguard**) for high **touch current** is required if the **touch current** exceeds the limits of 3,5 mA AC or 10 mA DC.

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Table 4 – Electrical energy source limits for steady state ES1 and ES2

Energy source	ES1 limits		ES2 limits		ES3
	Voltage	**Current** [a, c, d]	**Voltage**	**Current** [b, c, e]	
DC [c]	60 V	2 mA	120 V	25 mA	> ES2
AC up to 1 kHz	30 V RMS 42,4 V peak	0,5 mA RMS 0,707 mA peak	50 V RMS 70,7 V peak	5 mA RMS 7,07 mA peak	
AC > 1 kHz up to 100 kHz	30 V RMS + 0,4 f 42,4 V peak. + 0,4 $\sqrt{2}$ f		50 V RMS + 0,9 f 70,7 V peak + 0,9 $\sqrt{2}$ f		
AC above 100 kHz	70 V RMS 99 V peak		140 V RMS 198 V peak		
Combined AC and DC	$\frac{U_{DC}(V)}{60}+\frac{U_{AC\ RMS}(V)}{U_{RMS\ limit}}\le 1$ $\frac{U_{DC}(V)}{60}+\frac{U_{AC\ peak}(V)}{U_{peak\ limit}}\le 1$	$\frac{I_{DC}(mA)}{2}+\frac{I_{AC\ RMS}(mA)}{0,5}\le 1$ $\frac{I_{DC}(mA)}{2}+\frac{I_{AC\ peak}(mA)}{0,707}\le 1$	See Figure 23	See **Error! Reference source not found.**	

~~The formulation below as a function of frequency may be of interest to designers for sinusoidal waveforms~~ As an alternative to the requirements above, the values below can be used for purely sinusoidal waveforms

Energy source	ES1 limits	ES2 limits	ES3
	Current [c] RMS	**Current** [c] RMS	
AC up to 1 kHz	0,5 mA	5 mA	> ES2
AC > 1 kHz up to 100 kHz	0,5 mA × f [d]	5 mA + 0,95 f [e]	
AC above 100 kHz	50 mA [d]	100 mA [e]	

f is in kHz.

Peak values shall be used for non-sinusoidal voltage and current. RMS values may be used only for sinusoidal voltage and current.

See 5.7 for measurement of **prospective touch voltage** and **touch current**.

[a] Current is measured using the measuring network specified in Figure 4 of IEC 60990:~~1999~~ 2016.

[b] Current is measured using the measuring network specified in Figure 5 of IEC 60990:~~1999~~ 2016.

[c] For sinusoidal waveforms and DC, the current may be measured using a 2 000 Ω resistor.

[d] Above 22 kHz the **accessible** area is limited to 1 cm^2.

[e] Above 36 kHz the **accessible** area is limited to 1 cm^2.

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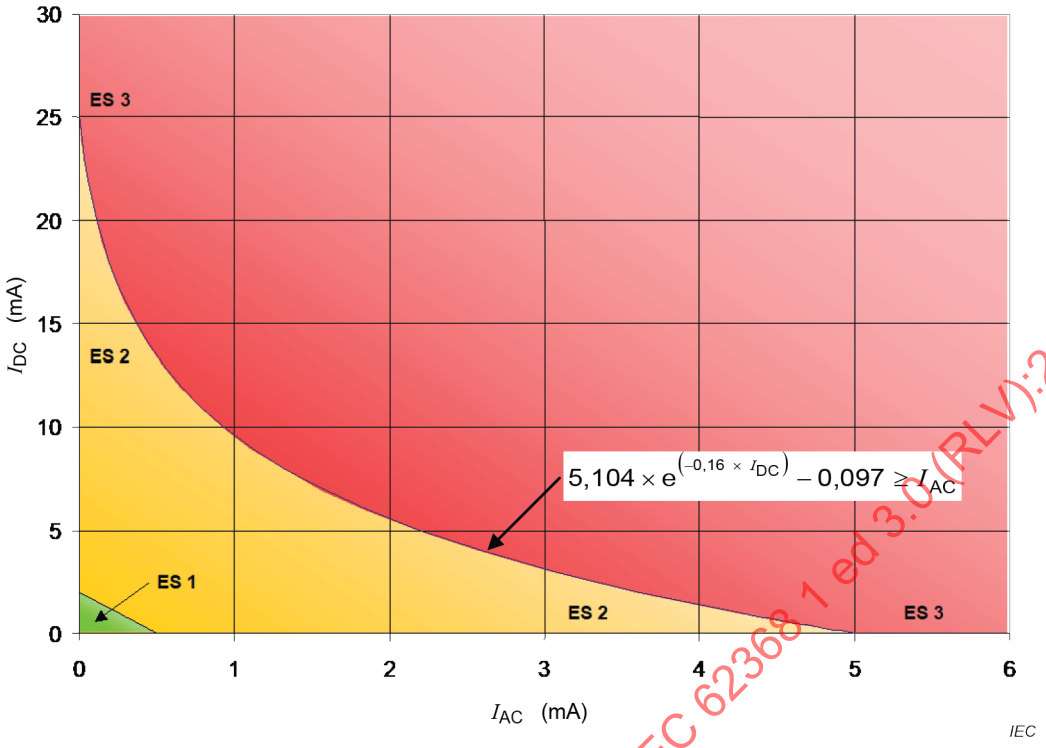


Figure 22 – Maximum values for combined AC current and DC current

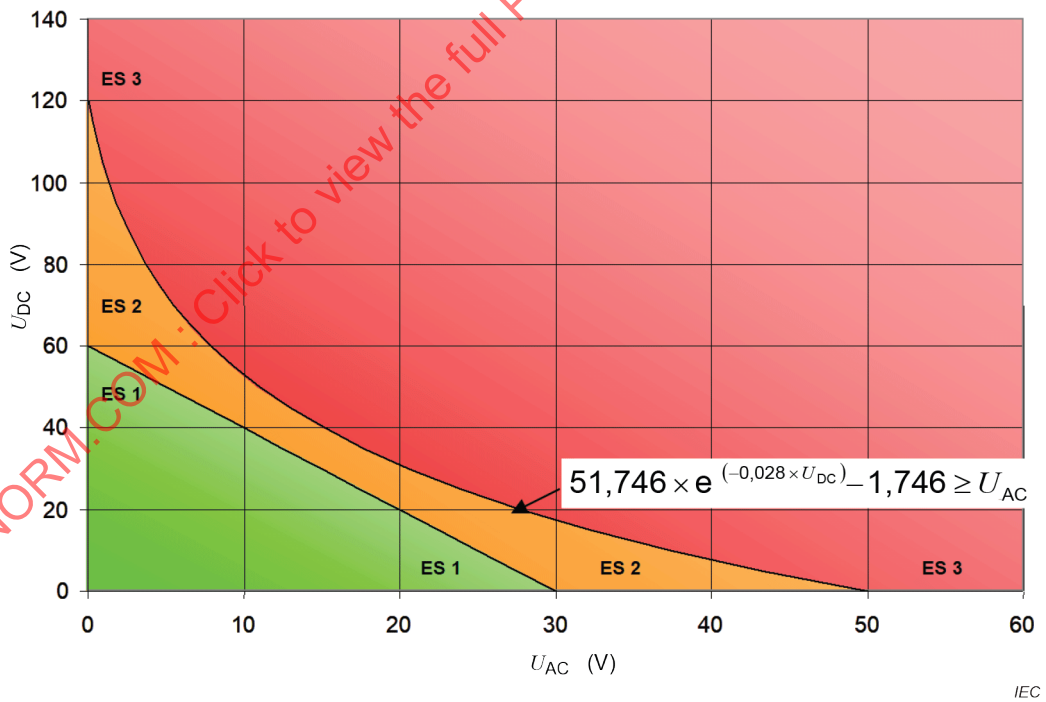


Figure 23 – Maximum values for combined AC voltage and DC voltage

5.2.2.3 Capacitance limits

Where the electrical energy source is a capacitor, the energy source is classified from both the charge voltage and the capacitance.

The capacitance is the rated value of the capacitor plus the specified tolerance.

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The ES1 and ES2 limits for various capacitance values are listed in Table 5.

NOTE 1 The capacitance values for ES2 are derived from Table A.2 of IEC TS 61201:2007.

NOTE 2 The values for ES1 are calculated by dividing the values from Table A.2 of IEC TS 61201:2007, by two (2).

Table 5 – Electrical energy source limits for a charged capacitor

C nF	**ES1** U_{peak} V	**ES2** U_{peak} V	**ES3** U_{peak} V
300 or greater	60	120	> ES2
170	75	150	
91	100	200	
61	125	250	
41	150	300	
28	200	400	
18	250	500	
12	350	700	
8,0	500	1 000	
4,0	1 000	2 000	
1,6	2 500	5 000	
0,8	5 000	10 000	
0,4	10 000	20 000	
0,2	20 000	40 000	
0,133 or less	~~25 000~~ 30 000	~~50 000~~ 60 000	
Linear interpolation may be used between the nearest two points.			

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5.2.2.4 Single pulse limits

Where the electrical energy source is a single pulse, the energy source is classified from both the voltage and the duration or from both the current and the duration. Values are given in Table 6 and Table 7. If the voltage exceeds the limit, then the current shall not exceed the limit. If the current exceeds the limit, the voltage shall not exceed the limit. Currents are measured according to 5.7. For repetitive pulses, see 5.2.2.5.

For pulse durations up to 10 ms, the voltage or current limit for 10 ms applies.

If more than one pulse is detected within a period of 3 s, then the electrical energy source is treated as a repetitive pulse and the limits of 5.2.2.5 apply.

NOTE 1 The pulse limits are calculated from Figure 22 and Table 10 of IEC TS 60479-1:2005.

NOTE 2 These single pulses do not include transients.

NOTE 3 Pulse duration is considered to be the time duration when the voltage or current exceeds ES1 limits.

Table 6 – Voltage limits for single pulses

Pulse duration up to and including ms	~~Electrical energy source level~~		
	ES1 U_{peak} V	ES2 U_{peak} V	ES3 U_{peak} V
10	60	196	> ES2
20		178	
50		150	
80		135	
100		129	
200 and longer		120	

If the time duration lies between the values in any two rows, either the lower ES2 value of ~~the~~ U_{peak} ~~in the row below~~ shall be used or a linear interpolation may be used between any two adjacent rows with the calculated peak voltage value rounded down to the nearest volt.

If the peak voltage for ES2 lies between the values in any two rows, either ~~the value of~~ the shortest time duration ~~in the row above~~ may be used or a linear interpolation may be used between any two adjacent rows with the calculated time duration rounded down to the nearest millisecond.

Table 7 – Current limits for single pulses

	~~Electrical energy source level~~		
Pulse duration up to and including ms	ES1 I_{peak} mA	ES2 I_{peak} mA	ES3 I_{peak} mA
10	2	200	> ES2
20		153	
50		107	
100		81	
200		62	
500		43	
1 000		33	
2 000 and longer		25	

If the time duration lies between the values in any two rows, either the lower ES2 value of ~~the~~ I_{peak} ~~in the row below~~ shall be used or a linear interpolation may be used between any two adjacent rows with the calculated value rounded down to the nearest milliampere.

If the peak current for ES2 lies between the values in any two rows, either the value of the shortest time duration ~~in the row above~~ may be used or a linear interpolation may be used between any two adjacent rows with the calculated time duration rounded down to the nearest millisecond.

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5.2.2.5 Limits for repetitive pulses

Except for pulses covered in Annex H, a repetitive pulse electrical energy source class is determined from either the available voltage or the available current ~~(see Table 8)~~. If the voltage exceeds the limit, then the current shall not exceed the limit. If the current exceeds the limit, the voltage shall not exceed the limit. Currents are measured according to 5.7.

~~**Table 8 – Electrical energy source limits for repetitive pulses**~~

~~Pulse off time~~		~~ES1~~	~~ES2~~	
~~Less than 3 s~~	~~Current~~	~~0,707 mA peak~~	~~7,07 mA peak~~	
	~~Voltage~~	~~42,4 V peak~~	~~70,7 V peak~~	
~~3 s or more~~	~~Current~~	~~See 5.2.2.4~~	~~See 5.2.2.4~~	
	~~Voltage~~			

For pulse off times less than 3 s, the peak values of 5.2.2.2 apply. For longer durations, the values of 5.2.2.4 apply.

5.2.2.6 Ringing signals

Where the electrical energy source is an analogue telephone network ringing signal as defined in Annex H, the energy source class is considered to be ES2.

5.2.2.7 Audio signals

For electrical energy sources ~~comprised of~~ that are audio signals, ~~see~~ the limits are specified in Clause E.1.

5.3 Protection against electrical energy sources

5.3.1 General

Except as given below, protection requirements for parts **accessible** to **ordinary persons**, **instructed persons**, and **skilled persons** are given in 4.3.

ES2 or ES3 circuits, from which **accessible** ES1 or ES2 circuits are derived, shall be separated from ES3 **mains** by a **double safeguard** or a **reinforced safeguard**. In addition, the following applies:

– under **single fault conditions** in the circuit between ES2/ES3 and the **accessible** ES1, the current or voltage levels shall not exceed the ES1 limits; and

– under **single fault conditions** in the circuit between ES2/ES3 and **accessible** ES2, the current or voltage levels shall not exceed the ES2 limits.

NOTE An example for this construction is a rectifier in the insulated (secondary) circuit in a switch mode power supply in which multiple components are present.

Bare conductors at ES3 shall be located or guarded so that unintentional contact with such conductors during service operations by a **skilled person** is unlikely (see Figure 19).

For a **battery** backed up supply capable of backfeeding to the input AC terminals, see 5.8.

5.3.2 Accessibility to electrical energy sources and safeguards

5.3.2.1 Requirements

For **ordinary persons**, the following shall not be **accessible**:

– bare parts at ES2, except for the pins of connectors. However, such pins shall not be **accessible** under **normal operating conditions** by the blunt probe of Figure V.3; and

– bare parts at ES3; and

– an ES3 **basic safeguard**.

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For bare parts of **outdoor equipment** that are **accessible** to an **ordinary person** in their intended **outdoor location,** the following shall not be **accessible**:

– bare parts exceeding 0,5 times ES1 voltage limits under **normal operating conditions** and **abnormal operating conditions** and **single fault conditions** of a component, device or insulation not serving as a **safeguard**; and

– bare parts exceeding ES1 voltage limits under **single fault conditions** of a **basic safeguard** or of a **supplementary safeguard** (see 5.2.1.1).

For **instructed persons**, the following shall not be **accessible**:

– bare parts at ES3; and

– an ES3 **basic safeguard**.

5.3.2.2 Contact requirements

For ES3 voltages up to 420 V peak, the appropriate test probe from Annex V shall not contact a bare internal conductive part.

For ES3 voltages above 420 V peak, the appropriate test probe from Annex V shall not contact a bare internal conductive part and shall have an air gap from that part (see Figure 24).

The air gap shall either:

a) pass an electric strength test in accordance with 5.4.9.1 at a test voltage (DC or peak AC) that is equal to the test voltage for **basic insulation** in Table 26 corresponding to the peak of the **working voltage**; or

b) have a minimum distance according to Table 8.

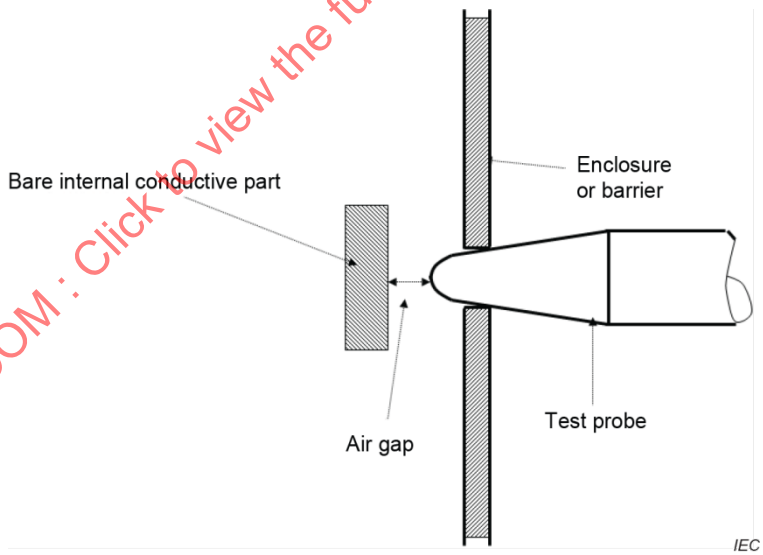


Figure 24 – Contact requirements to bare internal conductive parts

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Table 8 – Minimum air gap distance

~~Peak working~~ Voltage	Air gap distance mm	
V peak or DC up to and including	Pollution degree	
	2	3
> 420 and ≤ 1 000	0,2	0,8
1 200	0,25	
1 500	0,5	
2 000	1,0	
2 500	1,5	
3 000	2,0	
4 000	3,0	
5 000	4,0	
6 000	5,5	
8 000	8,0	
10 000	11	
12 000	14	
15 000	18	
20 000	25	
25 000	33	
30 000	40	
40 000	60	
50 000	75	
60 000	90	
80 000	130	
100 000	170	
Linear interpolation may be used between the nearest two points, the calculated minimum air gap distance being rounded up to the next higher 0,1 mm increment or the value in the next row below whichever is lower. For equipment intended to be used more than 2 000 m above sea level, the values in this table are multiplied by the multiplication factor for the desired altitude according to Table 16.		

5.3.2.3 Compliance criteria

Compliance is checked by the test of Clause T.3.

In addition, for bare ES3 parts at a voltage above 420 V peak, compliance is checked by distance measurement or by an electric strength test.

Components and subassemblies that comply with their respective IEC standards do not have to be tested when such components and subassemblies are used in the final product.

5.3.2.4 Terminals for connecting stripped wire

The use of a stripped wire to make connection with its associated terminal intended to be used:

– by an **ordinary person** shall not result in contact with ES2 or ES3; and

– by an **instructed person** shall not result in contact with ES3.

For audio signal voltages, see Table E.1 for the values of ES2 and ES3. Parts of audio signal terminals provided with one of the **safeguards** in Table E.1 are not tested.

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Compliance is checked by the test of V.1.6 for each wire terminal opening as well as any other openings within 25 mm from the terminal. During the test, no portion of the probe inserted into the terminal or opening shall contact ES2 or ES3.

5.4 Insulation materials and requirements

5.4.1 General

5.4.1.1 Insulation

Insulation consisting of insulating materials, **clearances**, **creepage distances** and **solid insulation**, and that is providing a **safeguard** function is designated **basic insulation**, **supplementary insulation**, **double insulation**, or **reinforced insulation**.

5.4.1.2 Properties of insulating material

The choice and application of insulating material shall take into account the needs for electrical strength, mechanical strength, dimension, frequency of the **working voltage** and other properties for the working environment (temperature, pressure, humidity and pollution) as specified in Clause 5 and Annex T.

Insulating material shall not be hygroscopic as determined by 5.4.1.3.

5.4.1.3 Compliance criteria

Compliance is checked by inspection and, where necessary, by evaluation of the data for the material.

Where necessary, if the data does not confirm that the material is non-hygroscopic, the hygroscopic nature of the material is determined by subjecting the component or subassembly using the insulation in question to the humidity treatment of 5.4.8. The insulation is then subjected to the relevant electric strength test of 5.4.9.1 while still in the humidity chamber, or in the room in which the samples were brought to the prescribed temperature.

5.4.1.4 Maximum operating temperatures for materials, components and systems

5.4.1.4.1 Requirements

Under **normal operating conditions**, insulating material temperatures shall not exceed the temperature limit of the EIS, including insulating materials of components, or the maximum temperature limit of the insulation system as given in Table 9.

For maximum temperatures below or equal to 100 ºC, no declared insulation system is required. An undeclared EIS is considered to be Class 105 (A).

5.4.1.4.2 Test method

Insulating material temperatures are measured in accordance with B.1.5.

*The equipment or parts of the equipment are operated under **normal operating conditions** (see Clause B.2) as follows:*

- *for continuous operation, until steady state conditions are established; and*
- *for **intermittent operation**, until steady state conditions are established, using the rated "ON" and "OFF" periods; and*
- *for **short-time operation**, for the operating time specified by the manufacturer.*

Components and other parts may be tested independently of the end product provided that the test conditions applicable to the end product are applied to the component or part.

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Equipment intended for building-in or rack-mounting, or for incorporation in larger equipment, is tested under the most adverse actual or simulated conditions specified in the installation instructions.

5.4.1.4.3 Compliance criteria

The temperature of the electrical insulation material or EIS shall not exceed the limits in Table 9.

For a single insulating material, the declared relative temperature index information from the material manufacturer can be used if it is suitable for the applicable class of insulation.

For an EIS, the available thermal class data of the EIS as indicated by the manufacturer can be used if it is suitable for the applicable class of insulation.

For thermal classifications above Class 105 (A), the EIS shall comply with IEC 60085.

Table 9 – Temperature limits for materials, components and systems

Part	Maximum temperature T_{max} °C
Insulation, including winding insulation:	
of Class 105 (A) material or EIS	100 [a]
of Class 120 (E) material or EIS	115 [a]
of Class 130 (B) material or EIS	120 [a]
of Class 155 (F) material or EIS	140 [a]
of Class 180 (H) material or EIS	165 [a]
of Class 200 (N) material or EIS	180 [a]
of Class 220 (R) material or EIS	200 [a]
of Class 250 material or EIS	225 [a]
Insulation of internal and external wiring, including power supply cords: – without temperature marking – with temperature marking	 70 Temperature marked on the wire or spool, or rating assigned by the manufacturer
Other thermoplastic insulation	See 5.4.1.10
Components	See also Annex G and 4.1.2
The classes are related to the temperature classes of electrical insulating materials and EIS in accordance with IEC 60085. The assigned letter designations are given in parentheses. For each material, account shall be taken of the data for that material to determine the appropriate maximum temperature.	
[a] If the temperature of a winding is determined by thermocouples, these values are reduced by 10 K, except in the case of: – a motor, or – a winding with embedded thermocouples.	

5.4.1.5 Pollution degrees

5.4.1.5.1 General

The different degrees of pollution of the operating or micro-environment for products covered by this document are given below.

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Pollution degree 1

No pollution or only dry, non-conductive pollution occurs. The pollution has no influence.

NOTE 1 Within the equipment, components or subassemblies that are sealed to exclude dust and moisture are examples of **pollution degree** 1.

Pollution degree 2

Only non-conductive pollution occurs except that occasionally a temporary conductivity caused by condensation is to be expected.

NOTE 2 **Pollution degree** 2 is generally appropriate for equipment covered by the scope of this document.

Pollution degree 3

Conductive pollution occurs or dry non-conductive pollution occurs that becomes conductive due to condensation, which is to be expected.

5.4.1.5.2 Test for pollution degree 1 environment and for an insulating compound

A sample is subjected to the thermal cycling sequence of 5.4.1.5.3.

It is allowed to cool to room temperature and is then subjected to the humidity conditioning of 5.4.8.

*If the test is conducted for verification of the insulating compound forming **solid insulation** as required by 5.4.4.3, the conditioning is immediately followed by the electric strength test of 5.4.9.1.*

*For printed boards, compliance is checked by external visual inspection. There shall be no delamination which affects the **creepage distances** required to fulfil the requirements of **pollution degree** 1.*

For other than printed boards, compliance is checked by inspection of the cross-sectional area, and there shall be no visible voids, gaps or cracks in the insulating material.

5.4.1.5.3 Thermal cycling test procedure

A sample of a component or subassembly is subjected to the following sequence of tests. The sample is subjected 10 times to the following sequence of thermal cycling:

68 h	*at*	*($T_1 \pm 2$) °C;*
1 h	*at*	*(25 ± 2) °C;*
2 h	*at*	*(0 ± 2) °C;*
≥ 1 h	*at*	*(25 ± 2) °C.*

$T_1 = T_2 + T_{ma} - T_{amb} + 10$ K~~, measured in accordance with B.1.6~~, or 85 °C, whichever is higher. However, the 10 K margin is not added if the temperature is measured by an embedded thermocouple or by the resistance method.

T_2 is the temperature of the parts measured during the test of 5.4.1.4.

The significance of T_{ma} and T_{amb} are as given in B.2.6.1.

The period of time taken for the transition from one temperature to another is not specified, but the transition may be gradual.

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5.4.1.6 Insulation in transformers with varying dimensions

If the insulation of a transformer has different **working voltages** along the length of the winding, the **clearances**, **creepage distances** and distances through insulation may vary in a corresponding fashion.

NOTE An example of such a construction is a 30 kV winding, consisting of multiple bobbins connected in series, and earthed or connected to a common point at one end.

5.4.1.7 Insulation in circuits generating starting pulses

For circuits generating starting pulses exceeding ES1 (for example, to ignite a discharge lamp), the requirements for **basic insulation**, **supplementary insulation** and **reinforced insulation** apply to **creepage distances** and distances through insulation.

NOTE 1 For **working voltages** in the above cases, see 5.4.1.8.1 i).

NOTE 2 If the starting pulse is an AC waveform, the pulse width is determined by connecting the peak values of the AC waveform.

The **clearances** are determined by one of the following methods:

– determine the minimum **clearance** in accordance with 5.4.2; or

– conduct one of the following electric strength tests, with the connection terminals of the starting pulse circuit (for example, a lamp) shorted together:

  - the test given in 5.4.9.1; or
  - apply 30 pulses having an amplitude equal to the required test voltage given in 5.4.9.1 generated by an external pulse generator. The pulse width shall be equal to or greater than that of the internally generated starting pulse.

Compliance is checked by inspection or test. During the test, the insulation shall show no breakdown or flashover.

5.4.1.8 Determination of working voltage

5.4.1.8.1 General

In determining **working voltages**, all of the following requirements apply:

a) unearthed **accessible** conductive parts are assumed to be earthed;

b) if a transformer winding or other part is not connected to a circuit that establishes its potential relative to earth, the winding or other part are assumed to be earthed at a point by which the highest **working voltage** is obtained;

c) except as specified in 5.4.1.6, for insulation between two transformer windings, the highest voltage between any two points in the two windings is the **working voltage**, taking into account the voltages to which the input windings will be connected;

d) except as specified in 5.4.1.6, for insulation between a transformer winding and another part, the highest voltage between any point on the winding and the other part is the **working voltage**;

e) where **double insulation** is used, the **working voltage** across the **basic insulation** is determined by imagining a short-circuit across the **supplementary insulation**, and vice versa. For **double insulation** between transformer windings, the short-circuit is assumed to take place at the point by which the highest **working voltage** is produced across the other insulation;

f) when the **working voltage** is determined by measurement, the input ~~power~~ voltage supplied to the equipment shall be the **rated voltage** or the voltage within the **rated voltage range** that results in the highest measured value;

g) the **working voltage** between any point in the circuit supplied by the **mains** and

  – any part connected to earth; and

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– ~~any point in the circuit supplied by the **mains** and~~ any point in a circuit isolated from the **mains**,

shall be ~~assumed to be~~ taken as the greater of the following:

– the **rated voltage** or the upper voltage of the **rated voltage range**; and

– the measured voltage;

h) when determining the **working voltage** for an ES1 or ES2 **external circuit**, the normal operating voltages shall be taken into account. If the operating voltages are not known, the **working voltage** shall be taken as the upper limits of ES1 or ES2 as applicable. Short duration signals (such as telephone ringing) shall not be taken into account for determining **working voltage**;

i) for circuits generating starting pulses (for example, discharge lamps, see 5.4.1.7), the ~~**peak**~~ **working voltage** is the peak value of the pulses with the lamp connected but before the lamp ignites. The frequency of the **working voltage** to determine the minimum **clearance** ~~may~~ shall be ~~assumed to be~~ taken as less than 30 kHz. The **working voltage** to determine minimum **creepage distances** is the voltage measured after the ignition of the lamp~~; and~~.

~~j) **temporary overvoltages** and recurring peak voltages have to be considered.~~

5.4.1.8.2 RMS working voltage

In determining the **RMS working voltage**, short-term conditions (for example, cadenced telephone ringing signals in **external circuits**) and non-repetitive transients (for example, due to atmospheric disturbances) are not taken into account.

NOTE The **creepage distances** are determined from the **RMS working voltages**.

~~#### 5.4.1.8.3 Peak working voltage~~

~~For the **peak working voltage** used to determine the **required withstand voltage** for minimum **clearances** and test voltages for electric strength:~~

~~– when determining the **peak working voltage** between circuits connected to the **mains** and circuits isolated from the **mains**, the voltage of any ES2 circuit, ES1 circuit or **external circuits** (including telephone ringing signals) shall be regarded as 0;~~

~~– when determining the **peak working voltage** for an **external circuit** that does not have transients, the **peak working voltage** of repetitive signals, such as telephone ringing signals, shall be taken into account;~~

~~– non-repetitive transients (for example, due to atmospheric disturbances) shall not be taken into account.~~

5.4.1.9 Insulating surfaces

An **accessible** insulating surface is considered to be covered by a thin metallic foil for determining **clearances**, **creepage distances** and distance through insulation (see Figure O.13).

5.4.1.10 Thermoplastic parts on which conductive metallic parts are directly mounted

5.4.1.10.1 Requirements

Thermoplastic parts on which conductive metallic parts are directly mounted shall be sufficiently resistant to heat if softening of the plastic could result in the failure of a **safeguard**.

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~~5.4.1.10.2 Compliance criteria~~

Compliance is checked by examination of the Vicat test or ball pressure data from the material manufacturer. If the data is not available, compliance is checked by either the Vicat test of 5.4.1.10.2 or by the ball pressure test of 5.4.1.10.3.

5.4.1.10.2 Vicat test

*The measured temperature during **normal operating conditions**, as specified in Clause B.2, shall be at least 15 K less than the Vicat softening temperature as specified in Vicat test B50 of ISO 306.*

*The measured temperature during **abnormal operating conditions** of Clause B.3 shall be less than the Vicat softening temperature.*

*The Vicat softening temperature of a non-metallic part supporting parts in a circuit supplied from the **mains** shall be not less than 125 °C.*

5.4.1.10.3 Ball pressure test

*Compliance is checked ~~by examination of the ball pressure test data from the manufacturer or~~ by subjecting the part to the ball pressure test according to IEC 60695-10-2. The test is made in a heating cabinet at a temperature of ($T - T_{amb} + T_{ma} + 15$ °C) $\pm$ 2 °C (see B.2.6.1 for the explanation of T, T_{ma} and T_{amb}). However, a thermoplastic part supporting parts in a circuit supplied from the **mains** is tested at a minimum of 125 °C.*

After the test, dimension d (diameter of the indentation) shall not exceed 2 mm.

The test is not made if it is clear from examination of the physical characteristics of the material that it will meet the requirements of this test.

5.4.2 Clearances

5.4.2.1 General requirements

Clearances shall be so dimensioned that the likelihood of breakdown due to:

– **temporary overvoltages**; and

– transient voltages that may enter the equipment; and

– recurring peak ~~**working**~~ voltages ~~that are generated within the equipment,~~ and their related frequencies that are generated within the equipment

is reduced.

All required **clearances** and test voltages apply to an altitude up to 2 000 m. For higher altitudes, the multiplication factors of 5.4.2.5 apply after any linear interpolation, but before rounding up, and before any other multiplication factors are applied as stated in Table 10, Table 11, Table 14 and Table 15.

NOTE For air gaps between contacts of **safety interlocks**, see Annex K. For air gaps between contacts of **disconnect devices**, see Annex L. For air gaps between contacts in components, see Annex G. For connectors, see G.4.1.

Unless otherwise specified by the manufacturer and supplied with means to assure minimum **clearances** during all modes of normal operation, the voice coil and adjacent conductive parts of a loudspeaker are considered to be conductively connected.

To determine the **clearance**, the highest value of the following two procedures shall be used:

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– Procedure 1: Determine **clearances** according to 5.4.2.2 ~~using the **peak working voltage**~~.

– Procedure 2: Determine **clearances** according to 5.2.2.3 ~~using the **required withstand voltages**~~. Alternatively, the adequacy of **clearances** may be determined using an electric strength test according to 5.2.2.4, in which case the values according to Procedure 1 shall be maintained.

For Overvoltage Category II, **clearances** in circuits connected to an AC **mains** not exceeding 420 V peak (300 V RMS) may be determined per Annex X as an alternative.

5.4.2.2 Procedure 1 for determining clearance ~~using peak working voltage~~

To determine the ~~**peak working**~~ voltage to be used in Table 10 and Table 11, the highest voltage of the following is ~~taken into account~~ used as applicable:

~~– steady state voltages; and~~

~~– recurring peak voltages to be taken as 1,1 times the **mains** voltage (see 5.3.3.2.4 of IEC 60664-1:2007); and~~

~~– **temporary overvoltages** as given below (see also 5.3.3.2.3 of IEC 60664-1:2007).~~

– the peak value of the **working voltage** across the **clearance**;

– the recurring peak voltages, if any, across the **clearance**;

– for circuits connected to the AC **mains**: the **temporary overvoltage** ~~value~~, which is taken as 2 000 V peak if the nominal AC **mains** system voltage does not exceed 250 V and is taken as 2 500 V peak if the nominal AC **mains** system voltage exceeds 250 V but does not exceed 600 V.

  Alternatively, the **temporary overvoltage** may be determined in accordance with 5.3.3.2.3 of IEC 60664-1:2007 at the discretion of the manufacturer, in which case the reference to “solid insulation” in 5.3.3.2.3 of IEC 60664-1:2007 is replaced by “clearances”. Moreover, the short term value equal to U_n + 1 200 V is taken as the voltage for use in Table 10.

  NOTE U_n is the nominal line-to-neutral voltage of the neutral-earthed supply system.

~~The highest value of the **clearance** determined as given below~~ This voltage shall be used to determine the **clearance** as follows:

– **clearance** values of Table 10 for circuits with fundamental frequencies up to 30 kHz; or

– **clearance** values of Table 11 for circuits with fundamental frequencies higher than 30 kHz; or

– the highest **clearance** values of Table 10 and Table 11 for circuits where both frequencies lower than 30 kHz and higher than 30 kHz are present.

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Table 10 – Minimum clearances for voltages with frequencies up to 30 kHz

~~Peak working voltage or d.c.~~ **Voltage up to and including** peak	**Basic insulation or supplementary insulation** mm			**Reinforced insulation** mm		
	Pollution degree			**Pollution degree**		
	1 [a]	**2**	**3**	**1** [a]	**2**	**3**
330	0,01	0,2	0,8	0,02	0,4	1,5
400	0,02			0,04		
500	0,04			0,08		
600	0,06			0,12		
800	0,13			0,26		
1 000	0,26	0,26		0,52	0,52	
1 200	0,42			0,84		
1 500	0,76			1,52		1,6
2 000	1,27			2,54		
2 500	1,8			3,6		
3 000	2,4			4,8		
4 000	3,8			7,6		
5 000	5,7			11,0		
6 000	7,9			15,8		
8 000	11,0			20		
10 000	15,2			27		
12 000	19			33		
15 000	25			42		
20 000	34			59		
25 000	44			77		
30 000	55			95		
40 000	77			131		
50 000	100			175		
60 000	120			219		
80 000	175			307		
100 000	230			395		

Linear interpolation may be used between the nearest two points, the calculated minimum **clearances** being rounded up to the next higher specified increment ~~or the value in the next row below whichever is lower~~. For values:

– not exceeding 0,5 mm, the specified increment is 0,01 mm; and

– exceeding 0,5 mm, the specified increment is 0,1 mm.

[a] The values for **pollution degree** 1 may be used if a sample complies with the tests of 5.4.1.5.2.

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Table 11 – Minimum clearances for voltages with frequencies above 30 kHz

~~Peak working voltage~~ Voltage up to and including peak	Basic insulation or supplementary insulation mm	Reinforced insulation mm
600	0,07	0,14
800	0,22	0,44
1 000	0,6	1,2
1 200	1,68	3,36
1 400	2,82	5,64
1 600	4,8	9,6
1 800	8,04	16,08
2 000	13,2	26,4
Linear interpolation may be used between the nearest two points, the calculated minimum **clearances** being rounded up to the next higher specified increment ~~or the value in the next row below whichever is lower~~. For values: – not exceeding 0,5 mm, the specified increment is 0,01 mm; and – exceeding 0,5 mm, the specified increment is 0,1 mm. For **pollution degree** 1, use a multiplication factor of 0,8. For **pollution degree** 3, use a multiplication factor of 1,4.		

5.4.2.3 Procedure 2 for determining clearance ~~using required withstand voltage~~

5.4.2.3.1 General

The dimension for a **clearance** that is subject to transient voltages from the **mains** or an **external circuit** is determined from the **required withstand voltage** for that **clearance**.

Each **clearance** shall be determined using the following steps:

– determine the transient voltage according to 5.4.2.3.2; and
– determine the **required withstand voltage** according to 5.4.2.3.3; and
– determine the minimum **clearance** according to 5.4.2.3.4.

5.4.2.3.2 Determining transient voltages

5.4.2.3.2.1 General

Transient voltages can be determined based on their origin, or can be measured in accordance with 5.4.2.3.2.5.

If different transient voltages affect the same **clearance**, the largest of those voltages is used. The values are not added together.

Outdoor equipment connected to the **mains** shall be suitable for the highest **mains transient voltage** expected in the installation location.

Consideration shall be given to the following:

– the prospective fault current of the supply to **outdoor equipment** can be higher than for indoor equipment, see IEC 60364-4-43; and
– the **mains transient voltage** for **outdoor equipment** can be higher than for indoor equipment.

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Components within **outdoor equipment** that reduce the **mains transient voltage** or the prospective fault current shall comply with the requirements of the IEC 61643 -series.

NOTE 1 The overvoltage category of **outdoor equipment** is normally considered to be one of the following:

– if powered via the normal building installation wiring, Overvoltage Category II;

– if powered directly from the **mains** distribution system, Overvoltage Category III;

– if at, or in the proximity of, the origin of the electrical installation, Overvoltage Category IV.

NOTE 2 For further information regarding protection from overvoltages, see IEC 60364-5-53.

Compliance is checked by inspection of the equipment, the installation instructions and, where necessary, by the applicable component tests specified in the IEC 61643-series.

5.4.2.3.2.2 Determining AC mains transient voltages

For equipment to be supplied from the AC **mains**, the value of the **mains transient voltage** depends on the overvoltage category and the AC **mains** voltage and is given in Table 12. In general, **clearances** in equipment intended to be connected to the AC **mains**, shall be designed for Overvoltage Category II.

NOTE See Annex I for further guidance on the determination of overvoltage categories.

Equipment that is likely, when installed, to be subjected to transient voltages that exceed those for its design overvoltage category requires additional transient voltage protection to be provided external to the equipment. In this case, the installation instructions shall state the need for such external protection.

Table 12 – Mains transient voltages

AC mains voltage [a] up to and including V RMS	**Mains transient voltage [b]** V peak			
	Overvoltage Category			
	I	**II**	**III**	**IV**
50	330	500	800	1 500
100 [c]	500	800	1 500	2 500
150 [d]	800	1 500	2 500	4 000
300 [e]	1 500	2 500	4 000	6 000
600 [f]	2 500	4 000	6 000	8 000

[a] For equipment designed to be connected to a three-phase 3-wire supply, where there is no neutral conductor, the AC **mains** supply voltage is the line-to-line voltage. In all other cases, where there is a neutral conductor, it is the line-to-neutral voltage.

[b] The **mains transient voltage** is always one of the values in the table. Interpolation is not permitted.

[c] In Japan, the value of the **mains transient voltages** for the nominal AC **mains** supply voltage of 100 V is determined from columns applicable to the nominal AC **mains** supply voltage of 150 V.

[d] Including 120/208 V and 120/240 V.

[e] Including 230/400 V and 277/480 V.

[f] Including 400/690 V.

5.4.2.3.2.3 Determining DC mains transient voltages

If an earthed DC power distribution system is entirely within a single building, the transient voltage is selected as follows:

– if the DC power distribution system is earthed at a single point, the transient voltage is taken to be 500 V peak; or

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– if the DC power distribution system is earthed at the source and the equipment, the transient voltage is taken to be 350 V peak; or

NOTE The connection to protective earth can be at the source of the DC power distribution system or at the equipment location, or both (see ITU-T Recommendation K.27).

– if the cabling associated with the DC power distribution system is shorter than 4 m or is installed entirely in continuous metallic conduit, the transient voltage is taken to be 150 V peak.

If a DC power distribution system is not earthed or is not within the same building, the transient voltage with respect to earth shall be taken to be equal to the **mains transient voltage** in the **mains** from which the DC power is derived.

If the DC power distribution system is not within the same building, and is constructed using installation and protection techniques similar to those of **external circuits**, the transient voltage shall be determined using the relevant classification from 5.4.2.3.2.4.

If equipment is supplied from a dedicated **battery** that has no provision for charging from a **mains** supply without removal from the equipment, the transient voltage shall be disregarded.

When determining the DC **mains transient voltage**, the installation and the source of the DC **mains** shall be taken into account. If these are not known, the **mains transient voltage** on the DC **mains** supply for an **outdoor equipment** shall be taken as 1,5 kV.

If the DC power distribution system is not within the same building, the manufacturer shall declare the **mains transient voltage** on the DC **mains** supply in the installation instructions.

5.4.2.3.2.4 Determining external circuit transient voltages

The applicable value of the transient voltage that may occur on an **external circuit** shall be determined using Table 13. Where more than one location or condition is applicable, the highest transient voltage applies. A ringing or other interrupted signal shall not be taken into account if the voltage of this signal is less than that of the transient voltage.

If the transient voltage is less than the peak voltage of a short duration signal (such as a telephone ringing signal), the peak voltage of the short duration signal shall be used as the transient voltage.

If the **external circuit** transient voltages are known to be higher than indicated in Table 13, the known value shall be used.

NOTE 1 Australia has published its overvoltage limits in AS/ACIF G624:2005.

NOTE 2 It is assumed that adequate measures have been taken to reduce the likelihood that the transient voltages presented to the equipment exceed the values specified in Table 13. In installations where transient voltages presented to the equipment are expected to exceed the values specified in Table 13, additional measures such as surge suppression can be necessary.

NOTE 3 In Europe, the requirement for interconnection with an **external circuit** is in addition given in EN 50491-3:2009, *General requirements for Home and Building Electronic Systems (HBES) and Building Automation and Control Systems (BACS) – Part 3: Electrical safety requirements*.

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Table 13 – External circuit transient voltages

ID	Cable type	Additional conditions	Transient voltages
1	Paired conductor [a] – shielded or unshielded	The building or structure may or may not have equipotential bonding.	1 500 V 10/700 µs Only differential if one conductor is earthed in the equipment
2	Any other conductors	The **external circuit** is not earthed at either end, but there is an earth reference (for example, from connection to **mains)**.	**Mains transient voltage** or **external circuit** transient voltage of the circuit from which the circuit in question is derived whichever is higher.
3	Coaxial cable in the cable distribution network	Equipment other than power-fed coaxial repeaters. Cable shield is earthed at the equipment.	4 000 V 10/700 µs Centre conductor to shield
4	Coaxial cable in the cable distribution network	Power fed coaxial repeaters (up to 4,4 mm coaxial cable). Cable shield is earthed at the equipment.	5 000 V 10/700 µs Centre conductor to shield
5	Coaxial cable in the cable distribution network	Equipment other than power-fed coaxial repeaters. Cable shield is not earthed at the equipment. Cable shield is earthed at building entrance.	4 000 V 10/700 µs Centre conductor to shield 1 500 V 1,2/50 µs shield to earth
6	Coaxial cable	Cable connects to an outdoor antenna	no transient ~~c~~ [b]
7	Paired conductor [a]	Cable connects to an outdoor antenna	no transient ~~c~~ [b]
8	Coaxial cable within the building ~~b~~	The connection of the cable coming from outside the building is made via a transfer point. The shield of the coaxial cable from outside the building and the shield of the coaxial cable of the cable within the building are connected together and are connected to earth.	Not applicable

In general, for **external circuits** installed wholly within the same building structure, transients are not taken into account. However, a conductor is considered to leave the building if it terminates on equipment earthed to a different earthing network.

The effects of unwanted steady state voltages generated outside the equipment (for example, earth potential differences and voltages induced on telecommunication networks by electric train systems) are controlled by installation practices. Such practices are application dependent and are not dealt with by this document.

For a shielded cable to affect a reduction in transients, the shield shall be continuous, earthed at both ends, and have a maximum transfer impedance of 20 Ω/km (for f less than 1 MHz).

NOTE 1 Home appliances like audio, video and multimedia products are addressed by ID 6, 7 and 8.

NOTE 2 In Norway and Sweden, the cable shield on coaxial cables is normally not earthed at the building entrance (see the note in 5.7.7). For installation conditions, see ~~EN~~ IEC 60728-11.

[a] A paired conductor includes a twisted pair.

~~[b] When determining the separation requirements in 5.4.10, the transients on **external circuits** are taken into account.~~

~~c~~ [b] These cables are not subject to any transients but they may be affected by a 10 kV electrostatic discharge voltage (from a 1 nF capacitor). The effect of such electrostatic discharge voltages is not taken into account when determining **clearances**. Compliance is checked by the test of G.10.4.

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5.4.2.3.2.5 Determining transient voltage levels by measurement

The transient voltage across the **clearance** is measured using the following procedure.

During the measurement, the equipment is not connected to the **mains**~~, to the external d.c. power distribution system~~ or to any **external circuit**. ~~Any~~ Only surge suppressors internal to the equipment in circuits connected to the **mains**~~ or the external d.c. power distribution system~~ are disconnected. If the equipment is intended to be used with a separate power supply, it is connected to the equipment during the measurement.

To measure the transient voltage across a **clearance**, the appropriate impulse test generator of Annex D is used to generate impulses. At least three impulses of each polarity, with intervals of at least 1 s between impulses, are applied between each relevant point.

a) Transient voltages from an AC **mains**

The impulse test generator circuit 2 of Table D.1 is used to generate 1,2/50 μs impulses equal to the AC **mains transient voltages** between the following points:

– line-to-line;
– all line conductors conductively joined together and neutral;
– all line conductors conductively joined together and protective earth; and
– neutral and protective earth.

b) Transient voltages from a DC **mains**

The impulse test generator circuit 2 of Table D.1 is used to generate 1,2/50 μs impulses equal to the DC **mains transient voltages**, at the following points:

– the positive and negative supply connection points; and
– all supply connection points joined together and protective earth.

c) Transient voltages from an **external circuit**

The appropriate test generator of Annex D is used to generate impulses as applicable and described in Table 13 and are applied between each of the following **external circuit** connection points of a single interface type:

– each pair of terminals (for example, A and B or tip and ring) in an interface; and
– all terminals of a single interface type joined together and earth.

A voltage measuring device is connected across the **clearance** in question.

Where there are several identical circuits, only one is tested.

5.4.2.3.3 Determining required withstand voltage

The **required withstand voltage** is equal to the transient voltage as determined in 5.4.2.3.2, except for the following cases:

– If a circuit isolated from the **mains** is connected to the main **protective earthing** terminal ~~that complies with 5.6.7~~ through a **protective bonding conductor**, the **required withstand voltage** may be one overvoltage category lower or one AC **mains** voltage lower in Table 12. For an AC **mains** up to and including 50 V RMS, no adjustments are made.
– In a circuit isolated from the **mains** supplied by a DC source with capacitive filtering, and connected to protective earth, the **required withstand voltage** shall be assumed to be equal to the peak value of the **DC voltage** of the source, or the peak of the **working voltage** of the circuit isolated from the **mains**, whichever is higher.
– If equipment is supplied from a dedicated **battery** that has no provision for charging from the **mains** supply without removal from the equipment, the transient voltage is zero and the **required withstand voltage** is equal to the peak of the **working voltage**.

5.4.2.3.4 Determining clearances using required withstand voltage

Each **clearance** shall comply with the relevant value of Table 14.

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Table 14 – Minimum clearances using required withstand voltage

Required withstand voltage	Basic insulation or supplementary insulation mm			Reinforced insulation mm		
V peak or DC	Pollution degree			Pollution degree		
up to and including	1 [a]	2	3	1 [a]	2	3
330	0,01	0,2	0,8	0,02	0,4	1,5
400	0,02			0,04		
500	0,04			0,08		
600	0,06			0,12		
800	0,10			0,2		
1 000	0,15			0,3		
1 200	0,25			0,5		
1 500	0,5			1,0		
2 000	1,0			2,0		
2 500	1,5			3,0		
3 000	2,0			3,8		
4 000	3,0			5,5		
5 000	4,0			8,0		
6 000	5,5			8,0		
8 000	8,0			14		
10 000	11			19		
12 000	14			24		
15 000	18			31		
20 000	25			44		
25 000	33			60		
30 000	40			72		
40 000	60			98		
50 000	75			130		
60 000	90			162		
80 000	130			226		
100 000	170			290		

Linear interpolation may be used between the nearest two points, the calculated minimum **clearances** ~~being~~ shall be rounded up to the next higher specified increment ~~or the value in the next row below whichever is lower~~. For values:

– not exceeding 0,5 mm, the specified increment is 0,01 mm; and

– exceeding 0,5 mm, the specified increment is 0,1 mm.

[a] The values for **pollution degree** 1 may be used if a sample complies with the tests of 5.4.1.5.2.

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5.4.2.4 Determining the adequacy of a clearance using an electric strength test

*The **clearances** shall withstand an electric strength test. The test may be conducted using an impulse voltage or an AC voltage or a **DC voltage**. The **required withstand voltage** is determined as given in 5.4.2.3.*

The impulse withstand voltage test is carried out with a voltage having an appropriate waveform (see Annex D) with the values specified in Table 15. Five impulses of each polarity are applied with an interval of at least 1 s between pulses.

The AC voltage test is conducted using a sinusoidal voltage with a peak value as specified in Table 15 and is applied for 5 s.

*The **DC voltage** test is conducted using a **DC voltage** specified in Table 15 and applied for 5 s in one polarity and then for 5 s in reverse polarity.*

Table 15 – Electric strength test voltages

Required withstand voltage up to and including kV peak	**Test voltage for electric strength for clearances for basic insulation or supplementary insulation** kV peak (impulse or AC or DC)
0,33	0,36
0,5	0,54
0,8	0,93
1,5	1,75
2,5	2,92
4,0	4,92
6,0	7,39
8,0	9,85
12,0	14,77
U [a]	1,23 × U [a]
Linear interpolation may be used between the nearest two points, the calculated minimum test voltage being rounded up to the next higher 0,01 kV increment. For **reinforced insulation**, the test voltage for electric strength is 160 % of the value for the **basic insulation** after which this calculated test voltage is rounded up to the next higher 0,01 kV increment. If the EUT fails the AC or DC test, the impulse test shall be used. If the test is conducted at an altitude of 200 m or more above sea level, Table F.5 of IEC 60664-1:2007 may be used, in which case linear interpolation between 200 m and 500 m altitudes and between the corresponding impulse test voltages of Table F.5 of IEC 60664-1:2007 may be used.	
[a] U is any **required withstand voltage** higher than 12,0 kV.	

5.4.2.5 Multiplication factors for altitudes higher than 2 000 m above sea level

For equipment intended and designed to be used more than 2 000 m above sea level, the minimum **clearances** in Table 10, Table 11 and Table 14 and the electric strength test voltages in Table 15 are multiplied by the ~~applicable~~ multiplication factor for the desired altitude according to Table 16.

NOTE 1 Higher altitudes can be simulated in a vacuum chamber.

NOTE 2 In China, special requirements in choosing multiplication factors for altitudes above 2 000 m exist.

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Table 16 – Multiplication factors for clearances and test voltages

Altitude m	Normal barometric pressure kPa	Multiplication factor for clearances	Multiplication factor for electric strength test voltages		
			< 1 mm	≥ 1 mm to < 10 mm	≥ 10 mm to < 100 mm
2 000	80,0	1,00	1,00	1,00	1,00
3 000	70,0	1,14	1,05	1,07	1,10
4 000	62,0	1,29	1,10	1,15	1,20
5 000	54,0	1,48	1,16	1,24	1,33
Linear interpolation may be used between the nearest two points, the calculated minimum multiplication factor being rounded up to the next higher 0,01 increment.					

5.4.2.6 Compliance criteria

Compliance is checked by measurement and test taking into account the relevant clauses of Annex O and Annex T.

The following conditions apply:

– *movable parts are placed in their most unfavourable positions;*

– ***clearances** from an **enclosure** of insulating material through a slot or opening are measured according to Figure O.13, point X;*

– *during the force tests, metal **enclosures** shall not come into contact with bare conductive parts of:*

- *ES2 circuits, unless the product is in a **restricted access area**, or*
- *ES3 circuits;*

– *after the tests of Annex T:*

- *the dimensions for **clearances** are measured, and*
- *the relevant electric strength test shall be applied, and*
- *for the glass impact test of Clause T.9, damage to the finish, small dents that do not reduce **clearances** below the specified values, surface cracks and the like are ignored. If a through crack appears, **clearances** shall not be reduced. For cracks not visible to the naked eye, an electric strength test shall be conducted; and*

– *components and parts, other than parts serving as an **enclosure**, are subjected to the test of Clause T.2. After the application of the force, **clearances** shall not be reduced below the required values.*

For circuits connected to coaxial cable distribution or outdoor antennas, compliance is checked by the tests of 5.5.8.

5.4.3 Creepage distances

5.4.3.1 General

Creepage distances shall be so dimensioned that, for a given **RMS working voltage**, **pollution degree** and material group, no flashover or breakdown of insulation (for example, due to tracking) will occur.

Creepage distances for **basic insulation** and **supplementary insulation** for frequencies up to 30 kHz shall comply with Table 17. **Creepage distances** for **basic insulation** and **supplementary insulation** for frequencies greater than 30 kHz and up to 400 kHz shall comply with Table 18.

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The **creepage distance** requirements for frequencies up to 400 kHz can be used for frequencies over 400 kHz until additional data is available.

NOTE ~~1~~ **Creepage distances** for frequencies higher than 400 kHz are under consideration.

The **creepage distance** between the outer insulating surface (see 5.4.3.2) of a connector (including an opening in the **enclosure**) and conductive parts that are connected to ES2 within the connector (or in the **enclosure**) shall comply with the requirements for **basic insulation**.

The **creepage distance** between the outer insulating surface (see 5.4.3.2) of a connector (including an opening in the **enclosure**) and conductive parts that are connected to ES3 within the connector (or in the **enclosure**) shall comply with the requirements for **reinforced insulation**.

As an exception, the **creepage distance** may comply with the requirements for **basic insulation** if the connector is:

– fixed to the equipment; and

– located internally to the outer **electrical enclosure** of the equipment; and

– only **accessible** after removal of a subassembly that

  - is required to be in place during **normal operating conditions**, and
  - is provided with an **instructional safeguard** to replace the removed subassembly.

~~NOTE 2 The tests of 5.4 apply to such connectors after removal of the subassembly.~~

For all other **creepage distances** in connectors, including connectors that are not fixed to the equipment, the minimum values determined in accordance with 5.4.3 apply.

The above minimum **creepage distances** for connectors do not apply to connectors listed in Clause G.4.

~~NOTE 3 For **creepage distances** below 2 mm, additional information is available in IEC 60664-5.~~

If the minimum **creepage distance** derived from Table 17 or Table 18 is less than the minimum **clearance**, then the minimum **clearance** shall be applied as the minimum **creepage distance**.

For glass, mica, glazed ceramic or similar inorganic materials, if the minimum **creepage distance** is greater than the applicable minimum **clearance**, the value of minimum **clearance** may be applied as the minimum **creepage distance**.

For **reinforced insulation**, the values for **creepage distances** are twice the values for **basic insulation** in Table 17 or Table 18.

5.4.3.2 Test method

The following conditions apply:

– *movable parts are placed in their most unfavourable positions;*

– *for equipment incorporating ordinary **non-detachable power supply cords**, **creepage distance** measurements are made with supply conductors of the largest cross-sectional area specified in Clause G.7, and also without conductors;*

– *when measuring **creepage distances** from an **accessible** outer surface of an **enclosure** of insulating material through a slot or opening in the **enclosure** or through an opening in an **accessible** connector, the **accessible** outer surface of the **enclosure** shall be*

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considered to be conductive as if it were covered by a metal foil during the test of V.1.2, applied without appreciable force (see Figure O.13, point X);

– *the dimensions for **creepage distances** functioning as **basic insulation**, **supplementary insulation** and **reinforced insulation** are measured after the tests of Annex T according to 4.4.3;*

– *for the glass ~~breakage~~ impact test of Clause T.9, damage to the finish, small dents that do not reduce **creepage distances** below the specified values, surface cracks and the like are ignored. If a through crack appears, **creepage distances** shall not be reduced;*

– *components and parts, other than parts serving as an **enclosure**, are subjected to the test of Clause T.2. After the application of the force, **creepage distances** shall not be reduced below the required values.*

5.4.3.3 Material group and CTI

Material groups are based on the CTI and are classified as follows:

Material Group I	600 ≤ CTI
Material Group II	400 ≤ CTI < 600
Material Group IIIa	175 ≤ CTI < 400
Material Group IIIb	100 ≤ CTI < 175

The material group is checked by evaluation of the test data for the material according to IEC 60112 using 50 drops of solution A.

If the material group is not known, Material Group IIIb shall be assumed.

If a CTI of 175 or greater is needed, and the data is not available, the material group can be established with a test for proof tracking index (PTI) as detailed in IEC 60112. A material may be included in a group if its PTI established by these tests is equal to, or greater than, the lower value of the comparative tracking index (CTI) specified for the group.

5.4.3.4 Compliance criteria

Compliance is checked by measurement taking into account Annex O, Annex T and Annex V.

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Table 17 – Minimum creepage distances for basic insulation and supplementary insulation in mm

RMS working voltage up to and including	Pollution degree						
	1 [a]	2			3		
	Material group						
V	I, II, IIIa, IIIb	I	II	IIIa, IIIb	I	II	IIIa, IIIb [b]
10	0,08	0,4	0,4	0,4	1,0	1,0	1,0
12,5	0,09	0,42	0,42	0,42	1,05	1,05	1,05
16	0,1	0,45	0,45	0,45	1,1	1,1	1,1
20	0,11	0,48	0,48	0,48	1,2	1,2	1,2
25	0,125	0,5	0,5	0,5	1,25	1,25	1,25
32	0,14	0,53	0,53	0,53	1,3	1,3	1,3
40	0,16	0,56	0,8	1,1	1,4	1,6	1,8
50	0,18	0,6	0,85	1,2	1,5	1,7	1,9
63	0,2	0,63	0,9	1,25	1,6	1,8	2,0
80	0,22	0,67	0,95	1,3	1,7	1,9	2,1
100	0,25	0,71	1,0	1,4	1,8	2,0	2,2
125	0,28	0,75	1,05	1,5	1,9	2,1	2,4
160	0,32	0,8	1,1	1,6	2,0	2,2	2,5
200	0,42	1,0	1,4	2,0	2,5	2,8	3,2
250	0,56	1,25	1,8	2,5	3,2	3,6	4,0
320	0,75	1,6	2,2	3,2	4,0	4,5	5,0
400	1,0	2,0	2,8	4,0	5,0	5,6	6,3
500	1,3	2,5	3,6	5,0	6,3	7,1	8,0
630	1,8	3,2	4,5	6,3	8,0	9.0	10
800	2,4	4,0	5,6	8,0	10	11	12,5
1 000	3,2	5,0	7,1	10	12,5	14	16
1 250	4,2	6,3	9,0	12,5	16	18	20
1 600	5,6	8,0	11	16	20	22	25
2 000	7,5	10	14	20	25	28	32
2 500	10	12,5	18	25	32	36	40
3 200	12,5	16	22	32	40	45	50
4 000	16	20	28	40	50	56	63
5 000	20	25	36	50	63	71	80
6 300	25	32	45	63	80	90	100
8 000	32	40	56	80	100	110	125
10 000	40	50	71	100	125	140	160
12 500	50	63	90	125			
16 000	63	80	110	160			
20 000	80	100	140	200			
25 000	100	125	180	250			
32 000	125	160	220	320			
40 000	160	200	280	400			
50 000	200	250	360	500			
63 000	250	320	450	600			

Linear interpolation may be used between the nearest two points, the calculated minimum **creepage distance** being rounded to the next higher 0,1 mm increment or the value in the next row below whichever is lower.

For **reinforced insulation**, the rounding to the next higher 0,1 mm increment or to double the value in the next row is done after doubling the calculated value for **basic insulation**.

[a] The values for **pollution degree** 1 may be used if a sample complies with the tests of 5.4.1.5.2.

[b] Material Group IIIb is not recommended for applications in **pollution degree** 3 with an **RMS working voltage** above 630 V.

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Table 18 – Minimum values of creepage distances (in mm) for frequencies higher than 30 kHz and up to 400 kHz

~~Peak working~~ Voltage kV	30 kHz < f ≤ 100 kHz	100 kHz < f ≤ 200 kHz	200 kHz < f ≤ 400 kHz
0,1	0,016 7	0,02	0,025
0,2	0,042	0,043	0,05
0,3	0,083	0,09	0,1
0,4	0,125	0,13	0,15
0,5	0,183	0,23	0,25
0,6	0,267	0,38	0,4
0,7	0,358	0,55	0,68
0,8	0,45	0,8	1,1
0,9	0,525	1,0	1,9
1	0,6	1,15	3

The values for the **creepage distances** in the table apply for **pollution degree** 1. For **pollution degree** 2 a multiplication factor of 1,2 and for **pollution degree** 3, a multiplication factor of 1,4 shall be used.

Linear interpolation may be applied, the result being rounded up to the next significant digit.

The data given in this Table 18 (from Table 2 of IEC 60664-4:2005) does not take into account the influence of tracking phenomena. For that purpose, Table 17 has to be taken into account. Therefore, if values in Table 18 are smaller than those in Table 17, the values of Table 17 apply.

5.4.4 Solid insulation

5.4.4.1 General requirements

The requirements of this subclause apply to **solid insulation**, including compounds and gel materials used as insulation.

Solid insulation shall not break down:

– due to overvoltages, including transients, that enter the equipment, and peak voltages that may be generated within the equipment; and

– due to pinholes in thin layers of insulation.

~~Solvent-based~~ Enamelled coatings shall not be used for **basic insulation**, **supplementary insulation** or **reinforced insulation** except as given in G.6.2.

Except for printed boards, **solid insulation** shall either:

– comply with minimum distances through insulation in accordance with 5.4.4.2; or

– meet the requirements and pass the tests in 5.4.4.3 to 5.4.4.7, as applicable.

Glass used as **solid insulation** shall comply with the glass ~~breakage~~ impact test as specified in Clause T.9. Damage to the finish, small dents that do not reduce **clearances** below the specified values, surface cracks and the like are ignored. If a through crack appears, **clearances** and **creepage distances** shall not be reduced below the specified values.

For printed boards, see Clause G.13. For antenna terminals, see 5.4.5. For **solid insulation** on internal wiring, see 5.4.6.

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5.4.4.2 Minimum distance through insulation

Except where another subclause of Clause 5 applies, distances through insulation shall be dimensioned according to the application of the insulation and as follows (see Figure O.15 and Figure O.16):

– if the **working voltage** does not exceed ES2 voltage limits, there is no requirement for distance through insulation;
– if the **working voltage** exceeds ES2 voltage limits, the following rules apply:
  - for **basic insulation**, no minimum distance through insulation is specified;
  - for **supplementary insulation** or **reinforced insulation** comprised of a single layer, the minimum distance through insulation shall be 0,4 mm;
  - for **supplementary insulation** or **reinforced insulation** comprised of multiple layers, the minimum distance through insulation shall comply with 5.4.4.6.

5.4.4.3 Insulating compound forming solid insulation

There is no minimum internal **clearance** or **creepage distance** required if:

– the insulating compound completely fills the casing of a component or subassembly, including a semiconductor device (for example, an optocoupler); and
– the component or subassembly meets the minimum distances through insulation of 5.4.4.2; and
– a single sample passes the tests of 5.4.1.5.2.

NOTE Some examples of such treatment are variously known as potting, encapsulation and vacuum impregnation.

Such constructions containing cemented joints shall also comply with 5.4.4.5.

Alternative requirements for semiconductor devices are given in 5.4.4.4.

For printed boards, see Clause G.13 and for wound components, see 5.4.4.7.

Compliance is checked by sectioning the sample. There shall be no visible voids in the insulating material.

5.4.4.4 Solid insulation in semiconductor devices

There is no minimum internal **clearance** or **creepage distance**, and no minimum distance through insulation for **supplementary insulation** or **reinforced insulation** consisting of an insulating compound completely filling the casing of a semiconductor component (for example, an optocoupler) provided that the component:

– passes the **type tests** and inspection criteria of 5.4.7; and passes **routine tests** for electric strength during manufacturing, using the appropriate test in 5.4.9.2; or
– complies with Clause G.12.

Such constructions containing cemented joints shall also comply with 5.4.4.5.

Alternatively, a semiconductor may be evaluated according to 5.4.4.3.

5.4.4.5 Insulating compound forming cemented joints

The requirements specified below apply when an insulating compound forms a cemented joint between two non-conductive parts or between another non-conductive part and itself. These requirements do not apply to optocouplers that comply with IEC 60747-5-5.

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Where the path between conductive parts is filled with insulating compound, and the insulating compound forms a cemented joint between two non-conductive parts or between a non-conductive part and itself (see Figure O.14, Figure O.15 and Figure O.16), one of the following a), b) or c) applies.

a) The distance along the path between the two conductive parts shall be not less than the minimum **clearances** and **creepage distances** for **pollution degree** 2. The requirements for distance through insulation of 5.4.4.2 do not apply along the joint.

b) The distance along the path between the two conductive parts shall not be less than the minimum **clearances** and **creepage distances** for **pollution degree** 1. Additionally, one sample shall pass the test of 5.4.1.5.2. The requirements for distance through insulation in 5.4.4.2 do not apply along the joint.

c) The requirements for distance through insulation of 5.4.4.2 apply between the conductive parts along the joint. Additionally, three samples shall pass the test of 5.4.7.

For a) and b) above, if the insulating materials involved have different material groups, the worst case is used. If a material group is not known, Material Group IIIb shall be used.

For b) and c) above, the tests of 5.4.1.5.2 and 5.4.7 are not applied to the inner layers of a printed board made using pre-preg if the temperature of the printed board measured during the heating test of 5.4.1.4 does not exceed 90 °C.

NOTE Some examples of cemented joints are as follows:

– two non-conductive parts cemented together (for example, two layers of a multilayer board, see Figure O.14) or the split bobbin of a transformer where the centre limb is secured by adhesive (see Figure O.16);

– spirally wrapped insulation on a winding wire, sealed by adhesive insulating compound, is an example of PD1; or

– the joint between a non-conductive part (the casing) and the insulating compound itself in an optocoupler (see Figure O.15).

5.4.4.6 Thin sheet material

5.4.4.6.1 General requirements

There is no dimensional or constructional requirement for insulation in thin sheet material used as **basic insulation**.

NOTE An instrument to carry out the electric strength test on thin sheets of insulating material is described in Figure 29.

Insulation in thin sheet materials may be used for **supplementary insulation** and **reinforced insulation**, irrespective of the distance through insulation, provided that:

– two or more layers are used; and

– the insulation is within the equipment **enclosure**; and

– the insulation is not subject to handling or abrasion during **ordinary person** or **instructed person** servicing; and

– the requirements and tests of 5.4.4.6.2 (for separable layers) or 5.4.4.6.3 (for non-separable layers) are met.

The two or more layers are not required to be fixed to the same conductive part. The two or more layers can be:

– fixed to one of the conductive parts requiring separation; or

– shared between the two conductive parts; or

– not fixed to either conductive part.

For insulation in three or more layers of non-separable thin sheet materials:

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– minimum distances through insulation are not required; and
– each layer of insulation does not have to be of the same material.

5.4.4.6.2 Separable thin sheet material

In addition to the requirements of 5.4.4.6.1, for:

– **supplementary insulation** consisting of two layers of material, each layer shall pass the electric strength test for **supplementary insulation**; or
– **supplementary insulation** consisting of three layers of material, any combination of two layers shall pass the electric strength test for **supplementary insulation**; or
– **reinforced insulation** consisting of two layers of material, each layer shall pass the electric strength test for **reinforced insulation**; or
– **reinforced insulation** consisting of three layers of material, any combination of two layers shall pass the electric strength test for **reinforced insulation**.

If more than three layers are used, layers may be divided into two or three groups of layers. Each group of layers shall pass the electric strength test for the appropriate insulation.

A test on a layer or group of layers is not repeated on an identical layer or group.

There is no requirement for all layers of insulation to be of the same material and thickness.

5.4.4.6.3 Non-separable thin sheet material

For insulation consisting of non-separable thin sheet materials, in addition to the requirements of 5.4.4.6.1, the test procedures in Table 19 are applied. There is no requirement for all layers of insulation to be of the same material and thickness.

Compliance is checked by inspection and by the tests specified in Table 19.

Table 19 – Tests for insulation in non-separable layers

Number of layers	Test procedure
Supplementary insulation	
Two or more layers:	The test procedure of 5.4.4.6.4 is applied
Reinforced insulation	
Two layers:	The test procedure of 5.4.4.6.4 is applied
Three or more layers:	The test procedures of 5.4.4.6.4 and 5.4.4.6.5 [a] are applied
NOTE The purpose of the tests in 5.4.4.6.5 is to ensure that the material has adequate strength to resist damage when hidden in inner layers of insulation. Therefore, the tests are not applied to insulation in two layers. The tests in 5.4.4.6.5 are not applied to **supplementary insulation**.	
[a] Where the insulation is integral to winding wire, the test does not apply.	

5.4.4.6.4 Standard test procedure for non-separable thin sheet material

For non-separable layers, electric strength tests are applied in accordance with 5.4.9.1 to all layers together. The test voltage is:

– *200 % of* U_{test} *if two layers are used; or*
– *150 % of* U_{test} *if three or more layers are used,*

where U_{test} *is the test voltage specified in 5.4.9.1 for* ***supplementary insulation*** *or* ***reinforced insulation*** *as appropriate.*

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NOTE Unless all the layers are of the same material and have the same thickness, there is a possibility that the test voltage will be divided unequally between layers, causing breakdown of a layer that would have passed if tested separately.

5.4.4.6.5 Mandrel test

*The test requirements for **reinforced insulation** made of three or more thin insulating sheets of material that are inseparable are specified below.*

NOTE This test is based on IEC 61558-1 and will give the same results.

*Three test samples, each individual sample consisting of three or more layers of non-separable thin sheet material forming **reinforced insulation**, are used. One sample is fixed to the mandrel of the test fixture given in Figure 25. The fixing shall be performed as shown in Figure 26.*

Dimensions in millimetres

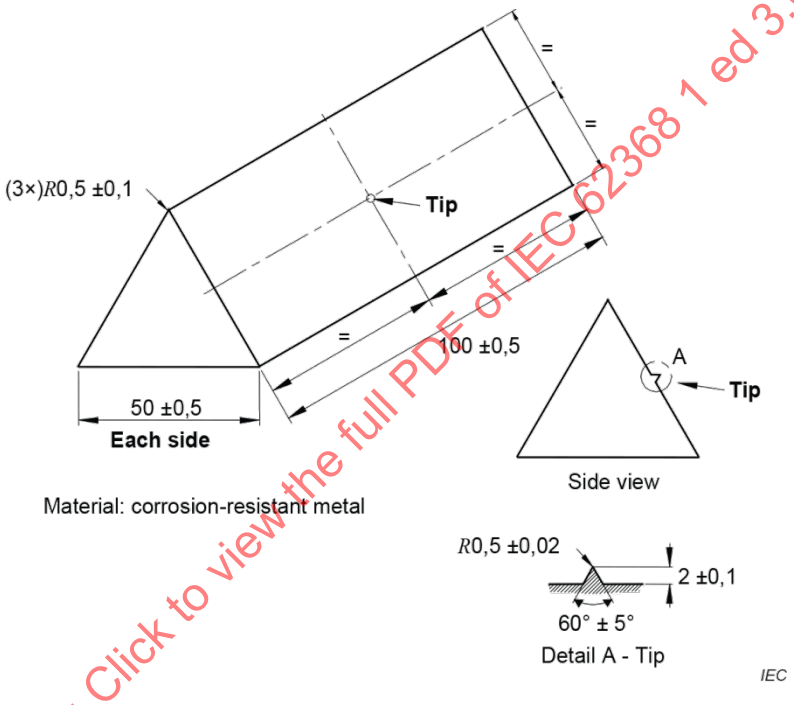


Figure 25 – Mandrel

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Dimensions in millimetres

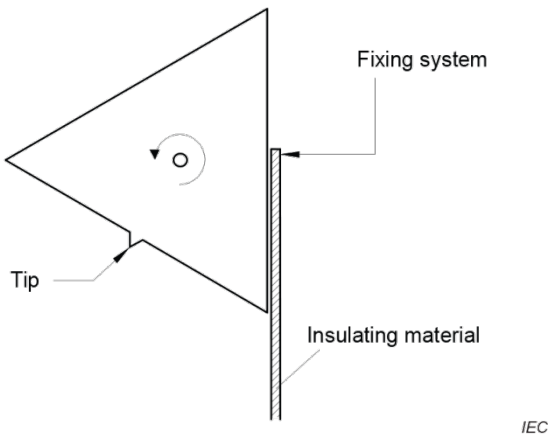
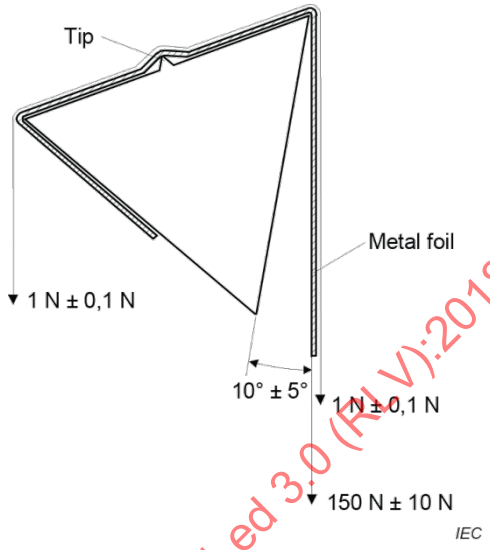


Figure 26 – Initial position of mandrel



The final position of the mandrel is rotated 230° ± 5° from the initial position.

Figure 27 – Final position of mandrel

A pull is applied to the free end of the sample, using an appropriate clamping device. The mandrel is rotated:

- *from the initial position (Figure 26) to the final position (Figure 27) and back;*
- *a second time from the initial position to the final position.*

If a sample breaks during rotation where it is fixed to the mandrel or to the clamping device, this does not constitute a failure. If a sample breaks at any other place, the test has failed.

After the above test, a sheet of metal foil, 0,035 mm ± 0,005 mm thick, at least 200 mm long, is placed along the surface of the sample, hanging down on each side of the mandrel (see Figure 27). The surface of the foil in contact with the sample shall be conductive, not oxidized or otherwise insulated. The foil is positioned so that its edges are not less than ~~20~~ 18 mm from the edges of the sample (see Figure 28). The foil is then tightened by two equal weights, one at each end, using appropriate clamping devices.

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Dimensions in millimetres

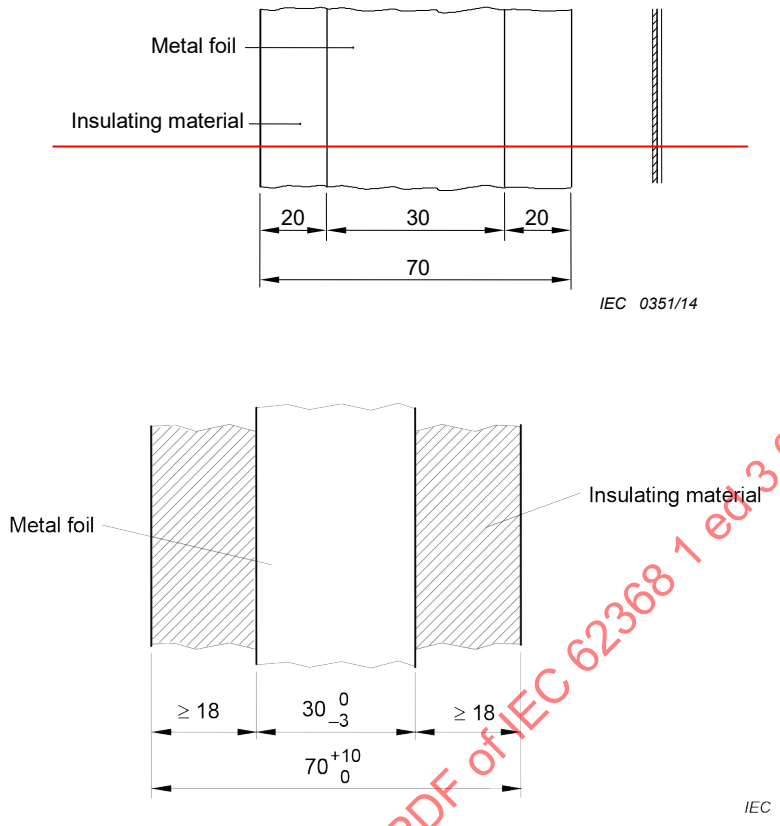


Figure 28 – Position of metal foil on insulating material

*While the mandrel is in its final position, and within the 60 s following the final positioning, an electric strength test is applied between the mandrel and the metal foil in accordance with 5.4.9.1. The test voltage is 150 % of U_{test}, but not less than 5 kV RMS, U_{test} is the test voltage specified in 5.4.9.1 for **reinforced insulation** as appropriate.*

The test is repeated on the other two samples.

5.4.4.7 Solid insulation in wound components

Basic insulation, **supplementary insulation** or **reinforced insulation** in a wound component may be provided by:

– the insulation on wound components (see Clause G.5); or

– the insulation on other wire (see Clause G.6); or

– a combination of the two.

Wound components containing cemented joints shall also comply with 5.4.4.5.

Planar transformers shall comply with the requirements of Clause G.13.

5.4.4.8 Compliance criteria

Compliance with the requirements of 5.4.4.2 to 5.4.4.7 for the adequacy of solid insulation is checked by inspection and measurement, taking into account Annex O, by the electric strength tests of 5.4.9.1 and the additional tests required in 5.4.4.2 to 5.4.4.7, as applicable.

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5.4.4.9 Solid insulation requirements at frequencies higher than 30 kHz

The suitability of the **solid insulation** shall be determined as follows:

– Determine the value of the breakdown electric field strength of the insulation material at **mains** power frequency E_P in kV/mm (RMS) for the insulating material. ~~See Table 21 for examples of commonly used materials at **mains** power frequency.~~ One of the following methods shall be used to determine the value of E_P:

- the value declared by the manufacturer based on material manufacturer's data; or
- the value from Table 20; or
- the value based on the test specified in IEC 60243-1.

The manufacturer is responsible for determining the value.

– Determine the reduction factor K_R for the breakdown electric field strength of the insulating material at the applicable frequency from Table 21 or Table 22. If the material is not one listed in Table 21 or Table 22, use the average reduction factor in the last row of Table 21 or Table 22 as applicable.

– Determine the value of the breakdown electric field strength at the applicable frequency E_F by multiplying the value E_P with the reduction factor K_R.

$$E_F = E_P \times K_R$$

– Determine the actual electric strength V_W of the insulating material by multiplying the value E_F with the total thickness (d in mm) of the insulating material.

$$V_W = E_F \times d$$

– For **basic insulation** or **supplementary insulation**, V_W shall exceed the measured high frequency **peak** of the **working voltage** V_{PW} by 20 %.

~~$V_W > 1{,}2 \times V_{PW}$~~

$$V_W > 1{,}2 \times V_{PW} / 1{,}41$$

– For **reinforced insulation**, V_W shall exceed twice the measured high frequency peak **of the working voltage** V_{PW} by 20 %.

~~$V_W > 1{,}2 \times 2 \times V_{PW}$~~

$$V_W > 1{,}2 \times 2 \times V_{PW} / 1{,}41$$

~~As an alternative to the above,~~

~~– the electric strength test of 5.4.9.1 may be applied under the following conditions:~~

- ~~the field strength is approximately uniform; and~~
- ~~no voids or air gaps are present in the **solid insulation**; or~~

~~– the insulation may be subjected to the high-frequency breakdown test according to 7.4 of IEC 60664-4:2005 with the test potential at the frequency of the actual measured **working voltage**.~~

~~NOTE In this context, the electric field is considered to be approximately uniform if the deviations are less than 20 % from the average value of the field strength.~~

As an alternative to the above, the electric strength test according to 5.4.9.1 may be applied except that the **mains** frequency test voltage shall be as follows:

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– for **basic insulation**: $1{,}2 \times V_{PW} / K_R$

– for **reinforced insulation**: $1{,}2 \times 2 \times V_{PW} / K_R$

There shall be no breakdown.

Table 20 – Electric field strength E_P for some commonly used materials

Material	Breakdown electric field strength E_P kV/mm				
	Thickness of the material mm				
	0,75	**0,08**	**0,06**	**0,05**	**0,03**
Porcelain [a]	9,2	-	-	-	-
Silicon-glass [a]	14	-	-	-	-
Phenolic [a]	17	-	-	-	-
Ceramic [a]	19	-	-	-	-
Teflon® [a] [1]	27	-	-	-	-
Melamine-glass [a]	27	-	-	-	-
Mica [a]	29	-	-	-	-
Paper phenolic [a]	38	-	-	-	-
Polyethylene [b]	49	-	-	52	-
Polystyrene [c]	55	65	-	-	-
Glass [a]	60	-	-	-	-
Kapton® [a] [2]	303	-	-	-	-
FR530L [a]	33	-	-	-	-
Mica-filled phenolic [a]	28	-	-	-	-
Glass-silicone laminate [a]	18	-	-	-	-
Cellulose-acetobutyrate [d]	-	-	120	-	210
Polycarbonate [d]	-	-	160	-	270
Cellulose-triacetate [d]	-	-	120	-	210

NOTE Missing values in the above and the values for other materials not in the list are under investigation.

[a] For the breakdown electric field strength of the specified materials, the EP value of 0,75 mm thickness may be used for all thicknesses.

[b] The EP value of 0,05 mm thickness is used for the insulation equal to or thinner than 0,05 mm. The EP value of 0,75 mm thickness is used otherwise.

[c] The EP value of 0,08 mm thickness is used for the insulation equal to or thinner than 0,08 mm. The EP value of 0,75 mm thickness is used otherwise.

[d] The EP value of 0,03 mm thickness is used for the insulation equal to or thinner than 0,03 mm. The EP value of 0,06 mm thickness is used for the insulation equal to or thinner than 0,06 mm and greater than 0,03 mm.

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1 Teflon® is the trademark of a product supplied by DuPont. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

2 Kapton® is the trademark of a product supplied by DuPont. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

Table 21 – Reduction factors for the value of breakdown electric field strength E_P at higher frequencies

Material [a]	Frequency kHz										
	30	100	200	300	400	500	1 000	2 000	3 000	5 000	10 000
	Reduction factor K_R										
Porcelain	0,52	0,42	0,40	0,39	0,38	0,37	0,36	0,35	0,35	0,34	0,30
Silicon-glass	0,79	0,65	0,57	0,53	0,49	0,46	0,39	0,33	0,31	0,29	0,26
Phenolic	0,82	0,71	0,53	0,42	0,36	0,34	0,24	0,16	0,14	0,13	0,12
Ceramic	0,78	0,64	0,62	0,56	0,54	0,51	0,46	0,42	0,37	0,35	0,29
Teflon®	0,57	0,54	0,52	0,51	0,48	0,46	0,45	0,44	0,41	0,37	0,22
Melamine-glass	0,48	0,41	0,31	0,27	0,24	0,22	0,16	0,12	0,10	0,09	0,06
Mica	0,69	0,55	0,48	0,45	0,41	0,38	0,34	0,28	0,26	0,24	0,20
Paper phenolic	0,58	0,47	0,40	0,32	0,26	0,23	0,16	0,11	0,08	0,06	0,05
Polyethylene	0,36	0,28	0,22	0,21	0,20	0,19	0,16	0,13	0,12	0,12	0,11
Polystyrene	0,35	0,22	0,15	0,13	0,13	0,11	0,08	0,06	0,06	0,06	0,06
Glass	0,37	0,21	0,15	0,13	0,11	0,10	0,08	0,06	0,05	0,05	0,04
Other materials	0,43	0,35	0,30	0,27	0,25	0,24	0,20	0,17	0,16	0,14	0,12
If the frequency lies between the values in any two columns, the reduction factor value in the next column shall be used or a logarithmic interpolation may be used between any two adjacent columns with the calculated value rounded down to the nearest 0,01 value.											
[a] This data is for materials that are 0,75 mm thick.											

Table 22 – Reduction factors for the value of breakdown electric field strength E_P at higher frequencies for thin materials

Thin material	Frequency kHz										
	30	100	200	300	400	500	1 000	2 000	3 000	5 000	10 000
	Reduction factor K_R										
Cellulose-acetobutyrate (0,03 mm)	0,67	0,43	0,32	0,27	0,24	0,20	0,15	0,11	0,09	0,07	0,06
Cellulose-acetobutyrate (0,06 mm)	0,69	0,49	0,36	0,30	0,26	0,23	0,17	0,13	0,11	0,08	0,06
Polycarbonate (0,03 mm)	0,61	0,39	0,31	0,25	0,23	0,20	0,14	0,10	0,08	0,06	0,05
Polycarbonate (0,06 mm)	0,70	0,49	0,39	0,33	0,28	0,25	0,19	0,13	0,11	0,08	0,06
Cellulose-triacetate (0,03 mm)	0,67	0,43	0,31	0,26	0,23	0,20	0,14	0,10	0,09	0,07	0,06
Cellulose-triacetate (0,06 mm)	0,72	0,50	0,36	0,31	0,27	0,23	0,17	0,13	0,10	0,10	0,06
Other thin foil materials	0,68	0,46	0,34	0,29	0,25	0,22	0,16	0,12	0,10	0,08	0,06
If the frequency lies between the values in any two columns, the reduction factor value in the next column shall be used or a logarithmic interpolation may be used between any two adjacent columns with the calculated value rounded down to the nearest 0,01 value.											

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5.4.5 Antenna terminal insulation

5.4.5.1 General

The insulation

~~– between antenna terminals and the **mains**, and~~

~~– between antenna terminals and ES1 circuits or ES2 circuits~~

~~• isolated from the antenna circuits, and~~

~~• having terminals for connection to **external circuits**.~~

– between **mains** and antenna terminals; and

– between **mains** and **external circuits** providing non-**mains** supply voltages to other equipment having antenna terminals

shall withstand electrostatic discharges at the antenna terminals.

This test does not apply to equipment where one antenna terminal on the equipment is connected to earth in accordance with 5.6.7.

NOTE In China, connection of the CATV to the main **protective earthing** terminal of equipment is not permitted.

~~If a **mains**-connected equipment provides non-**mains** supply voltages to other equipment having antenna terminals, the test shall apply between **mains** terminals and the non-**mains** supply voltage terminals.~~

5.4.5.2 Test method

~~*The insulation shall be conditioned as described in G.10.3.1 and tested as described in G.10.3.2. The equipment shall be placed on an insulating surface. The impulse test generator output shall be connected to the antenna terminals connected together and to the **mains** terminals connected together. The equipment is not energized during this test.*~~

~~*If the equipment has ES1 circuits or ES2 circuits that are isolated from the antenna circuits and that have terminals for connection to **external circuits**, the test is repeated with the generator connected to the antenna terminals connected together and the **external circuit** terminals connected together.*~~

*The sample is subjected to 50 discharges from the antenna interface test generator (circuit 3) of Clause D.2, at not more than 12 discharges per minute, with U_c equal to 10 kV. The equipment shall be placed on an insulating surface. The antenna interface test generator output shall be connected to the antenna terminals connected together and to the mains terminals connected together. If the equipment has external circuits providing non-mains supply voltages to other equipment having antenna terminals, the test is repeated with the generator connected to the mains terminals connected together and the **external circuit** terminals connected together. The equipment is not energized during these tests.*

NOTE Test personnel are cautioned not to touch the equipment during this test.

5.4.5.3 Compliance criteria

Compliance is checked by measuring the insulation resistance with 500 V DC.

The equipment complies with the requirement if the insulation resistance measured after 1 min is not less than the values given in Table 23.

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Table 23 – Values for insulation resistance

Insulation requirements between parts	Insulation resistance MΩ
Between parts separated by **basic insulation** or by **supplementary insulation**	2
Between parts separated by **double insulation** or **reinforced insulation**	4

*As an alternative to the above, compliance may be checked by an electric strength test in accordance with 5.4.9.1 for **basic insulation** or **reinforced insulation** as applicable. The test voltage shall be the highest of the test voltages determined by methods 1, 2 and 3. There shall be no insulation breakdown.*

5.4.6 Insulation of internal wire as a part of a supplementary safeguard

The requirements of this subclause apply where the insulation of an internal wire, alone, meets the requirements for **basic insulation**, but does not meet the requirements for **supplementary insulation**.

Where wire insulation is used as part of a **supplementary insulation** system and the wire insulation is **accessible** to an **ordinary person**:

– the wire insulation does not need to be handled by the **ordinary person**; and

– the wire is placed such that the **ordinary person** is unlikely to pull on it, or the wire shall be so fixed that the connecting points are relieved from strain; and

– the wire is routed and fixed such as not to touch unearthed **accessible** conductive parts; and

– the wire insulation passes the electric strength test of 5.4.9.1 for **supplementary insulation**; and

– the distance through the wire insulation shall be at least as given in Table 24.

Table 24 – Distance through insulation of internal wiring

Working voltage in case of failure of basic insulation		Minimum distance through insulation
V peak or DC	V RMS (sinusoidal)	mm
> 71 ≤ 350	> 50 ≤ 250	0,17
> 350	> 250	0,31

Compliance is checked by inspection and measurement, and by the test of 5.4.9.1.

5.4.7 Tests for semiconductor components and for cemented joints

Three samples are subjected to the thermal cycling sequence of 5.4.1.5.3. Before testing a cemented joint, any winding of ~~solvent-based~~ enamelled wire used in the component is replaced by metal foil or by a few turns of bare wire, placed close to the cemented joint.

The three samples are then tested as follows:

– *one of the samples is subjected to the electric strength test of 5.4.9.1, immediately after the last period at (T_1 ± 2) °C during thermal cycling, except that the test voltage is multiplied by 1,6; and*

– *the other samples are subjected to the relevant electric strength test of 5.4.9.1 after the humidity conditioning of 5.4.8, except that the test voltage is multiplied by 1,6.*

Compliance is checked by test and the following inspections:

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Except for cemented joints on the same inner surface of a printed board, compliance is checked by inspection of the cross-sectional area, and there shall be no visible voids, gaps or cracks in the insulating material.

In the case of insulation between conductors on the same inner surface of printed boards and the insulation between conductors on different surfaces of multilayer boards, compliance is checked by external visual inspection. There shall be no delamination.

5.4.8 Humidity conditioning

Humidity conditioning is carried out for 48 h in a cabinet or room containing air with a relative humidity of (93 ± 3) %. The temperature of the air, at all places where samples can be located, is maintained within ± 2 °C of any value T between 20 °C and 30 °C so that condensation does not occur. During this conditioning, the component or subassembly is not energized.

For tropical conditions the time duration shall be 120 h at a temperature of (40 ± 2) °C and a relative humidity of (93 ± 3) %.

Before the humidity conditioning, the sample is brought to a temperature between the specified temperature T and (T + 4) °C.

5.4.9 Electric strength test

5.4.9.1 Test procedure for type testing of solid insulation

Unless otherwise specified, compliance is checked either:

- *immediately following the temperature test in 5.4.1.4; or*
- *if a component or subassembly is tested separately outside the equipment, it is brought to the temperature attained by that part during the temperature test in 5.4.1.4 (for example, by placing it in an oven) prior to performing the electric strength test.*

*Alternatively, thin sheet material for **supplementary insulation** or **reinforced insulation** may be tested at room temperature.*

*Unless otherwise specified, the test voltage for the electric strength of **basic insulation**, **supplementary insulation** or **reinforced insulation** is the highest value of the following three methods:*

- *Method 1: Determine the test voltage according to Table 25 using the **required withstand voltage** (based on transient voltages from the AC **mains** or DC **mains** or from **external circuits**).*
- *Method 2: Determine the test voltage according to Table 26 using the peak of the **working voltage** or the recurring peak voltages, whichever is higher.*
- *Method 3: Determine the test voltage according to Table 27 using the nominal AC **mains** voltage (to cover **temporary overvoltages**).*

The insulation is subjected to the highest test voltage as follows:

- *by applying an AC voltage of substantially sine-wave form having a frequency of 50 Hz or 60 Hz; or*
- *by applying a **DC voltage** ~~in one polarity~~ for the time specified below ~~and then repeat it in reverse polarity~~.*

*The voltage applied to the insulation under test is gradually raised from zero to the prescribed voltage and maintained at that value for 60 s (for **routine tests** see 5.4.9.2).*

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~~Insulation coatings are~~ Where necessary, the insulation is tested with a metal foil in contact with the insulating surface. This procedure is limited to places where the insulation is likely to be weak (for example, where there are sharp metal edges under the insulation). If practicable, insulating linings are tested separately. Care is taken that the metal foil is so placed that no flashover occurs at the edges of the insulation. Where adhesive metal foil is used, the adhesive shall be conductive.

To avoid damage to components or insulations that are not involved in the test, ICs or the like, may be disconnected and equipotential bonding may be used. A varistor complying with Clause G.8 may be removed during the test.

*For equipment incorporating **basic insulation** and **supplementary insulation** in parallel with **reinforced insulation**, care is taken that the voltage applied to the **reinforced insulation** does not overstress **basic insulation** or **supplementary insulation**.*

Where capacitors are in parallel with the insulation under test (for example, radio-frequency filter capacitors) and the capacitors can affect the test results, DC test voltages shall be used.

Components providing a DC path in parallel with the insulation to be tested, such as discharge resistors for filter capacitors and voltage limiting devices, may be disconnected.

Where insulation of a transformer winding varies along the length of the winding in accordance with 5.4.1.6, an electric strength test method is used that stresses the insulation accordingly.

EXAMPLE Such a test method may be an induced voltage test that is applied at a frequency sufficiently high to avoid saturation of the transformer. The input voltage is raised to a value that would induce an output voltage equal to the required test voltage.

Table 25 – Test voltages for electric strength tests based on transient voltages

Required withstand voltage up to and including	**Test voltage for basic insulation or supplementary insulation**	**Test voltage for reinforced insulation**
kV peak	kV peak or DC	
0,33	0,33	0,5
0,5	0,5	0,8
0,8	0,8	1,5
1,5	1,5	2,5
2,5	2,5	4
4	4	6
6	6	8
8	8	12
12	12	18
U_R [a]	U_R [a]	1,5 × U_R [a]
Linear interpolation may be used between the nearest two points.		
[a] U_R is any **required withstand voltage** higher than 12 kV.		

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Table 26 – Test voltages for electric strength tests based on the peak of the working voltages and recurring peak voltages

~~Peak working~~ Voltage up to and including	Test voltage for basic insulation or supplementary insulation	Test voltage for reinforced insulation
kV peak	kV peak or DC	
0,33	0,43	0,53
0,5	0,65	0,8
0,8	1,04	1,28
1,5	1,95	2,4
2,5	3,25	4
4	5,2	6,4
6	7,8	9,6
8	10,4	12,8
12	15,6	19,2
U_P [a]	1,3 × U_P [a]	1,6 × U_P [a]
Linear interpolation may be used between the nearest two points.		
[a] U_P is any ~~peak working~~ voltage higher than 12 kV.		

Table 27 – Test voltages for electric strength tests based on temporary overvoltages

Nominal mains system voltage	Test voltage for basic insulation or supplementary insulation	Test voltage for reinforced insulation
V RMS	kV peak or DC	
Up to and including 250	2	4
Over 250 up to and including 600	2,5	5

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Dimensions in millimetres

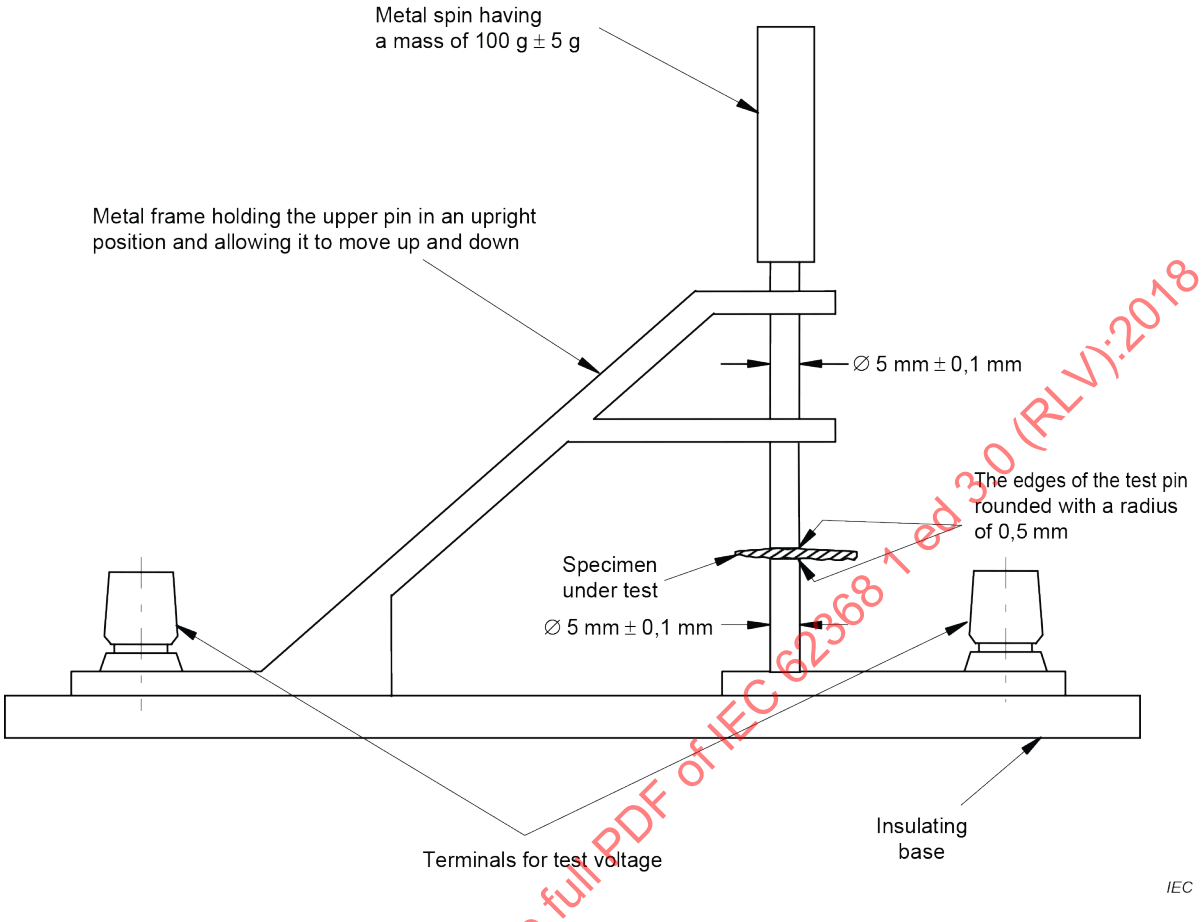


Figure 29 – Example of electric strength test instrument for solid insulation

NOTE Thin sheet insulation can be tested using the instrument of Figure 29. When applying the test fixture, ensure that the specimen sample diameter is of sufficient size to prevent breakdown around the edges.

There shall be no insulation breakdown during the test. Insulation breakdown is considered to have occurred when the current that flows as a result of the application of the test voltage, rapidly increases in an uncontrolled manner, that is, the insulation does not restrict the flow of the current. Corona discharge or a single momentary flashover is not regarded as insulation breakdown.

5.4.9.2 Test procedure for routine tests

Where required, ***routine tests*** *are performed according to 5.4.9.1, except for the following:*

– *the test may be performed at room temperature; and*

– *the duration of the electric strength test shall be between 1 s to 4 s; and*

– *the test voltage may be reduced by 10 %.*

NOTE ~~The above test conditions are also applicable to **routine tests** in production of the equipment or subassemblies.~~ **Routine testing** for equipment is specified in IEC 62911.

There shall be no insulation breakdown during the test. Insulation breakdown is considered to have occurred when the current that flows as a result of the application of the test voltage, rapidly increases in an uncontrolled manner, that is, the insulation does not restrict the flow of the current. Corona discharge or a single momentary flashover is not regarded as insulation breakdown.

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5.4.10 Safeguards against transient voltages from external circuits

5.4.10.1 Requirements

Adequate electrical separation shall be provided between the circuitry intended to be connected to **external circuits** ~~of equipment~~ as indicated in Table 13, ID number 1, Figure 30 and:

a) non-conductive parts and unearthed conductive parts of the equipment expected to be held or otherwise maintained in continuous contact with the body during normal use (for example, a telephone handset or head set or the palm rest surface of a laptop or notebook computer);

b) **accessible** parts and circuitry, except for the pins of connectors. However, such pins shall not be **accessible** under **normal operating conditions** by the blunt probe of Figure V.3;

c) another ES1 or ES2 part separated from the circuitry intended to be connected to an **external circuit**. The requirement for separation applies whether or not the ES1 or ES2 part is **accessible**.

These requirements do not apply where circuit analysis and equipment investigation indicate that adequate protection is assured by other means (for example, between two circuits each of which has a permanent connection to protective earth).

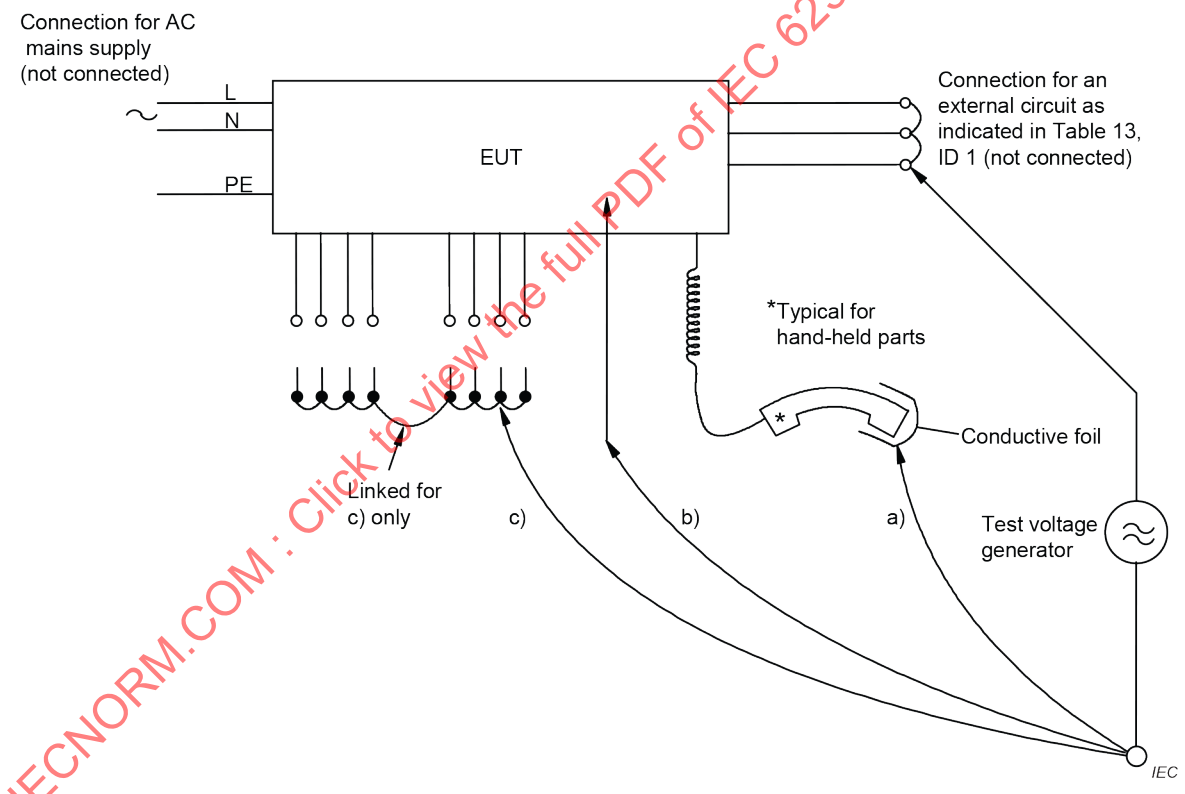


Figure 30 – Application points of test voltage

5.4.10.2 Test methods

5.4.10.2.1 General

The separation is checked by the test of either 5.4.10.2.2 or 5.4.10.2.3.

NOTE In Australia, the tests of both 5.4.10.2.2 and 5.4.10.2.3 apply.

During the test:

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– *all conductors intended to be connected to the **external circuit** are connected together, including any conductors that may be connected to earth in the **external circuit**; and*

– *all conductors intended to be connected to other **external circuits** are also connected together.*

Table 28 – Test values for electric strength tests

Parts	Impulse test (see Annex D)		Steady state test
	U_c	Test generator	
Parts indicated in 5.4.10.1 a) [a]	2,5 kV ~~10/700 µs~~	circuit 1	1,5 kV
Parts indicated in 5.4.10.1 b) and c) [b]	1,5 kV ~~10/700 µs~~ [c]	circuit 1 [c]	1,0 kV

[a] Surge suppressors shall not be removed.

[b] Surge suppressors may be removed, provided that such devices pass the impulse test of 5.4.10.2.2 when tested as components outside the equipment.

[c] During this test, it is allowed for a surge suppressor to operate and for a sparkover to occur in a GDT.

5.4.10.2.2 Impulse test

The electrical separation is subjected to ten impulses of alternating polarity as given in Table 28. The interval between successive impulses is 60 s ~~with a voltage as given in Table 29~~. U_c is the value to which the capacitor needs to be charged.

NOTE In Australia, a value of U_c = 7,0 kV is used for hand-held telephones and for headsets and 2,5 kV for other equipment in 5.4.10.1 a). The 7 kV impulse simulates lightning surges on typical rural and semi-rural network lines.

5.4.10.2.3 Steady state test

The electrical separation is subjected to an electric strength test according to 5.4.9.1, with a voltage as given in Table 28.

NOTE In Australia, the steady state test voltage is 3 kV for 5.4.10.1 a), and 1,5 kV for 5.4.10.1 b) and c). These values have been determined considering the low frequency induced voltages from the power supply distribution system.

5.4.10.3 Compliance criteria

During the tests of 5.4.10.2.2 and 5.4.10.2.3:

– *there shall be no insulation breakdown; and*

– *except as indicated in Table 28, footnote ~~b~~ [c], a surge suppressor shall not operate, or a sparkover shall not occur within a GDT.*

For the electric strength test, insulation breakdown is considered to have occurred when the current that flows as a result of the application of the test voltage rapidly increases in an uncontrolled manner.

For the impulse tests, insulation breakdown is verified in one of the following two ways:

– *during the application of the impulses, by observation of oscillograms, surge suppressor operation or breakdown through insulation is judged from the shape of an oscillogram;*

– *after application of all the impulses, by an insulation resistance test. Disconnection of surge suppressors is permitted while insulation resistance is being measured. The test voltage is 500 V DC or, if surge suppressors are left in place, a DC test voltage that is 10 % less than the surge suppressor operating or striking voltage. The insulation resistance shall not be less than 2 MΩ.*

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5.4.11 Separation between external circuits and earth

5.4.11.1 General

These requirements apply only to equipment intended to be connected to **external circuits** indicated in Table 13, ID number~~s~~ 1 ~~and 2~~.

These requirements do not apply to:

– **permanently connected equipment**; or

– **pluggable equipment type B**; or

– **stationary pluggable equipment type A**, that is intended to be used in a location having equipotential bonding (such as a telecommunication centre, a dedicated computer room or a **restricted access area**) and has installation instructions that require verification of the **protective earthing** connection of the socket-outlet by a **skilled person**; or

– **stationary pluggable equipment type A**, that has provision for a permanently connected **protective earthing conductor**, including instructions for the installation of that conductor to building earth by a **skilled person**.

5.4.11.2 Requirements

There shall be separation between circuitry intended to be connected to **external circuits** mentioned above and any parts or circuitry that will be earthed in some applications, either within the EUT or via other equipment.

SPDs that bridge the separation between ES1 or ES2 circuitry intended to be connected to **external circuits** and earth shall have a minimum rated operating voltage U_{op} (for example, the sparkover voltage of a gas discharge tube) of:

$$U_{op} = U_{peak} + \Delta U_{sp} + \Delta U_{sa}$$

where:

U_{peak} is one of the following values:

– for equipment intended to be installed in an area where the nominal voltage of the AC **mains** exceeds 130 V: 360 V;

– for all other equipment: 180 V.

ΔU_{sp} is the ~~maximum increase~~ negative tolerance of the rated operating voltage due to variations in SPD production, obtained by subtracting the minimum rated operating voltage from the nominal rated operating voltage. If this is not specified by the SPD manufacturer, ΔU_{sp} shall be taken as 10 % of the rated operating voltage of the SPD.

ΔU_{sa} is the ~~maximum increase~~ change of the rated operating voltage due to the SPD ageing over the expected life of the equipment, obtained by subtracting the minimum operating voltage after ageing from the rated operating voltage. If this is not specified by the SPD manufacturer, ΔU_{sa} shall be taken as 10 % of the rated operating voltage of the SPD.

($\Delta U_{sp} + \Delta U_{sa}$) may be a single value provided by the component manufacturer.

5.4.11.3 Test method and compliance criteria

*Compliance is checked by inspection and by the electric strength test of 5.4.9.1 with a test voltage according to Table 25 for **basic insulation** or **supplementary insulation** based on the **required withstand voltage** for the **mains** voltage of the equipment.*

Components, other than capacitors, that bridge the separation, may be removed during electric strength testing. Components that are left in place during the test shall not be damaged.

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If components are removed, the following additional test with a test circuit according to Figure 31 is performed with all components in place.

*For equipment powered from AC **mains**, the test is performed with a voltage equal to the **rated voltage** of the equipment or to the upper voltage of the **rated voltage range**. For equipment powered from DC **mains**, the test is performed with a voltage equal to the highest nominal voltage of the AC **mains** in the region where the equipment is to be used (for example, 230 V for Europe or 120 V for North America).*

The current flowing in the test circuit of Figure 31 shall not exceed 10 mA.

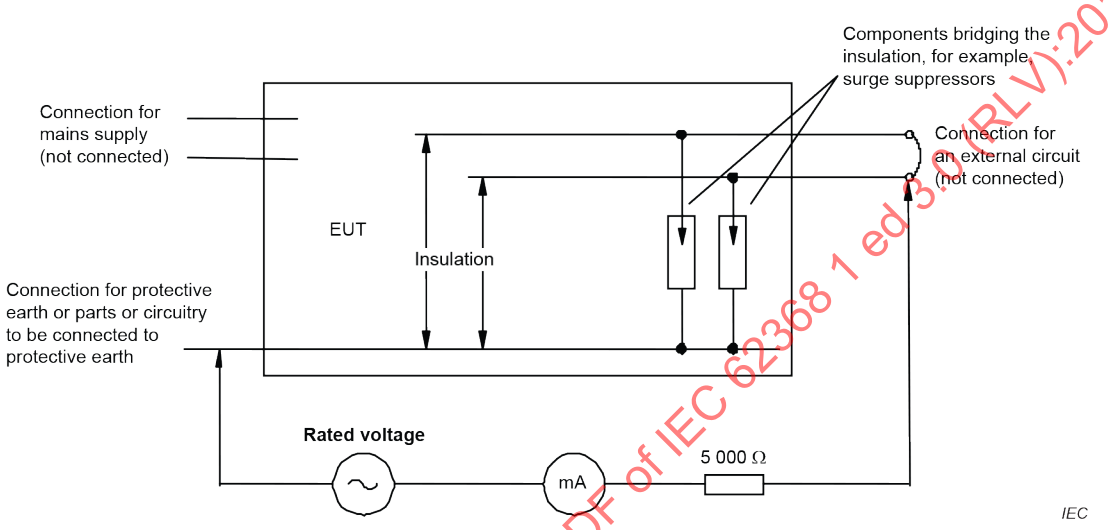


Figure 31 – Test for separation between an external circuit and earth

5.4.12 Insulating liquid

5.4.12.1 General requirements

An **insulating liquid** shall not break down due to overvoltages, including transients, that enter the equipment, and peak voltages that may be generated within the equipment.

The **insulating liquid** shall comply with 5.4.12.2 and 5.4.12.3. The container for the **insulating liquid** shall comply with 5.4.12.4.

5.4.12.2 Electric strength of an insulating liquid

The electric strength of the **insulating liquid** shall comply with the electric strength test in 5.4.9 with the **insulating liquid** in the equipment.

5.4.12.3 Compatibility of an insulating liquid

The **insulating liquid** shall not react with or otherwise deteriorate **safeguards**, such as:

– **solid insulation;** or

– the **insulating liquid** itself.

*For **insulating liquids** with a thermal classification of IEC 60085 Class 105 (A), compliance is checked by operating the immersed equipment for 60 days followed by an electric strength test in accordance with 5.4.9. There shall be no breakdown and there shall be no visible damage or deformation of the other immersed **equipment safeguards**.*

For higher thermal classes the requirements of 5.4.1.4.3 are applicable.

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5.4.12.4 Container for insulating liquid

The container for the **insulating liquid** shall be provided with a means of pressure relief if there is a closed vessel.

The **insulating liquid** container shall comply with G.15.2.1 for a closed vessel.

For an **insulating liquid** that is also considered to be a **hazardous substance**, the container shall also comply with the requirements of 7.2.

Compliance is checked by the relevant tests.

5.5 Components as safeguards

5.5.1 General

A component is considered a **safeguard** if the classification of the energy source changes due to a failure of the component.

A component used as a **safeguard** shall:

– comply with all the applicable requirements for that **safeguard**; and

– be used within its rating.

NOTE See Annex G for the qualification of components used as a **safeguard**.

5.5.2 Capacitors and RC units

5.5.2.1 General requirements

Capacitors and RC units that serve as (electrical) **safeguards** shall comply with IEC 60384-14. RC units may consist of discrete components.

Capacitors or RC units with one or multiple capacitors shall:

– comply with Clause G.11; however, the requirements of Clause G.11 do not apply to the capacitor and RC unit used as a **basic safeguard** between:

  - ES3 isolated from the **mains** and protective earth; and
  - ES2 and protective earth; and
  - ES2 and ES1;

  and

– pass the electric strength test of 5.4.9.1, taking into account the total **working voltage** across the capacitor(s) and RC unit. Capacitors complying with IEC 60384-14 do not need to be tested if:

  - the required peak impulse test voltage of Table G.12; and
  - the required RMS test voltage of Table G.12 multiplied by 1,414

  are equal to or greater than the required test voltage of 5.4.9.1.

  When multiple capacitors are used, the test voltages of Table G.12 are multiplied by the number of capacitors used.

Under **single fault conditions,** if a capacitor or RC unit consists of more than one capacitor, the voltage on each of the remaining individual capacitors shall not exceed the voltage rating of the relevant individual capacitors.

NOTE In Norway, due to the IT power system used, capacitors are required to be rated for the applicable line-to-line voltage (230 V).

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Class X capacitors may be used as **basic safeguards** in circuits isolated from the **mains** but shall not be used as a:

– **basic safeguard** in circuits connected to the **mains**; or

– **supplementary safeguard**.

Class X capacitors shall not be used as a **reinforced safeguard**.

5.5.2.2 ~~Safeguards against~~ Capacitor discharge after disconnection of a connector

Where a capacitor voltage becomes **accessible** upon disconnection of a connector (for example, the **mains** connector) the **accessible** voltage measured 2 s after disconnection of the connector, shall comply with:

– the ES1 limits of Table 5 under **normal operating conditions** for an **ordinary person**; and

– the ES2 limits of Table 5 under **normal operating conditions** for an **instructed person**; and

– the ES2 limits of Table 5 under **single fault conditions** for both an **ordinary person** and an **instructed person**.

A resistor or a group of resistors used as a **safeguard** against capacitor discharge is not subjected to simulated **single fault conditions** if the resistor or the group of resistors complies with 5.5.6.

If an IC that includes a capacitor discharge function (ICX) is used to comply with the above ~~then under a **single fault condition** of an ICX or of any one component in the associated capacitor discharge circuit~~:

– the **accessible** voltage (for example, at the **mains** connector) shall not exceed the limits given above under a **single fault condition** of an ICX or of any one component in the associated capacitor discharge circuit; or

– the ICX with the associated circuitry as provided in the equipment shall comply with the requirements of Clause G.16. Any impulse attenuating components (such as varistors and GDTs) are disconnected; or

– three samples of the ICX tested separately shall comply with the requirements of Clause G.16.

The measurement is made with an instrument having an input impedance consisting of a resistance of 100 MΩ ± 5 MΩ in parallel with an input capacitance of 25 pF or less.

If a switch (for example, the **mains** switch) has an influence on the test result, it is placed in the most unfavourable position. The disconnection of the connector (start of discharge time) has to be done at the moment when the input ~~capacity~~ capacitor of the device under test is charged to its peak value.

Other methods that give a similar result as the above method may be used.

5.5.3 Transformers

Transformers used as a **safeguard** shall comply with G.5.3.

5.5.4 Optocouplers

Insulation of optocouplers used as a **safeguard** shall comply with the requirements of 5.4 or with Clause G.12.

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5.5.5 Relays

Insulation of relays used as a **safeguard** shall comply with the requirements of 5.4.

5.5.6 Resistors

~~The requirements below apply to resistors:~~

~~– used as a **safeguard**; or~~

~~– that bridge **basic insulation**, **supplementary insulation** or **reinforced insulation**.~~

~~A single resistor or a group of resistors shall comply with **clearance** and **creepage distance** requirements of 5.4.2 and 5.4.3 respectively between its terminations for the total **working voltage** across the insulation (see Figure O.4).~~

~~A single resistor used as a **reinforced safeguard** or bridging a **reinforced insulation** shall comply with G.10.1 and the test of G.10.2.~~

~~NOTE In Finland, Norway and Sweden, resistors used as a **basic safeguard** or for bridging **basic insulation** in **class I pluggable equipment type A** shall comply with G.10.1 and the test of G.10.2.~~

~~For a group of resistors used as a **reinforced safeguard** or for bridging **reinforced insulation** the **clearance** and **creepage distance** are assessed as if each resistor were short-circuited in turn unless the group complies with G.10.1 and the test of G.10.2.~~

The following resistor applications shall comply with the relevant tests as indicated in Table 29:

– a single resistor used as a **reinforced safeguard** or for bridging **reinforced insulation**;

– a resistor or a group of resistors serving as a **safeguard** between a circuit connected to the **mains** and a circuit intended to be connected to coaxial cable;

– resistors serving as a capacitor discharge **safeguard**.

NOTE In Finland, Norway and Sweden, resistors used as a **basic safeguard** or for bridging **basic insulation** in **class I pluggable equipment type A** shall comply with the relevant requirements of Clause G.10.

In addition, resistors that bridge **basic insulation**, **supplementary insulation** or **reinforced insulation** shall comply with each of the following:

– a single resistor or a group of resistors shall comply with **clearance** and **creepage distance** requirements of 5.4.2 and 5.4.3, respectively, between its terminations for the total **working voltage** across the insulation (see Figure O.4);

– for a group of resistors used as a **reinforced safeguard** or for bridging **reinforced insulation**, the **clearance** and **creepage distance** are assessed as if each resistor were short-circuited in turn unless the group complies with the relevant requirements of Clause G.10.

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Table 29 – Overview of tests for resistor applications

Resistor application	Conditioning	Resistor test	Voltage surge test	Impulse test	Overload test
	G.10.2	G.10.3	G.10.4	G.10.5	G.10.6
Reinforced safeguard or bridging **reinforced insulation**	X	X			
Between a **mains** connected circuit and a coaxial cable	X		X [a]	X [b]	
Capacitor discharge **safeguard**	X				X
[a] For an **external circuit** indicated in Table 13, ID 6 and 7.					
[b] For an **external circuit** indicated in Table 13, ID 3, 4 and 5.					

5.5.7 SPDs

~~**5.5.7.1 Use of an SPD connected to reliable earthing**~~

Where a varistor is used between ~~the **mains** and earth~~ a **mains** circuit at ES3 voltage and **protective earthing**:

– the earth connection shall comply with 5.6.7; and

– the varistor shall comply with Clause G.8.

~~**5.5.7.2 Use of an SPD between mains and protective earth**~~

Where a varistor is used between line and neutral or between lines, it shall comply with Clause G.8.

Where an SPD is used between the **mains** and **protective earthing**, it shall consist of a varistor and a GDT connected in series, where the following applies:

– the varistor shall comply with Clause G.8;

– the GDT shall comply with:

- the electric strength test of 5.4.9.1 for **basic insulation**; and
- the external **clearance** and **creepage distance** requirements of 5.4.2 and 5.4.3 respectively for **basic insulation**.

NOTE 1 Some examples of SPDs are MOVs, varistors and GDTs. A varistor is sometimes referred to as a VDR or a metal oxide varistor (MOV).

The above requirements do not apply to SPDs connected to reliable earthing (see 5.6.7).

~~– intended for attenuating transient voltages from **external circuits**; and~~

~~connected to reliable earth (see 5.5.7.1).~~

NOTE 2 It is not a requirement of this document that surge suppressors comply with any particular component standard. However, attention is drawn to the IEC 61643 series of standards, in particular:

– IEC 61643-21 (surge suppressors in telecommunications application)

– IEC 61643-311 (gas discharge tubes)

– IEC 61643-321 (avalanche breakdown diodes)

– IEC 61643-331 (metal oxide varistors)

– IEC 61643-341 (thyristor surge suppressors TSS).

NOTE 3 SPDs between an **external circuit** and earth are not considered to be a **safeguard**. Requirements for those SPDs are covered in 5.4.11.2.

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5.5.8 Insulation between the mains and an external circuit consisting of a coaxial cable

The insulation between the **mains** and the connection to a coaxial cable, including any resistor in parallel with this insulation, shall be able to withstand surges from the **external circuit** and from the **mains**.

This requirement does not apply in any of the following equipment:

– equipment for indoor use provided with a built-in (integral) antenna and not provided with a connection to a coaxial cable; or

– equipment connected to a reliable earthing in accordance with 5.6.7.

The combination of the insulation with the resistor is tested after the conditioning of G.10.2 as follows:

– *for equipment intended to be connected to a coaxial cable connected to an outdoor antenna, the voltage surge test of G.10.4; or*

– *for equipment intended to be connected to another coaxial cable, the impulse test of G.10.5; or*

– *for equipment intended to be connected to both an outdoor antenna and other coaxial connections, the voltage surge test of G.10.4 and the impulse test of G.10.5.*

After the tests:

– *the insulation shall comply with 5.4.5.3 and the resistor may be removed during this test; and*

– *the resistors shall comply with G.10.3, unless available data shows compliance of the resistor.*

5.5.9 Safeguards for socket-outlets in outdoor equipment

A residual current protective device (RCD) with rated residual operating current not exceeding 30 mA shall be used in the **mains** supply to socket-outlets intended for general use.

The RCD shall be an integral part of the **outdoor equipment** or shall be part of the building installation. If the RCD is not an integral part of the equipment, the instructions shall provide the installation requirements for the RCD.

Compliance is checked by inspection.

5.6 Protective conductor

5.6.1 General

Under **normal operating conditions**, a **protective conductor** may serve:

– as a **basic safeguard** to prevent **accessible** conductive parts from exceeding ES1 limits; and

– as a means to limit transient voltages in an earthed circuit.

Under **single fault conditions**, a **protective conductor** may serve as a **supplementary safeguard** to prevent **accessible** conductive parts from exceeding ES2 limits.

5.6.2 Requirements for protective conductors

5.6.2.1 General requirements

Protective conductors shall not contain switches, current limiting devices or overcurrent protective devices.

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The current-carrying capacity of **protective conductors** shall be adequate for the duration of the fault current under **single fault conditions**.

The connections for the **protective conductors** shall make earlier and shall break later than the supply connections in each of the following:

– a connector (on a cable) or a connector attached to a part or a subassembly that can be removed by other than a **skilled person**;

NOTE It is good practice that this construction also be applied when it is expected that the **skilled person** will replace powered parts and assemblies while the equipment is operational.

– a plug on a power supply cord;

– an appliance coupler.

Solder shall not serve as the sole means to provide mechanical securement of a **protective conductor**.

A **protective conductor** termination shall be made such that it is not likely to be loosened during servicing, other than servicing of the actual conductor itself. A single terminal may be used to connect multiple **protective bonding conductors**. A **protective earthing conductor** termination shall not serve as a means to ~~fix~~ secure any ~~other~~ component or part other than a **protective bonding conductor**.

A single wiring terminal of the screw or stud type may be used to secure both the **protective earthing conductor** and the **protective bonding conductor** in equipment having a **non-detachable power supply cord**. In this case, the wiring termination of the **protective earthing conductor** shall be separated by a nut from that of the **protective bonding conductor**. The **protective earthing conductor** shall be on the bottom of the stack, so that it is the last connection disturbed.

5.6.2.2 Colour of insulation

The insulation of the **protective earthing conductor** shall be green-and-yellow.

If a **protective bonding conductor** is insulated, the insulation shall be green-and-yellow except in the following two cases:

– for an earthing braid, the insulation, if provided, may be transparent;

– a **protective bonding conductor** in assemblies such as ribbon cables, bus bars, printed wiring, etc., may be of any colour provided that no misinterpretation of the use of the conductor is likely to arise.

Compliance is checked by inspection.

5.6.3 Requirements for protective earthing conductors

Protective earthing conductors shall comply with the minimum conductor sizes in Table G.7.

NOTE 1 For **permanently connected equipment** provided with terminal(s) for connection to **mains** supply, reference is made to the national building wiring requirements for the size of the **protective earthing conductor**.

NOTE 2 IEC 60364-5-54 can also be used to determine the minimum conductor size.

For cord connected equipment supplied from a DC **mains**, the **protective earthing** connection may be provided by a separate terminal.

A **protective earthing conductor** serving as a **reinforced safeguard** may be used on **pluggable equipment type B** or on **permanently connected equipment** only and shall:

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– be included in and protected by a sheathed supply cord that complies with G.7.1 and which is not lighter than heavy duty as specified in Annex C of IEC 62440:2008; or

~~NOTE 3 Heavy duty is defined in either IEC 60227-1 or IEC 60245-1.~~

– have a minimum conductor size not less than 4 mm^2 if not protected from physical damage; or

– have a minimum conductor size not less than 2,5 mm^2 if protected from physical damage; or

– be protected by a conduit intended to be connected to the equipment and have a minimum size in accordance with Table 30.

NOTE ~~4~~ 3 For **mains** supply cords, see also Clause G.7.

NOTE ~~5~~ 4 A heavy duty cord jacket is considered suitable for protection against physical damage.

Table 30 – Protective earthing conductor sizes for reinforced safeguards for permanently connected equipment

Protection provided by	Minimum protective earthing conductor size mm^2
Non-metallic flexible conduit	4
Metallic flexible conduit	2,5
Non-flexible metal conduit	1,5
The **protective earthing conductor** is intended for installation by a **skilled person**.	

A **protective earthing conductor** serving as a **double safeguard** may be used on **pluggable equipment type B** or on **permanently connected equipment** only and shall consist of two independent **protective earthing conductors**.

*Compliance is checked by inspection and measurement of **protective earthing conductor** sizes in accordance with Table 30 or Table G.7 as applicable.*

5.6.4 Requirements for protective bonding conductors

5.6.4.1 Requirements

Protective bonding conductors of parts required to be earthed for safety purposes shall comply with one of the following:

– the minimum conductor sizes in Table G.7; or

– ~~the requirements of 5.6.6 and,~~ if either the **rated current** of the equipment or the **protective current rating** of the circuit ~~is more than~~ exceeds 25 A, with the minimum conductor sizes in Table 31; or

– ~~the requirements of 5.6.6 and,~~ if both the **rated current** of the equipment ~~or~~ and the **protective current rating** of the circuit do~~es~~ not exceed 25 A; either

  - with the minimum conductor sizes in Table 31; or
  - with the limited short-circuit test of Annex R; or

– for components only, be not smaller than the conductors supplying power to the component.

If the **rated current** of the equipment is not declared by the manufacturer, it is the calculated value of the **rated power** divided by **rated voltage**.

NOTE The value of the **protective current rating** is used in Table 31 and in the test of 5.6.6.2.

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Table 31 – Minimum protective bonding conductor size of copper conductors

Smaller of the rated current of the equipment or the protective current rating of the circuit under consideration A **up to and including**	**Minimum conductor sizes**	
	Cross-sectional area mm^2	**AWG** [cross-sectional area in mm^2]
3	0,3	22 [0,324]
6	0,5	20 [0,519]
10	0,75	18 [0,8]
13	1,0	16 [1,3]
16	1,25	16 [1,3]
25	1,5	14 [2]
32	2,5	12 [3]
40	4,0	10 [5]
63	6,0	8 [8]
80	10	6 [13]
100	16	4 [21]
125	25	2 [33]
160	35	1 [42]
190	50	0 [53]
230	70	000 [85]
260	95	0000 [107]
		kcmil [cross-sectional area in mm^2]
300	120	250 [126]
340	150	300 [152]
400	185	400 [202]
460	240	500 [253]
NOTE AWG and kcmil sizes are provided for information only. The associated cross-sectional areas have been rounded to show significant figures only. AWG refers to the American Wire Gage and the term "cmil" refers to circular mils where one circular mil is equal to (diameter in mils)^2. These terms are commonly used to designate wire sizes in North America.		

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5.6.4.2 Determination of the protective current rating

5.6.4.2.1 Mains supply as the source

Where the source is the **mains** supply, the **protective current rating** of the circuit is the rating of the overcurrent protective device provided in the building installation, or as part of the equipment.

Where the overcurrent protective device is provided in the building installation, then:

– for **pluggable equipment type A**, the **protective current rating** is the rating of an overcurrent protective device provided external to the equipment (for example, in the building wiring, in the **mains** plug or in an equipment rack), with a minimum of 16 A;

NOTE 1 In most countries, 16 A is considered to be suitable as the **protective current rating** of the circuit supplied from the **mains**.

NOTE 2 In Canada and the USA, the **protective current rating** of the circuit supplied from the **mains** is taken as 20 A.

NOTE 3 In the UK and Ireland, the **protective current rating** is taken to be 13 A, this being the largest rating of fuse used in the **mains** plug.

NOTE 4 In France, in certain cases, the **protective current rating** of the circuit supplied from the **mains** is taken as 20 A instead of 16 A.

– for **pluggable equipment type B**, and **permanently connected equipment** the **protective current rating** is the maximum rating of the overcurrent protective device specified in the equipment installation instructions to be provided external to the equipment.

5.6.4.2.2 Other than mains supply as the source

Where the source is an external supply having the maximum current inherently limited by the internal source impedance (such as an impedance protected transformer), the **protective current rating** of the circuit is the highest current available from that supply into any load.

Where the maximum current from the external supply source is limited by electronic components in the source, the **protective current rating** shall be taken as the maximum output current with any resistive load, including a short-circuit. If the current is limited by an impedance, a fuse, a PTC device or a circuit breaker, the current is measured 60 s after the application of the load. If the current is limited by other means, the current is measured 5 s after the application of the load.

5.6.4.2.3 Internal circuit as the source

Where the source is a circuit within the equipment, the **protective current rating** of the circuit is:

– the rating of the overcurrent protective device if the current is limited by an overcurrent protective device; or

– the maximum output current, if the current is limited by the source impedance of the supply. The output current is measured with any resistive load including a short-circuit measured 60 s after the application of the load if current is limited by impedance or the current limiting device is a fuse, a circuit breaker or a PTC device, or 5 s in other cases.

5.6.4.2.4 Current limiting and overcurrent protective devices

A current limiting device (a PTC device) or an overcurrent protective device (a fuse or a circuit breaker) shall not be connected in parallel with any other component that could fail to a low-resistance state.

5.6.4.3 Compliance criteria

*Compliance is checked by inspection and measurement of the **protective bonding conductor** sizes in accordance with Table 31 or Table G.7 and the test of 5.6.6 or Annex R as applicable.*

5.6.5 Terminals for protective conductors

5.6.5.1 Requirements

Terminals for connecting **protective earthing conductors** shall comply with the minimum terminal sizes in Table 32.

Terminals for connecting **protective bonding conductors** shall comply with one of the following:

– the minimum terminal sizes in Table 32; or

– ~~the requirements of 5.6.6 and,~~ if either the **rated current** of the equipment or the **protective current rating** of the circuit ~~is more than~~ exceeds 25 A, with terminal sizes that are not more than one size smaller than in Table 32; or

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– ~~the requirements of 5.6.6 and,~~ if both the **rated current** of the equipment ~~or~~ and the **protective current rating** of the circuit do~~es~~ not exceed 25 A; either

  - with terminal sizes that are not more than one size smaller than in Table 32; or
  - with the limited short-circuit test of Annex R;

  or

– for components only, be not smaller than the terminal sizes supplying power to the component.

Table 32 – Sizes of terminals for protective conductors

Conductor size mm² (from Table G.7)	Minimum nominal thread diameter mm		Area of cross section mm²	
	Pillar type or stud type	Screw type [a]	Pillar type or stud type	Screw type [a]
1	3,0	3,5	7	9,6
1,5	3,5	4,0	9,6	12,6
2,5	4,0	5,0	12,6	19,6
4	4,0	5,0	12,6	19,6
6	5,0	5,0	19,6	19,6
10 [b]	6,0	6,0	28	28
16 [b]	7,9	7,9	49	49

[a] "Screw type" refers to a terminal that clamps the conductor under the head of a screw, with or without a washer.

[b] As an alternative to the requirements of this table, the **protective earthing conductor** may be attached to special connectors, or suitable clamping means (for example, an upturned spade or closed loop pressure type; clamping unit type; saddle clamping unit type; mantle clamping unit type; etc.) that is secured by a screw and nut mechanism to the metal chassis of the equipment. The sum of the cross-sectional areas of the screw and the nut shall not be less than three times the cross-sectional area of the conductor size in Table 31 or Table G.7 as applicable. The terminals shall comply with IEC 60998-1 and IEC 60999-1 or IEC 60999-2.

Compliance is checked by inspection and measurement of protective terminal sizes in accordance with Table 32, the test of 5.6.6 or Annex R as applicable.

5.6.5.2 Corrosion

Conductive parts in contact at the main **protective earthing** terminal, protective bonding terminals and connections shall be selected in accordance with Annex N so that the potential difference between any two different metals is 0,6 V or less.

Compliance is checked by inspection of the materials of the conductors and terminals and associated parts and determination of the potential difference.

5.6.6 Resistance of the protective bonding system

5.6.6.1 Requirements

Protective bonding conductors and their terminations shall not have excessive resistance.

NOTE A protective bonding system in the equipment consists of a single conductor or a combination of conductive parts, connecting a main **protective earthing** terminal to a part of the equipment that is to be earthed for safety purposes.

Protective bonding conductors that meet the minimum conductor sizes in Table G.7 throughout their length and whose terminals all meet the minimum sizes in Table 32 are considered to comply without test.

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On equipment where the protective earth connection to a subassembly or to a separate unit is made by means of one core of a multicore cable that also supplies power to that subassembly or unit and where the cable is protected by a suitably rated protective device that takes into account the size of the conductor, the resistance of the **protective bonding conductor** in that cable is not included in the measurement.

5.6.6.2 Test method

*The test current can be either AC or DC and the test voltage shall not exceed 12 V. The measurement is made between the main **protective earthing** terminal and the point in the equipment that is required to be earthed.*

*The resistance of the **protective earthing conductor** and of any earthed conductor in other external wiring is not included in the measurement. However, if the **protective earthing conductor** is supplied with the equipment, the conductor may be included in the test circuit but the measurement of the voltage drop is made only from the main **protective earthing** terminal to the part required to be earthed.*

Care is taken that the contact resistance between the tip of the measuring probe and the conductive part under test does not influence the test results. The test current and duration of the test are as follows:

*a) For equipment powered from the **mains** where the **protective current rating** of the circuit under test is 25 A or less, the test current is 200 % of the **protective current rating** applied for 2 min.*

*b) For equipment powered from the AC **mains** where the **protective current rating** of the circuit under test exceeds 25 A, the test current is 200 % of the **protective current rating** or 500 A, whichever is less, and the duration of the test is as shown in Table 33.*

Table 33 – Test duration, mains connected equipment

Protective current rating of the circuit A up to and including	**Duration of the test** min
30	2
60	4
100	6
200	8
over 200	10

*c) As an alternative to b), the tests are based on the time-current characteristic of the overcurrent protective device that limits the fault current in the **protective bonding conductor**. This device is either one provided in the EUT or specified in the installation instructions to be provided external to the equipment. The tests are conducted at 200 % of the **protective current rating**, for the duration corresponding to 200 % on the time-current characteristic. If the duration for 200 % is not given, the nearest point on the time-current characteristic may be used.*

*d) For equipment powered from a DC **mains**, if the **protective current rating** of the circuit under test exceeds 25 A, the test current and duration are as specified by the manufacturer.*

*e) For equipment receiving its power from an **external circuit**, the test current is 1,5 times the maximum current available from the **external circuit** or 2 A, whichever is greater, for a duration of 2 min. For parts connected to the **protective bonding conductor** to limit the transients or to limit **touch current** to an **external circuit** and that do not exceed an ES2 level during **single fault conditions**, the test is conducted in accordance with the relevant test method of either a), b), c) or d) based on the power source assumed.*

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5.6.6.3 Compliance criteria

*Where the **protective current rating** ~~is less than~~ does not exceed 25 A, the resistance of the protective bonding system, calculated from the voltage drop, shall not exceed 0,1 Ω.*

*Where the **protective current rating** ~~is~~ exceeds 25 A ~~or more~~, the voltage drop over the protective bonding system shall not exceed 2,5 V.*

5.6.7 Reliable connection of a protective earthing conductor

For **permanently connected equipment**, earthing is considered to be reliable.

For cord connected **mains** equipment, earthing is also considered to be reliable for:

– **pluggable equipment type B**; or

– **stationary pluggable equipment type A**,

- that is intended to be used in a location having equipotential bonding (such as a telecommunication centre, a dedicated computer room, or a **restricted access area**); and
- has installation instructions that require verification of the **protective earthing** connection of the socket-outlet by a **skilled person**; or

– **stationary pluggable equipment type A**

- that has provision for a permanently connected **protective earthing conductor** ~~including~~; and
- has instructions for the installation of that conductor to building earth by a **skilled person**.

For equipment connected to an **external circuit** as indicated in Table 13, ID numbers 1, 2, 3, 4 and 5, earthing is considered to be reliable for **pluggable equipment type A** and **pluggable equipment type B** that have provision for:

– a permanently connected **protective earthing conductor** ~~including~~; and

– has instructions for the installation of that conductor to building earth by a **skilled person**.

5.6.8 Functional earthing

If a **protective earthing conductor** in the **mains** supply cord is only used for establishing **functional earthing**:

– the requirements for conductor size as given in G.7.2 apply to the earthing conductor of the **mains** supply cord; and

– the marking for **class II equipment** with **functional earthing** shall be used as specified in F.3.6.2: and

– the appliance inlet, if used, shall comply with the **creepage distance** and **clearance** requirements for **double insulation** or **reinforced insulation**.

NOTE 1 Some appliance inlets for **class I equipment** do not have sufficient insulation to serve as **double insulation** or **reinforced insulation** between the phases and the **protective earthing** terminal. Equipment using such an inlet is not considered to be **class II equipment**.

NOTE 2 In Norway, equipment connected with an earthed **mains** plug is classified as **class I equipment**. See the marking requirement in the country note to 4.1.15. The symbol IEC 60417-6092, as specified in F.3.6.2, is accepted.

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5.7 Prospective touch voltage, touch current and protective conductor current

5.7.1 General

Measurements of **prospective touch voltage**, **touch current**, and **protective conductor current** are made with the EUT ~~operating~~ supplied at the most unfavourable supply voltage (see B.2.3).

5.7.2 Measuring devices and networks

5.7.2.1 Measurement of touch current

For measurements of **touch current**, the instrument used for measuring U_2 and U_3 specified in Figures 4 and 5 respectively in IEC 60990:~~1999~~ 2016 shall indicate peak voltage. If the **touch current** waveform is sinusoidal, an RMS indicating instrument may be used.

5.7.2.2 Measurement of voltage

Equipment, or parts of equipment, that are intended to be earthed in the intended application, but are unearthed as provided, shall be connected to earth during the measurement at the point by which the highest **prospective touch voltage** is obtained.

5.7.3 Equipment set-up, supply connections and earth connections

The equipment set-up, equipment supply connections and equipment earthing shall be in accordance with Clause 4, 5.3 and 5.4 of IEC 60990:~~1999~~ 2016.

Equipment provided with a connection to earth separate from the **protective earthing conductor** shall be tested with that connection disconnected.

Systems of interconnected equipment with separate connections to the **mains** shall have each equipment tested separately.

Systems of interconnected equipment with one connection to the **mains** shall be tested as a single equipment.

NOTE 1 Systems of interconnected equipment are specified in more detail in Annex A of IEC 60990:~~1999~~ 2016.

Equipment that is designed for multiple connections to the **mains**, where only one connection is required at a time, shall have each connection tested while the other connections are disconnected.

Equipment that is designed for multiple connections to the **mains**, where more than one connection is required, shall have each connection tested while the other connections are connected, with the **protective earthing conductors** connected together. If the **touch current** exceeds the limit in 5.2.2.2, the **touch current** shall be measured individually.

NOTE 2 It is not necessary that the EUT operates normally during this test.

5.7.4 Unearthed accessible parts

Under **normal operating conditions**, **abnormal operating conditions** and **single fault conditions** (except for a **safeguard** fault), touch voltage or **touch current** shall be measured from all unearthed **accessible** conductive parts. **Touch current** (current [a] and current [b] of Table 4) shall be measured in accordance with 5.1, 5.4 and 6.2.1 of IEC 60990:2016.

Under **single fault conditions** of a relevant **basic safeguard** or a **supplementary safeguard**, including 6.2.2.2 of IEC 60990:2016, touch voltage or **touch current** shall be measured from all unearthed **accessible** conductive parts. **Touch current** (current [b] of Table 4) shall be measured with the network specified in Figure 5 of IEC 60990:2016.

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For an **accessible** non-conductive part, the test is made with a metal foil as specified in 5.2.1 of IEC 60990:2016.

5.7.5 Earthed accessible conductive parts

At least one earthed **accessible** conductive part shall be tested for **touch current** following supply connection faults in accordance with 6.1 and 6.2.2 of IEC 60990:~~1999~~ 2016, except 6.2.2.8. Except as permitted in 5.7.6, the **touch current** shall not exceed the ES2 limits in 5.2.2.2.

Subclause 6.2.2.3 of IEC 60990:~~1999~~ 2016 does not apply to equipment with a switch or other **disconnect device** that disconnects all poles of the supply.

NOTE An appliance coupler is an example of a **disconnect device**.

~~**5.7.5 Protective conductor current**~~

~~**The** protective conductor current **shall not exceed the ES2 limits in 5.2.2.2, unless all of the following conditions are met:**~~

~~– the current shall not exceed 5 % of the input current measured under **normal operating conditions**;~~

~~– the construction of the **protective conductor** circuit and its connections shall have:~~

~~• a **protective earthing conductor** serving as a **reinforced safeguard** or two independent **protective earthing conductors** serving as **double safeguard** as specified in 5.6.3, and~~

~~• a reliable earthing as specified in 5.6.7.~~

~~If the **protective conductor current** exceeds the ES2 limits of 5.2.2.2, then an **instructional safeguard** shall be provided in accordance with Clause F.5, except that element 3 is optional.~~

5.7.6 Requirements when touch current exceeds ES2 limits

Where the **touch current** exceeds the ES2 limits in 5.2.2.2 under the supply fault conditions specified in 6.2.2.2 of IEC 60990:2016, all of the following conditions apply:

– the **protective conductor current** measured according to Clause 8 of IEC 60990:2016 shall not exceed 5 % of the input current measured under **normal operating conditions**;

– the construction of the **protective earthing conductor** circuit and its connections shall have:

  • a **protective earthing conductor** serving as a **reinforced safeguard** as specified in 5.6.3 or two independent **protective earthing conductors** serving as a **double safeguard**, and

  • a reliable connection to **protective earthing** as specified in 5.6.7;

– the manufacturer shall indicate the value of the **protective conductor current** in the installation instructions if the current exceeds 10 mA;

– an **instructional safeguard** shall be provided in accordance with Clause F.5, except that element 3 is optional. The elements of the **instructional safeguard** shall be as follows:

  • element 1a:  , IEC 60417-6042 (2010-11); and



, IEC 60417-6173 (2012-10); and

 , IEC 60417-5019 (2006-08)

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- element 2: “Caution” or equivalent word or text, and “High touch current” or equivalent text
- element 3: optional
- element 4: “Connect to earth before connecting to supply” or equivalent text

The elements of the **instructional safeguard** that are required to be placed on the equipment shall be affixed to the equipment adjacent to the equipment supply connection.

NOTE In Denmark, the installation instruction shall be affixed to the equipment if the **protective conductor current** exceeds the limits of 3,5 mA AC or 10 mA DC.

5.7.7 Prospective touch voltage and touch current ~~due to~~ associated with external circuits

5.7.7.1 Touch current from coaxial cables

~~For~~ If the equipment is connected to **external circuits** ~~connected to~~ with a coaxial cable and if such connection is likely to create a hazard, the manufacturer shall provide instructions to connect the shield of the coaxial cable to the building earth in accordance with 6.2 g) and 6.2 l) of IEC 60728-11:~~2005~~ 2016.

NOTE 1 In Norway and Sweden, the screen of the television distribution system is normally not earthed at the entrance of the building and there is normally no equipotential bonding system within the building. Therefore the **protective earthing** of the building installation needs to be isolated from the screen of a cable distribution system.

It is however accepted to provide the insulation external to the equipment by an adapter or an interconnection cable with galvanic isolator, which may be provided by a retailer, for example.

The user manual shall then have the following or similar information in Norwegian and Swedish language respectively, depending on in what country the equipment is intended to be used in:

“Apparatus connected to the **protective earthing** of the building installation through the **mains** connection or through other apparatus with a connection to **protective earthing** – and to a television distribution system using coaxial cable, may in some circumstances create a fire hazard. Connection to a television distribution system therefore has to be provided through a device providing electrical isolation below a certain frequency range (galvanic isolator, see ~~EN~~ IEC 60728-11)”.

NOTE 2 In Norway, due to regulation for CATV-installations, and in Sweden, a galvanic isolator shall provide electrical insulation below 5 MHz. The insulation shall withstand a dielectric strength of 1,5 kV RMS, 50 Hz or 60 Hz, for 1 minute.

Translation to Norwegian (the Swedish text will also be accepted in Norway):

“Apparater som er koplet til beskyttelsesjord via nettplugg og/eller via annet jordtilkoplet utstyr – og er tilkoplet et koaksialbasert kabel-TV nett, kan forårsake brannfare. For å unngå dette skal det ved tilkopling av apparater til kabel-TV nett installeres en galvanisk isolator mellom apparatet og kabel-TV nettet.”

Translation to Swedish:

”Apparater som är kopplad till skyddsjord via jordat vägguttag och/eller via annan utrustning och samtidigt är kopplad till kabel-TV nät kan i vissa fall medföra risk för brand. För att undvika detta skall vid anslutning av apparaten till kabel-TV nät galvanisk isolator finnas mellan apparaten och kabel-TV nätet.”

5.7.7.2 Prospective touch voltage and touch current associated with paired conductor cables

For circuits intended to be connected to **external circuits** such as those described in ID 1 of Table 13:

– the **prospective touch voltage** shall comply with ES2; or

– the **touch current** shall not exceed 0,25 mA.

The above requirements do not apply ~~to~~ if the corresponding **external circuits** are connected to a **protective earthing conductor**.

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Compliance is checked by measurement according 5.7.2 and 5.7.3 by using the measurement arrangement in Figure 32 for single-phase equipment and Figure 33 for three-phase equipment.

NOTE For other power distribution systems, see IEC 60990:2016.

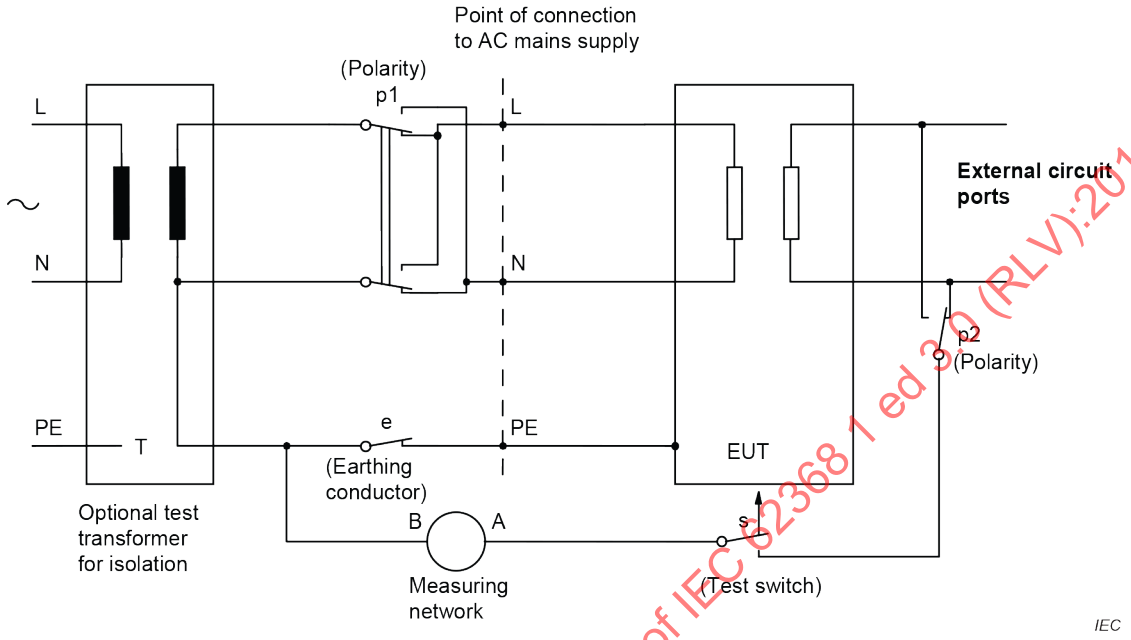


Figure 32 – Test circuit for touch current of single-phase equipment

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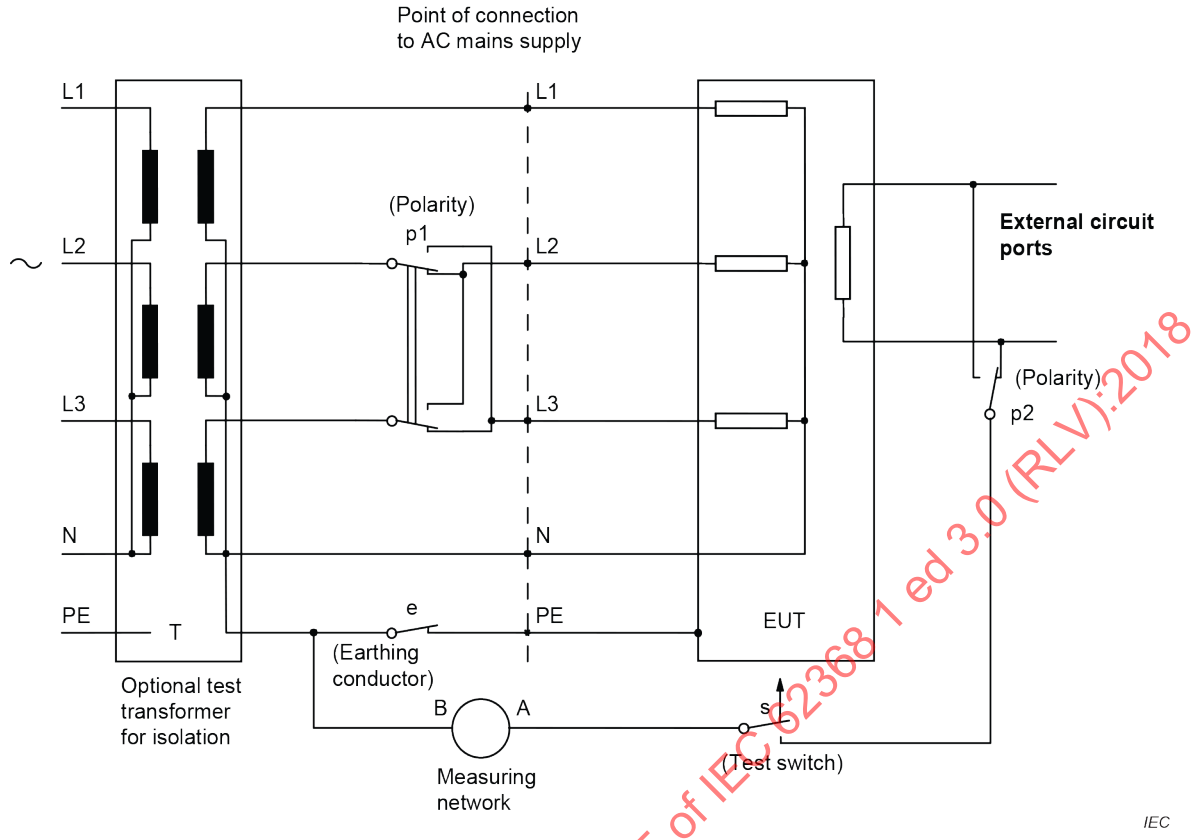


Figure 33 – Test circuit for touch current of three-phase equipment

5.7.8 Summation of touch currents from external circuits

The requirements below specify when a permanently connected **protective earthing conductor** is required for **pluggable equipment type A** or **pluggable equipment type B**, should the **mains** connection be disconnected.

The requirements apply only to equipment ~~with~~ intended to be connected to an **external circuit~~s~~** such as described in Table 13, ID numbers 1, 2, 3 and 4.

NOTE These types of **external circuits** are typically telecommunication networks.

The summation of **touch currents** from equipment that provides multiple **external circuits**, shall not exceed the limits for ES2 (see Table 4).

The following abbreviations are used:

– I_1: **touch current** received from other equipment via ~~a network at an external **circuit** of the equipment~~ an external network;

– $S(I_1)$: summation of **touch current** received from all other equipment ~~at all such external **circuit** of the equipment~~ via an external network;

– I_2: **touch current** due to the **mains** of the equipment.

It shall be assumed that each circuit of the equipment connected to an **external circuit** receives 0,25 mA (I_1) from the other equipment, unless the actual current from the other equipment is known to be lower.

The following requirements, a) or b) as applicable, shall be met:

a) Equipment ~~with~~ connected to an earthed **external circuit**

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For equipment in which each circuit that can be connected to an **external circuit** is connected to a terminal for the **protective earthing conductor** of the equipment, the following ~~items 1), and 2)~~ shall be considered:

1) If $S(I_1)$ (not including I_2) exceeds ES2 limits of Table 4:
   - the equipment shall have provision for a permanent connection to protective earth in addition to the **protective earthing conductor** in the power supply cord of **pluggable equipment type A** or **pluggable equipment type B**; and
   - the installation instructions shall specify the provision of a permanent connection to protective earth with a cross-sectional area of not less than 2,5 mm^2, if mechanically protected, or otherwise 4,0 mm^2; and
   - provide a marking in accordance with 5.7.6 and Clause F.3.
2) Such equipment shall comply with 5.7.6. The value of I_2 shall be used to calculate the 5 % input current limit per phase specified in 5.7.6.
3) The sum of $S(I_1)$ and I_2 shall comply with the limits of Table 4.

Compliance with item a) is checked by inspection and if necessary by test.

If the equipment has provision for a permanent protective earth connection in accordance with item 1) above, it is not necessary to make any measurements, except that I_2 shall comply with the relevant requirements of 5.7.

***Touch current** tests, if necessary, are made using the relevant measuring instrument described in IEC 60990:~~1999~~ 2016, Figure 5, or any other instrument giving the same results. A source (for example, a capacitively coupled AC source of the same line frequency and phase as the AC **mains**) is applied to each **external circuit** and adjusted so that 0,25 mA, or the actual current from other equipment, if known to be lower, is available to flow into that **external circuit**. The current flowing in the earthing conductor is then measured.*

b) Equipment ~~whose **external circuit** have no reference to protective earth~~ connected to an unearthed **external circuit**

If each circuit of the equipment that can be connected to an **external circuit** does not have a common connection, the **touch current** for each ~~**external**~~ circuit shall not exceed the ES2 limits of Table 4.

If all ~~**external**~~ circuits of the equipment that can be connected to an **external circuit** or any groups of such ports have a common connection, the total **touch current** from each common connection shall not exceed the ES2 limits of Table 4.

Compliance with item b) is checked by inspection and, if there are common connection points, by the following test.

*A capacitively coupled AC source of the same frequency and phase as the AC **mains** is applied to each circuit of the equipment that can be connected to an **external circuit** so that 0,25 mA, or the actual current from the other equipment if known to be lower, is available to flow into that ~~**external**~~ circuit. Common connection points are tested in accordance with 5.7.3, whether or not the points are **accessible**.*

5.8 Backfeed safeguard in battery backed up supplies

A **battery** backed up supply that is an integral part of the equipment and is capable of backfeeding shall prevent greater than ES1 from being present on the **mains** terminals after interruption of the **mains** power.

No hazard shall exist at the **mains** terminals when measured 1 s after de-energization of the **mains** for **pluggable type A equipment**, 5 s for **pluggable type B equipment** or 15 s for **permanently connected equipment** using the measurement instruments described in 5.7.2. Where the measured open-circuit voltage does not exceed the ES1 limits, the **touch current** does not have to be measured.

*Compliance is checked by inspection of the equipment and the relevant circuit diagram, by measurement and by **single fault conditions** in accordance with B.4.*

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NOTE 1 For standards related to **battery** backed up power supply systems that are not an integral part of the equipment, see standards related to UPS, such as IEC 62040-1. For transfer switches, see IEC 62310-1:2005.

NOTE 2 See also the explanatory information in IEC TR 62368-2.

When an air gap is employed as a **backfeed safeguard**, the requirements of 5.4.2 for **clearances** and 5.4.3 for **creepage distances** apply in addition to the following:

– subject to confirmation from the manufacturer, the **battery** backed up supply output, in **stored energy mode** may be considered a transient free circuit of Overvoltage Category I;

– the **clearances** and **creepage distances** shall comply with the requirements for **pollution degree** 2 or higher if expected in the intended installation location;

– **reinforced insulation** shall be applied between the unit output and the unit input if during **stored energy mode** of operation not all input poles are isolated by the **backfeed safeguard** device. In all other cases, **basic insulation** shall be applied.

Compliance is checked by inspection.

6 Electrically-caused fire

6.1 General

To reduce the likelihood of injury or property damage due to an electrically-caused fire originating within the equipment, equipment shall be provided with the **safeguards** specified in Clause 6.

6.2 Classification of power sources (PS) and potential ignition sources (PIS)

6.2.1 General

Electrical sources of heating can be classified into available power levels PS1, PS2 and PS3 (see 6.2.2.4, 6.2.2.5 and 6.2.2.6) that may cause resistive heating of both components and connections. These power sources are based on available energy to a circuit.

Within a power source, a **PIS** may arise due to arcing of either broken connections or opening of contacts (**arcing PIS**) or from components dissipating more than 15 W (**resistive PIS**).

Depending on the power source classification of each circuit, one or more **safeguards** are required either to reduce the likelihood of ignition or to reduce the likelihood of spread of fire beyond the equipment.

6.2.2 Power source circuit classifications

6.2.2.1 General

An electric circuit is classified PS1, PS2, or PS3 based on the electrical power available to the circuit from the power source.

The electrical power source classification shall be determined by measuring the maximum power under each of the following conditions:

– for load circuits: a power source under **normal operating conditions** as specified by the manufacturer into a worst-case fault (see 6.2.2.2);

– for power source circuits: a worst-case power source fault into the specified normal load circuit (see 6.2.2.3).

The power is measured at points X and Y in Figure 34 and Figure 35.

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6.2.2.2 Power measurement for worst-case fault

With reference to Figure 34:

– *the measurement may be performed without the load circuit L_{NL} connected, unless the maximum power is dependent on the connection of the load;*

– *at points X and Y, insert a wattmeter (or a voltmeter, V_A, and a current meter, I_A);*

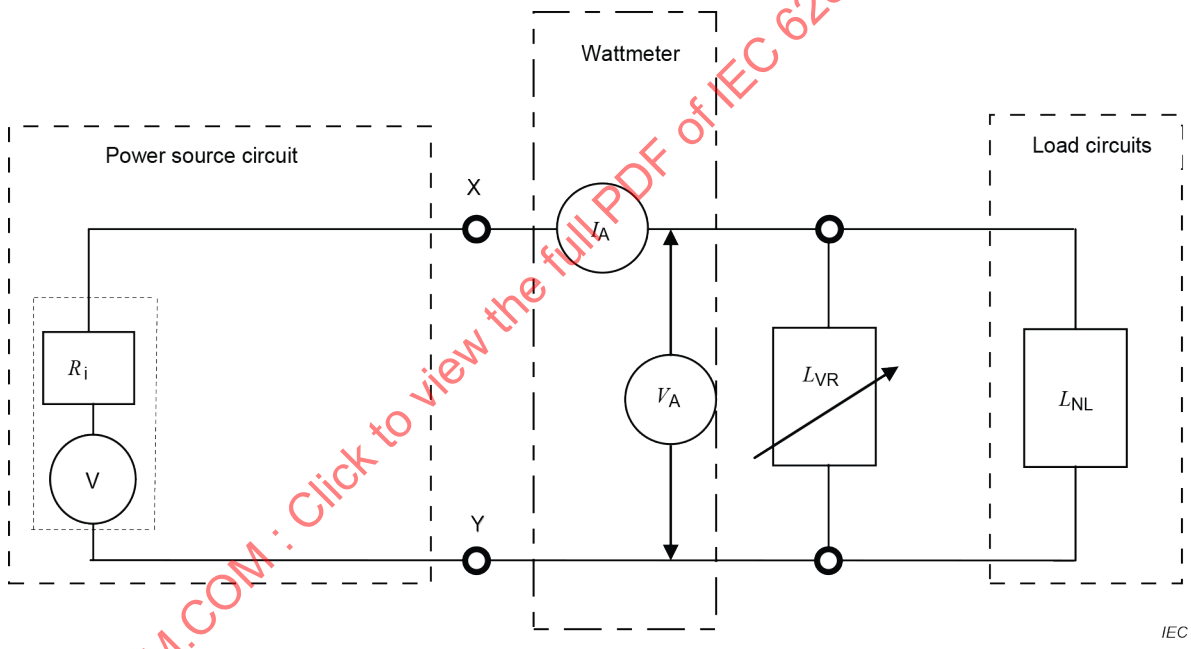
– *connect a variable resistor, L_{VR}, as shown;*

– *adjust the variable resistor, L_{VR}, for maximum power. Measure the maximum power and classify the power source according to 6.2.2.4, 6.2.2.5 or 6.2.2.6.*

If an overcurrent protective device operates during the test, the measurement shall be repeated at 125 % of the current rating of the overcurrent protective device.

If a power limiting device or circuit operates during the test, the measurement shall be repeated at a point just below the current at which the power limiting device or circuit operated.

When evaluating accessories connected via cables to the equipment, the impedance of the cable may be taken into account in the determination of PS1 or PS2 on the accessory side.



Key

V voltage source

R_i internal resistance of the power source

I_A current from the power source

V_A voltage at the points where determination of PS power is made

L_{VR} variable resistor load

L_{NL} normal load

Figure 34 – Power measurement for worst-case fault

6.2.2.3 Power measurement for worst-case power source fault

With reference to Figure 35:

– *At points X and Y, insert a wattmeter (or a voltmeter, V_A, and a current meter, I_A).*

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– *Within the power source circuit, simulate any **single fault condition** that will result in maximum power to the circuit being classified. All relevant components in the power source circuits shall be short-circuited or disconnected one at a time at each measurement.*

– *Equipment containing audio amplifiers shall also be tested under **abnormal operating conditions** as specified in Clause E.3.*

– *Measure the maximum power as specified and classify circuits supplied by the power source according to 6.2.2.4, 6.2.2.5 or 6.2.2.6.*

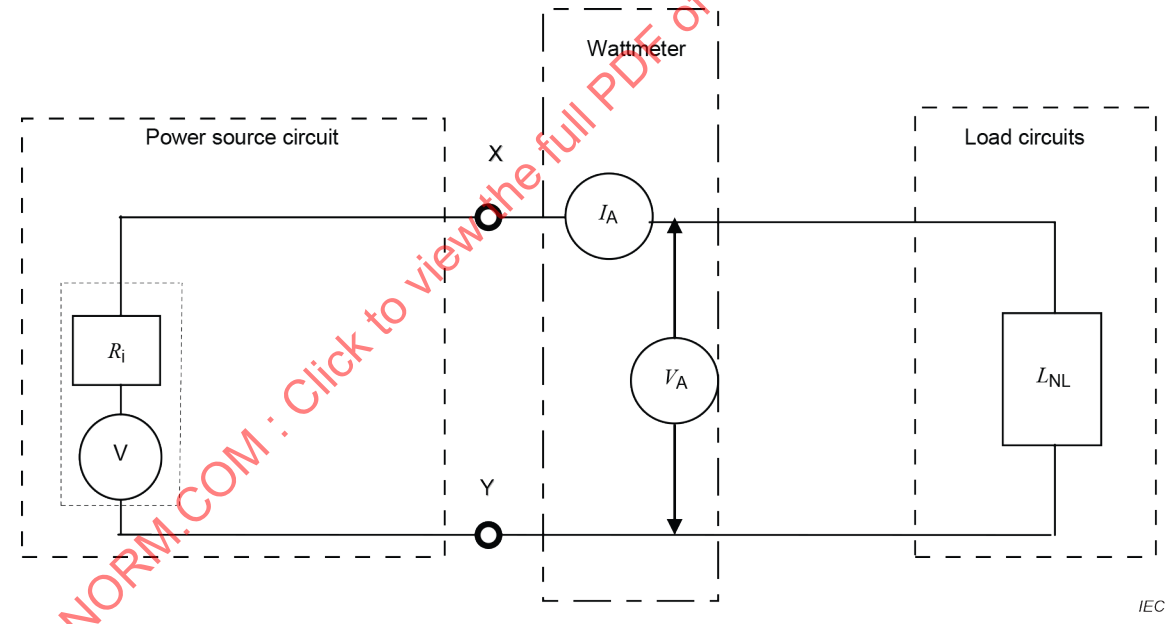
If an overcurrent protective device operates during the test, the measurement shall be repeated at 125 % of the current rating of the overcurrent protective device.

If a power limiting device or circuit operates during the test, the measurement shall be repeated at a point just below the current at which the power limiting device or circuit operated.

When the tests are repeated, a variable resistance may be used to simulate the component under fault.

To avoid damage to the components of the normal load, a resistor (equal to the normal load) may be substituted for the normal load.

NOTE Experimentation can be ~~necessary~~ used to identify the single component fault that produces maximum power.



Key

V voltage source

R_i internal resistance of the power source

I_A current from the power source

V_A voltage at the points where determination of PS power is made

L_{NL} normal load

Figure 35 – Power measurement for worst-case power source fault

6.2.2.4 PS1

PS1 is a circuit where the power source, (see Figure 36) measured according to 6.2.2, does not exceed 15 W measured after 3 s.

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The power available from **external circuits** described in Table 13, ID numbers 1 and 2, are considered to be limited to PS1.

6.2.2.5 PS2

PS2 is a circuit where the power source, (see Figure 36) measured according to 6.2.2:

– exceeds PS1 limits; and

– does not exceed 100 W measured after 5 s.

6.2.2.6 PS3

PS3 is a circuit whose power source exceeds PS2 limits, or any circuit whose power source has not been classified (see Figure 36).

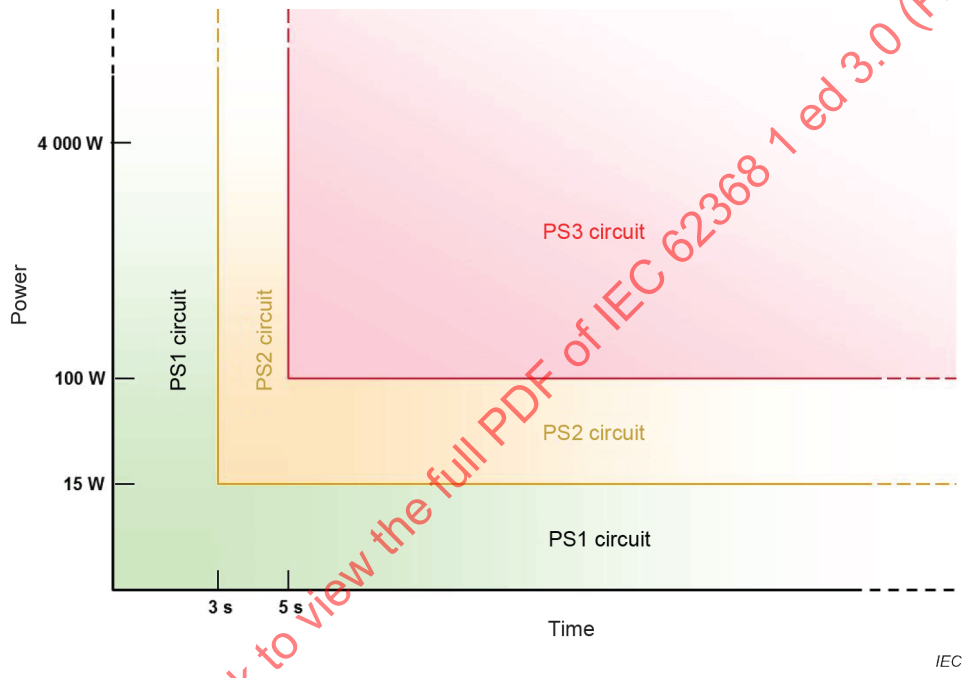


Figure 36 – Illustration of power source classification

6.2.3 Classification of potential ignition sources

6.2.3.1 Arcing PIS

~~Determination of an **arcing PIS** is performed under **normal operating conditions** unless otherwise specified.~~

An **arcing PIS** is a location with the following characteristics:

– an open circuit voltage (measured after 3 s) across an open conductor or opening electrical contact exceeding 50 V (peak) AC or DC; and

– the product of the peak of the open circuit voltage (V_p) and the measured RMS current (I_{rms}) exceeds 15 (that is, $V_p \times I_{rms} > 15$) for any of the following:

- a contact, such as a switch or connector;
- a termination, such as one made by a crimp, spring or solder termination;
- opening of a conductor, such as a printed wiring board trace, as a consequence of a **single fault condition**. This condition does not apply if electronic protection circuits or additional constructional measures are used to reduce the likelihood that such a fault becomes an **arcing PIS**.

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An **arcing PIS** is considered not to exist in a PS1 because of the limits of the power source.

NOTE 1 An open conductor in an electric circuit includes those interruptions that occur in conductive patterns on printed boards.

Reliable or redundant connections are not considered to be an **arcing PIS**.

Redundant connections are any kind of two or more connections in parallel, where in the event of the failure of one connection, the remaining connections are still capable of handling the full power.

Reliable connections are connections that are considered not to open.

NOTE 2 ~~Examples of~~ Connections that could be considered reliable are:

– holes of solder pads on a printed board that are through-metallized;

– tubular rivets/eyelets that are additionally soldered;

– machine-made or tool-made crimp or wire-wrap connections.

NOTE 3 Other means to avoid the occurrence of an **arcing PIS** can be used.

NOTE 4 Connection failure due to thermal fatigue phenomena could be prevented by selection of components with a coefficient of thermal expansion similar to that of the printed board material, taking into account the location of the component with respect to the fibre direction of the board material.

6.2.3.2 Resistive PIS

~~Determination of a **resistive PIS** is performed under **normal operating conditions** unless otherwise specified.~~

A **resistive PIS** is any part in a PS2 or PS3 circuit that:

– dissipates more than 15 W measured after 30 s ~~of normal operation~~ under **normal operating conditions**; or

NOTE During the first 30 s there is no limit.

– under **single fault conditions**:

- ~~has a power exceeding 100 W measured during the 30 s~~ dissipates more than 100 W measured for 30 s, disregarding the first 3 s, immediately after the introduction of the fault if electronic circuits, regulators or PTC devices are used; or
- ~~has an available power exceeding~~ dissipates more than 15 W measured 30 s after the introduction of the fault.

A **resistive PIS** is considered not to exist in a PS1 because of the limits of the power source.

6.3 Safeguards against fire under normal operating conditions and abnormal operating conditions

6.3.1 Requirements

Under **normal operating conditions** and **abnormal operating conditions**, the following **basic safeguards** are required:

– ignition shall not occur; and

– no part of the equipment shall attain a temperature value greater than 90 % of the spontaneous ignition temperature limit, in Celsius, of the part as defined by ISO 871. When the spontaneous ignition temperature of the material is not known, the temperature shall be limited to 300 °C; and

NOTE This document currently does not contain requirements for flammable dust or liquids ~~and dust~~ other than for **insulating liquids**.

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– **combustible materials** for components and other parts ~~outside **fire enclosures**~~ (including **electrical enclosures**, **mechanical enclosures** and decorative parts) not inside a **fire enclosure** shall ~~have a~~ comply with:

- **HB75 class material** if the thinnest significant thickness of this material is < 3 mm, or
- **HB40 class material** if the thinnest significant thickness of this material is ≥ 3 mm, or
- **HBF class foamed material**; or
- shall pass the Glow-Wire test at 550 °C according to IEC 60695-2-11.

These requirements do not apply to:

- parts with a ~~size~~ volume of less than 1 750 mm^3;
- parts with a mass of **combustible material** of less than 4 g;
- supplies, **consumable materials**, media and recording materials;
- parts that are required to have particular properties in order to perform intended functions, such as synthetic rubber rollers, ink tubes and material requiring optical characteristics; and
- gears, cams, belts, bearings and other parts that would contribute negligible fuel to a fire, including, labels, mounting feet, key caps, knobs and the like.

6.3.2 Compliance criteria

*Compliance is checked by inspection of the data sheets and by test under **normal operating conditions** according to Clause B.2 and under **abnormal operating conditions** according to Clause B.3. The temperatures of materials are measured continuously until thermal equilibrium has been attained.*

NOTE See B.1.5 for details on thermal equilibrium.

*Temperature limiting **basic safeguards** that comply with the applicable requirements of this document or the applicable safety device standard shall remain in the circuit being evaluated.*

6.4 Safeguards against fire under single fault conditions

6.4.1 General

This subclause defines the possible **safeguard** methods that can be used to reduce the likelihood of ignition or spread of fire under **single fault conditions**.

There are two methods of providing protection. Either method may be applied to different ~~circuits~~ parts of the same equipment ~~under the following conditions~~.

– **Reduce the likelihood of ignition:** Equipment is so designed that under **single fault conditions** no part shall have sustained flaming. This method can be used for any circuit in which the available steady state power to the circuit does not exceed 4 000 W. The appropriate requirements and tests are detailed in 6.4.2 and 6.4.3.

- **Pluggable equipment type A** is considered not to exceed the steady state value of 4 000 W.
- **Pluggable equipment type B** and **permanently connected equipment** are considered not to exceed the steady state value of 4 000 W if the product of the nominal **mains** voltage and the **protective current rating** of the installation overcurrent protective device ($V_{mains} \times I_{max}$) does not exceed 4 000 W.

– **Control fire spread:** Selection and application of **supplementary safeguards** for components, wiring, materials and constructional measures that reduce the spread of fire and, where necessary, by the use of a second **supplementary safeguard** such as a **fire enclosure**. This method can be used for any type of equipment. The appropriate requirements are detailed in 6.4.4, 6.4.5 and 6.4.6.

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6.4.2 Reduction of the likelihood of ignition under single fault conditions in PS1 circuits

No **supplementary safeguards** are needed for protection against PS1. A PS1 is not considered to ~~contain~~ be capable of providing enough energy to result in materials reaching ignition temperatures.

6.4.3 Reduction of the likelihood of ignition under single fault conditions in PS2 circuits and PS3 circuits

~~**6.4.3.1 General**~~

~~Requirements for **supplementary safeguards** needed to reduce the likelihood of ignition under **single fault conditions** in PS2 circuits and PS3 circuits where the available power does not exceed 4 000 W (see 6.4.1) are specified in 6.4.3.2.~~

6.4.3.1 Requirements

~~The likelihood of ignition can be reduced by using the following **supplementary safeguards** as applicable:~~

- ~~providing separation from an **arcing PIS** or a **resistive PIS** as specified in 6.4.7;~~
- ~~using protective devices that comply with G.3.1 to G.3.4 or the relevant IEC component standards for such devices;~~
- ~~using components that comply with G.5.3, G.5.4 or the relevant IEC component standard;~~
- ~~for components associated with the **mains**, using components that comply with the relevant IEC component standards and requirements of other parts of this standard.~~

~~NOTE Examples of components associated with the **mains** are the supply cord, appliance couplers, EMC filtering components, switches, etc.~~

~~The opening of a conductor on a printed board, except as specified below, shall not be used as a **safeguard**.~~

~~Conductors of a printed board of **V-1 class material** may open under **overload condition** provided that the open circuit is not an **arcing PIS**. Conductors on a printed board material that has no **material flammability class** or is classed lower than **V-1 class material** shall not open.~~

~~Under a **single fault condition**, the peeling of conductors on a printed board shall not result in the failure of any **supplementary safeguard** or **reinforced safeguard**.~~

The likelihood of ignition under **single fault conditions** in PS2 circuits and PS3 circuits where the available power does not exceed 4 000 W (see 6.4.1) shall be reduced by using the following **supplementary safeguards** as applicable:

NOTE For PS3 circuits where the available power exceeds 4 000 W, see 6.4.6.

- an **arcing PIS** or a **resistive PIS** shall be separated as specified in 6.4.7 with the **accessible** outer surface of the equipment considered to be covered with a **combustible material**;
- protective devices acting as a **safeguard** shall comply with G.3.1 to G.3.4 or the relevant IEC component standards;
- motors and transformers shall comply with G.5.3, G.5.4 or the relevant IEC component standard;
- varistors shall comply with G.8.2; and
- components associated with the **mains** shall comply with the relevant IEC component standards and the requirements of other parts of this document.

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In addition, the tests of 6.4.3.2 apply.

EXAMPLES Components associated with the **mains** include the supply cord, appliance couplers, EMC filtering components, switches, etc.

6.4.3.2 Test method

The conditions of Clause B.4, that are possible causes for ignition, are applied in turn. A consequential fault may either interrupt or short-circuit a component. In case of doubt, the test shall be repeated two more times with replacement components in order to check that sustained flaming does not occur.

*The equipment is operated under **single fault conditions** and the temperatures of materials are ~~measured~~ monitored continuously until thermal equilibrium has been attained.*

*If a conductor opens during a simulated **single fault condition**, the conductor shall be bridged and the simulated **single fault condition** shall be continued. In all other cases, where an applied **single fault condition** results in interruption of the current before steady state has been reached, the temperatures are measured immediately after the interruption.*

NOTE 1 See B.1.5 for details on thermal equilibrium.

~~*Spontaneous ignition temperatures of surrounding materials of the heat source shall be taken into account.*~~

NOTE 2 Temperature rise can be observed after interruption of the current due to thermal inertia.

*If the temperature is limited by a fuse, under a **single fault condition:***

- *a fuse complying with the IEC 60127 series shall open within 1 s; or*
- *a fuse not complying with the IEC 60127 series shall open within 1 s for three consecutive times; or*
- *the fuse shall comply with the following test.*

*The fuse is short-circuited and the current that would have passed through the fuse under the relevant **single fault condition** is measured.*

If the fuse current remains less than 2,1 times the current rating of the fuse, the temperatures are measured after a steady state has been attained.

If the current either immediately reaches 2,1 times the current rating of the fuse or more, or reaches this value after a period of time equal to the maximum pre-arcing time for the relevant current through the fuse under consideration, both the fuse and the short-circuit link are removed after an additional time corresponding to the maximum pre-arcing time of the fuse under consideration and the temperatures are measured immediately thereafter.

If the fuse resistance influences the current of the relevant circuit, the maximum resistance value of the fuse shall be taken into account when establishing the value of the current.

*Printed board conductors are tested by applying the relevant **single fault conditions** of B.4.4.*

6.4.3.3 Compliance criteria

Compliance is checked by inspection, tests and measurements. See B.4.8 for compliance criteria.

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6.4.4 Control of fire spread in PS1 circuits

No **supplementary safeguards** are needed for protection against PS1. A PS1 is not considered to ~~contain~~ be capable of providing enough energy to result in materials reaching ignition temperatures.

6.4.5 Control of fire spread in PS2 circuits

6.4.5.1 General

For the purposes of reducing the likelihood of fire spread in PS2 circuits to nearby **combustible materials**, circuits that meet the requirements of Annex Q are considered to be PS2 circuits.

6.4.5.2 Requirements

A **supplementary safeguard** is required to control the spread of fire from any possible **PIS** to other parts of the equipment as given below.

~~For~~ Conductors and devices that constitute a **PIS** shall comply with the following ~~apply~~:

– printed boards shall be made of **V-1 class material** or **VTM-1 class material**; and

– wire insulation and tubing shall comply with ~~IEC 60332-1-2, IEC 60332-1-3, IEC 60332-2-2 or IEC/TS 60695-11-21~~ 6.5.1;

Motors shall comply with G.5.4.

Transformers shall comply with G.5.3.

All other components in a PS2 circuit shall comply with one of the following:

– be mounted on **V-1 class material** or **VTM-1 class material;** or

– be made of **V-2 class material**, **VTM-2 class material** or **HF-2 class foamed material**; or

– comply with the requirements of Clause S.1; or

– have a size of less than 1 750 mm^3; or

– have a mass of **combustible material** of less than 4 g~~, provided that when the part is ignited, the fire does not spread to another part~~; or

– be separated from a **PIS** by the requirements of 6.4.7; or

~~– not ignite during **single fault conditions** as specified in 6.4.3.3; or~~

– comply with the flammability requirements of the relevant IEC component standard; or

~~– comply with G.5.4 for motors; or~~

~~– comply with G.5.3 for transformers; or~~

– be in a sealed **enclosure** of 0,06 m^3 or less, consisting totally of non-**combustible material** and having no ventilation openings; or

– the component shall not ignite during **single fault conditions** as specified in 6.4.3.2.

If the following materials ~~shall be~~ and parts are not separated from a **PIS** according to the requirements of 6.4.7, ~~or~~ then the materials and parts shall not ignite during **single fault conditions** as specified in 6.4.3.2:

– supplies, **consumable materials**, media and recording materials; and

– parts that are required to have particular properties in order to perform intended functions, such as synthetic rubber rollers, ink tubes and material requiring optical characteristics.

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6.4.5.3 Compliance criteria

Compliance is checked by testing or by inspection of the equipment and material data sheets.

6.4.6 Control of fire spread in a PS3 circuit

Fire spread in PS3 circuits shall be controlled by applying all of the following **supplementary safeguards**:

– conductors and devices within a PS3 circuit shall meet the requirements of 6.4.5;

– devices subject to arcing or changing contact resistance (for example, pluggable connectors) shall comply with one of the following:

- have materials made of **V-1 class material**, or
- comply with the flammability requirements of the relevant IEC component standard, or
- comply with the requirements of Clause S.1, or
- be mounted on material made of **V-1 class material** or **VTM-1 class material** and be of a volume not exceeding 1 750 mm^3 or have a mass of **combustible material** of less than 4 g; and

– by providing a **fire enclosure** as specified in 6.4.8.

Within the **fire enclosure**, **combustible materials** that ~~are not part of a~~ do not comply with the flammability requirements for PS2 or PS3 circuits shall comply with the flammability test of Clause S.1 or be made of **V-2 class material**, **VTM-2 class material** or **HF-2 class foamed material**. These requirements do not apply to:

– parts with a ~~size~~ volume of less than 1 750 mm^3;

– parts with a mass of **combustible material** of less than 4 g;

– supplies, **consumable materials**, media and recording materials;

– parts that are required to have particular properties in order to perform intended functions, such as synthetic rubber rollers, ink tubes and material requiring optical characteristics;

– gears, cams, belts, bearings and other parts that would contribute negligible fuel to a fire, including, labels, mounting feet, key caps, knobs and the like; and

– tubing for air or fluid systems, containers for powders or liquids and foamed plastic parts, provided that they are of **HB75 class material** if the thinnest significant thickness of the material is < 3 mm, or **HB40 class material** if the thinnest significant thickness of the material is ≥ 3 mm, or **HBF class foamed material** or pass the glow-wire test at 550 °C according to IEC 60695-2-11.

A **fire enclosure** is not necessary for the following components and materials:

– wire insulation and tubing complying with ~~IEC 60332-1-2, IEC 60332-1-3, IEC 60332-2-2 or IEC/TS 60695-11-21~~ 6.5.1;

– components, including connectors, complying with the requirements of 6.4.8.2.1, and that fill an opening in a **fire enclosure**;

– plugs and connectors forming part of a power supply cord or interconnecting cable complying with 6.4.9, G.4.1 and Clause G.7;

– motors complying with G.5.4; and

– transformers complying with G.5.3.

Compliance is checked by inspection of the material data sheets or by test, or both.

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6.4.7 Separation of combustible materials from a PIS

6.4.7.1 General

When required, the minimum separation requirements between a **PIS** and **combustible materials**, in order to reduce the likelihood of sustained flaming or spread of fire, may be achieved by either separation by distance (6.4.7.2) or separation by a fire barrier (6.4.7.3).

~~Separation requirements from a **PIS** to a **fire enclosure** are specified in 6.4.8.4.~~

Additional requirements for a **fire enclosure** or a fire barrier of **combustible material** located within 13 mm of an **arcing PIS** or 5 mm of a **resistive PIS** are given in 6.4.8.4.

6.4.7.2 Separation by distance

Combustible material, except the material on which the **PIS** is mounted, shall be separated from an **arcing PIS** or a **resistive PIS** according to Figure 37~~, Figure 38, Figure 39~~ and Figure ~~40~~ 38.

Base material of printed boards, on which an **arcing PIS** is located, shall be made of **V-1 class material**, **VTM-1 class material** or **HF-1 class foamed material**.

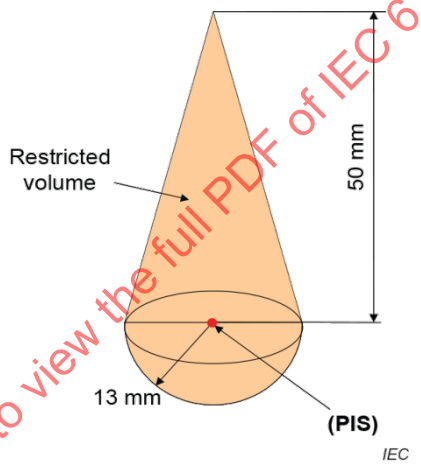
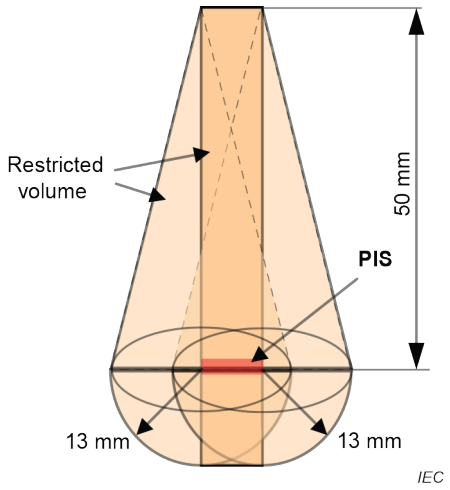


Figure 37 – Minimum separation requirements from ~~an arcing~~ a PIS

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NOTE This figure can be used for:

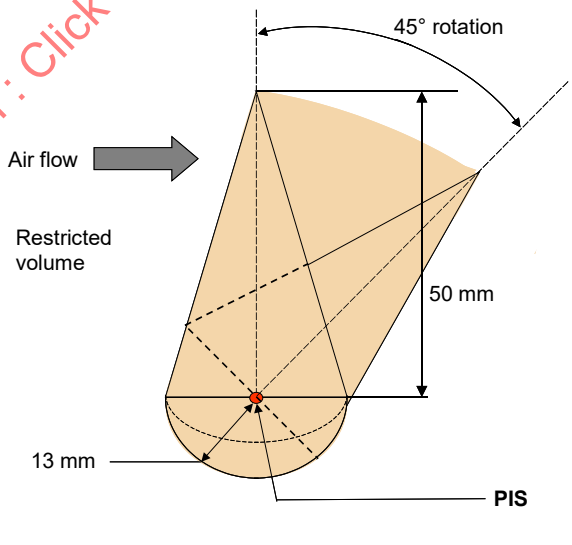
– an **arcing PIS** that consists of tracks or areas on printed boards;

– the **resistive PIS** areas of components. Measurements are made from the nearest power dissipating element of the component involved. If in practice it is not readily possible to define the power dissipating part, then the outer surface of the component is used.

Figure 38 – Extended separation requirements from a PIS

~~When the airflow across a circuit is moving due to air moving devices, the vertical orientation of the restricted volumes described in Figure 37, Figure 38 and Figure 40 shall be rotated to reflect the effect of the airflow on the flame path. When determining the restricted volumes for each figure, each cone shall be rotated (tilted) around the **PIS** location from 0° (vertical orientation, shown in Figure 39) to 45° in the direction of the forced airflow.~~

~~Any available data, including manufacturer's data, may be used in determining direction of forced airflow where it is not clear. Consequential air flow due to the by-product of a moving part that is not for air moving purposes may be ignored.~~



~~**Figure 39 – Rotated separation requirements due to forced air flow**~~

When the distance between a **PIS** and **combustible materials** is less than specified in Figure 37 and Figure 38~~ and Figure 39~~ as applicable, the **combustible materials** shall:

– have a volume of less than 1 750 mm^3;

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– have a mass of **combustible material** of less than 4 g ~~provided that when the part is ignited, the fire does not spread to another part~~; or

– comply with ~~the following flammability requirements~~:

- the flammability requirements of the relevant IEC component standard; or
- be made of **V-1 class material**, **VTM-1 class material** or **HF-1 class foamed material**, or comply with IEC 60695-11-5. Severities are identified in Clause S.2.

6.4.7.3 Separation by a fire barrier

Combustible material shall be separated from an **arcing PIS** or a **resistive PIS** by a fire barrier as defined in 6.4.8.2.1 (see Figure 39).

Printed boards are not considered to be a fire barrier against an **arcing PIS** located on the same board. Printed boards complying with 6.4.8 may be considered to be a fire barrier against an **arcing PIS** located on a different board.

Printed boards can be considered to be a fire barrier against a **resistive PIS** provided that the following conditions are met:

– the printed board shall:

- comply with the flammability test of Clause S.1 as used in the application; or
- be made of **V-1 class material**, **VTM-1 class material** or **HF-1 class foamed material**;

– within the restricted volume, components shall meet the flammability requirements of the relevant component standard and no other materials rated less than **V-1 class material** shall be mounted on the same side of a printed board as the **resistive PIS**; and

– within the restricted volume, the printed board shall have no PS2 conductors or PS3 conductors (except for the conductors that supply the circuit under consideration). This applies to any side of the printed board as well as the inner layer of the printed board.

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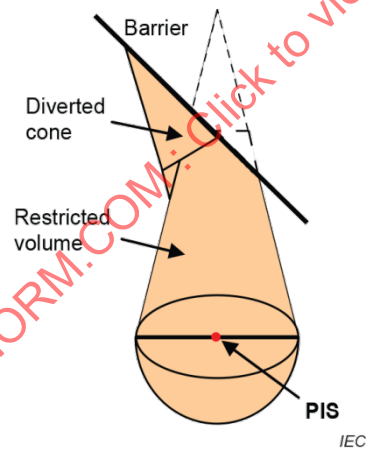


Figure 39a – Illustration showing an angled barrier

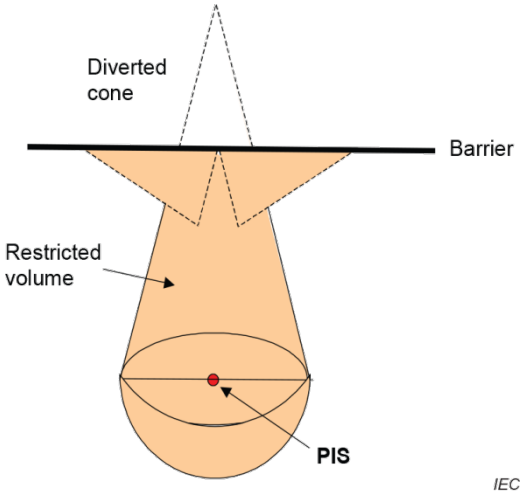


Figure 39b – Illustration showing a horizontal barrier

NOTE 1 The volume of the flame is nearly constant; consequently the shape of the flame is dependent upon the position and the shape of the barrier. Different shapes of barriers might give different flame shapes and result in a different restricted area and separation requirements.

NOTE 2 Dimensions are identical to Figure 37 and Figure 38 but, except as ~~required~~ given in 6.4.8.4, the distance of the barrier from the **PIS** is not significant.

Figure 39 – Deflected separation requirements from a PIS when a fire barrier is used

6.4.7.4 Compliance criteria

Compliance is checked by inspection or measurement or both.

6.4.8 Fire enclosures and fire barriers

6.4.8.1 General

The **safeguard** function of the **fire enclosure** and the fire barrier is to impede the spread of fire through the **enclosure** or barrier.

The **fire enclosure** may be the overall **enclosure**, or it may be within the overall **enclosure**. The **fire enclosure** need not have an exclusive function, but may provide other functions in addition to that of a **fire enclosure**.

6.4.8.2 Fire enclosure and fire barrier material properties

6.4.8.2.1 Requirements for a fire barrier

A fire barrier shall comply with the requirements of Clause S.1.

These requirements do not apply provided that the material is:

– made of non-**combustible material** (for example, metal, glass, ceramic, etc.); or

– made of **V-1 class material** or **VTM-1 class material**.

6.4.8.2.2 Requirements for a fire enclosure

For circuits where the available power does not exceed 4 000 W (see 6.4.1), a **fire enclosure** shall:

– comply with the requirements of Clause S.1; or

– be made of non-**combustible material** (for example, metal, glass, ceramic, etc.); or

– be made of **V-1 class material**.

For circuits where the available power exceeds 4 000 W, a **fire enclosure** shall:

– comply with the requirements of Clause S.5; or

~~These requirements do not apply provided that the material is:~~

– be made of non-**combustible material** (for example, metal, glass, ceramic, etc.); or

– be made of **5VA class material** or **5VB class material**.

- ~~**V-1 class material** if the available power does not exceed 4 000 W; or~~
- ~~**5VA class material** or **5VB class material** if the available power exceeds 4 000 W.~~

Material for components that fill an opening in a **fire enclosure** or that is intended to be mounted in such opening shall:

– comply with the flammability requirements of the relevant IEC component standard; or

– be made of **V-1 class material**; or

– comply with Clause S.1.

6.4.8.2.3 Compliance criteria

Compliance is checked by inspection of applicable data sheets or test.

*The **material flammability class** is checked for the thinnest significant thickness used.*

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6.4.8.3 Constructional requirements for a fire enclosure and a fire barrier

6.4.8.3.1 Fire enclosure and fire barrier openings

Openings in a **fire enclosure** or in a fire barrier shall be of such dimensions that fire and products of combustion passing through the openings are not likely to ignite material on the outside of the **enclosure** or on the side of a fire barrier opposite to the **PIS**.

The openings to which these properties apply are relative to the site or location of the **PIS** and of **combustible materials**. The locations of openings relative to the flame property are shown in Figure 41 and Figure 42.

Regardless of the equipment orientation, the flame orientation property of the **PIS** is always vertical~~, unless the equipment contains a forced airflow~~. Where the equipment has two or more **normal operating condition** orientations, opening properties apply to each possible orientation ~~and airflow direction~~.

~~When the forced airflow across a **PIS** is moving due to air moving devices, the vertical orientation of the volume described in Figure 38 is rotated (tilted) around the **PIS** location from 0° (vertical orientation shown in Figure 38) to 45° in the direction of the forced airflow (see also Figure 39).~~

Requirements for the **fire enclosure** of a **secondary lithium battery** are specified in M.4.3.

Determination of top openings, side openings and bottom openings shall be done in accordance with Figure 40, taking into account all possible orientations of use (see also 4.1.6).

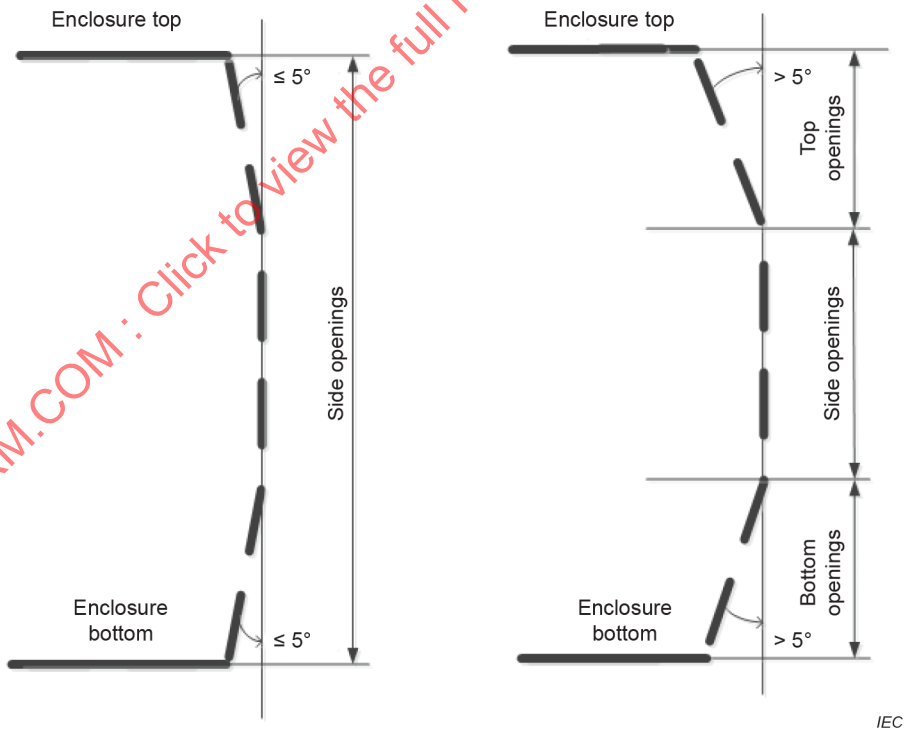


Figure 40 – Determination of top, bottom and side openings

6.4.8.3.2 Fire barrier dimensions

~~A fire barrier shall have dimensions sufficient to prevent ignition of the edges of the barrier.~~ The edges of the fire barriers shall extend ~~to~~ beyond the ~~fire cone~~ restricted volume (see Figure 39).

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6.4.8.3.3 Top openings and top opening properties

~~Top opening properties of a **fire enclosure** and a fire barrier shall apply to openings above a **PIS** as shown in Figure 41.~~

~~NOTE Any openings within the zone as shown in Figure 41 are regarded to be top openings, including side openings.~~

~~*Top openings that fall within the volume defined in Figure 41 shall comply with the following test.*~~

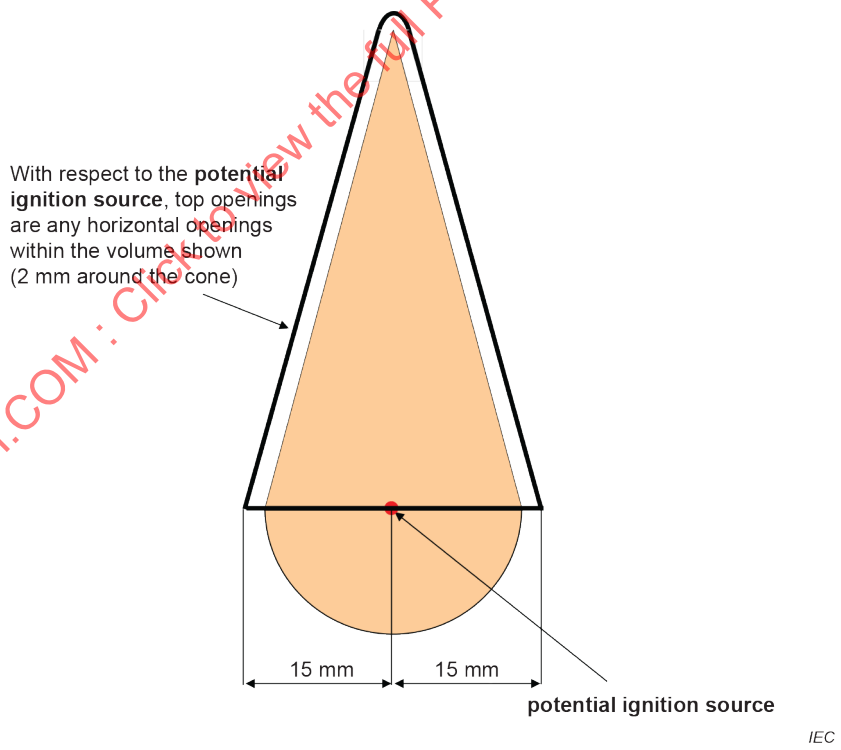
~~*The test is conducted using the needle-flame burner as specified in Clause S.2 placed vertically in a draft-free location. The distance between the inner side of the top openings and the centre of the burner tube is 7 mm ± 1 mm. The sample is placed in its normal operating position. The top openings are covered with a single layer of **cheesecloth**.*~~

~~*The flame is applied for a period of 1 min. The **cheesecloth** shall not ignite.*~~

~~*In case of openings having different dimensions, the test shall be conducted on one opening of each group of the top openings with the same dimensions.*~~

Top opening properties of a **fire enclosure** shall apply to openings on a horizontal surface or any surface with an inclination of more than 5 degrees from vertical (see Figure 40) above a **PIS** located in a PS3 circuit as shown in Figure 41. Top opening properties of a fire barrier shall apply to openings above a **PIS** as shown in Figure 41.

Top openings that fall within the volume defined in Figure 41 shall comply with Clause S.2.



NOTE Dimensions of the cone are identical to Figure 37 and Figure 38.

Figure 41 – Top openings

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No test is required provided that the openings do not exceed:

– *5 mm in any dimension, or*

– *1 mm in width regardless of length.*

6.4.8.3.4 Bottom openings and bottom opening properties

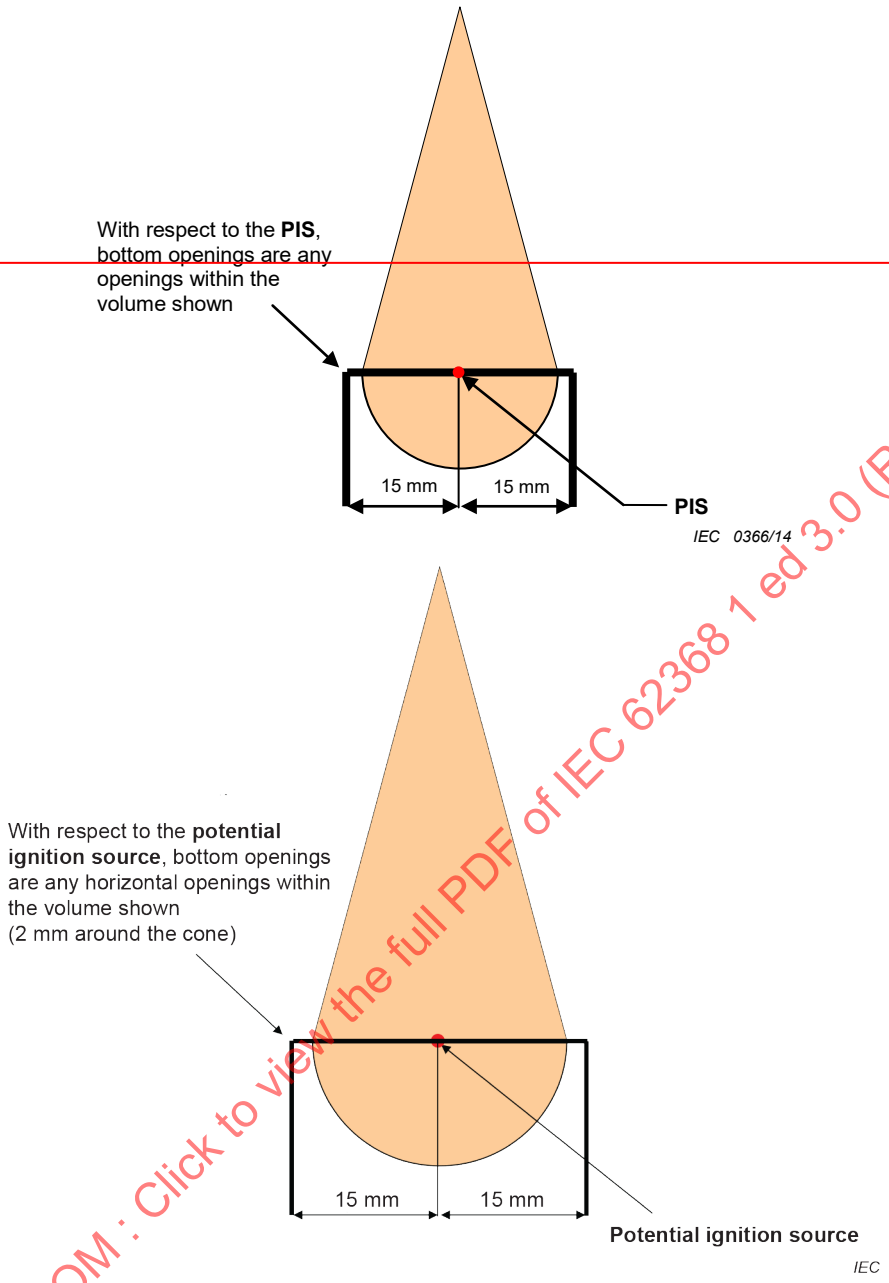
~~Bottom opening properties of a **fire enclosure** and a fire barrier shall apply to openings that are located in the volume as shown in Figure 42.~~

~~NOTE Any openings within the zone as shown in Figure 42 are regarded to be bottom openings, including side openings.~~

Bottom opening properties of a **fire enclosure** and a fire barrier shall apply to openings on a horizontal surface or any other surface with an inclination of more than 5 degrees from the vertical (see Figure 40) below a **PIS** located in a PS3 circuit as shown in Figure 42. Openings on other surfaces below the **PIS** shall be considered side openings and 6.4.8.3.5 applies.

Bottom openings are those openings below a **PIS** and within 30 mm diameter cylinder extending indefinitely below the **PIS**.

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NOTE Dimensions of the cone are identical to Figure 37 and Figure 38.

Figure 42 – Bottom openings

Bottom openings shall comply with Clause S.3.

No test is necessary provided that one of the following conditions is met:

a) the bottom openings do not exceed:
   - 3 mm in any dimension; or
   - 1 mm in width regardless of length.

b) under components and parts meeting the requirements for **V-1 class material**, or **HF-1 class foamed material** or under components that pass the needle-flame test of IEC 60695-11-5 using a 30 s flame application, bottom openings shall not exceed:
   - 6 mm in any dimension; or
   - 2 mm in width regardless of length.

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c) the bottom openings do not exceed a 2 mm by 2 mm mesh of at least 0,45 mm diameter metal wire.

d) the openings in the metal bottom **enclosure** comply with Table 34.

Table 34 – Size and spacing of holes in metal bottoms of fire enclosures

	Circular holes		Other shaped openings	
Metal bottom minimum thickness mm	Maximum diameter of holes mm	Minimum spacing of holes centre to centre mm	Maximum area mm^2	Minimum spacing of openings border to border mm
0,66	1,1	1,7	1,1	0,56
0,66	1,2	2,4	1,2	1,1
0,76	1,1	1,7	1,1	0,55
0,76	1,2	2,4	1,2	1,1
0,81	1,9	3,2	2,9	1,1
0,89	1,9	3,2	2,9	1,2
0,91	1,6	2,8	2,1	1,1
0,91	2,0	3,2	3,1	1,2
1,0	1,6	2,8	2,1	1,1
1,0	2,0	3,0	3,2	1,0

Equipment intended only for use in fixed installations and intended to be floor standing on a non-combustible surface need not be provided with a **fire enclosure** bottom. Such equipment shall be marked in accordance with Clause F.5 in a clearly visible location with the following or equivalent wording:

RISK OF FIRE

Install only on concrete or other non-combustible floor

c) comply with a baffle plate construction as illustrated in Figure 43.

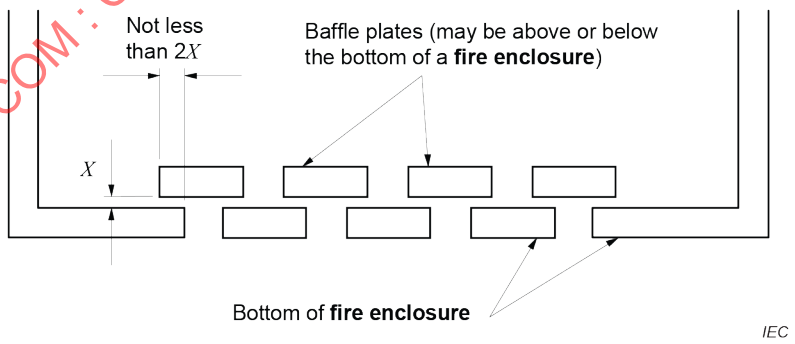


Figure 43 – Baffle plate construction

Fixed equipment intended to be floor standing on a non-combustible surface does not require a **fire enclosure** bottom. Such equipment shall be marked in accordance with Clause F.5, except that element 3 is optional.

The elements of the **instructional safeguard** shall be as follows:

– element 1a: not available

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– element 2: “RISK OF FIRE” or equivalent text
– element 3: optional
– element 4: “Install only on concrete or other non-combustible surface” or equivalent text

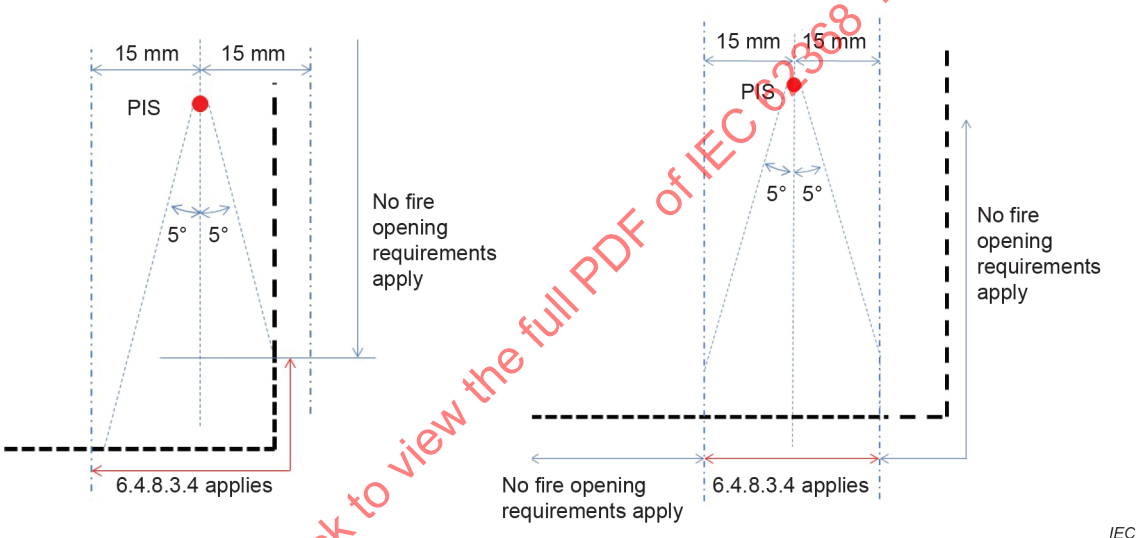
6.4.8.3.5 Side openings and side opening properties

Side opening properties of a **fire enclosure** and a fire barrier shall apply to openings that are on a vertical (± 5 degrees) side surface.

Where a portion of the side of a **fire enclosure** falls within the area indicated by the 5 degree angle in Figure 44, the limitations in 6.4.8.3.4 on sizes of openings in bottoms of **fire enclosures** also apply to this portion of the side.

*Compliance is checked by inspection and measurement. Except for that portion of the side of a **fire enclosure** that is subject to the requirements of 6.4.8.3.5 (see above paragraph), there are no other considerations for side openings.*

NOTE Limitations affecting the size of side openings are contained in other clauses of this document.



The **PIS** can be either a point, a component or a trace on a printed board.

Figure 44 – PIS trajectory downwards

6.4.8.3.6 Integrity of a fire enclosure

If part of a **fire enclosure** consists of a door or cover that can be opened by an **ordinary person**, the door or cover shall comply with requirements a), b), or c):

a) the door or cover shall be interlocked and comply with the **safety interlock** requirements in Annex K.

b) a door or cover, intended to be routinely opened by the **ordinary person**, shall comply with both of the following conditions:
   – it shall not be removable from other parts of the **fire enclosure** by the **ordinary person**; and
   – it shall be provided with a means to keep it closed during **normal operating conditions**.

c) a door or cover intended only for occasional use by the **ordinary person**, such as for the installation of accessories, may be removable if an **instructional safeguard** is provided for correct removal and reinstallation of the door or cover.

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6.4.8.3.7 Compliance criteria

Compliance is checked by inspection of applicable data sheets and, where necessary, by test.

6.4.8.4 Separation of a PIS from a fire enclosure and a fire barrier

A **fire enclosure** or fire barrier made of **combustible material** shall:

– have a minimum distance of 13 mm to an **arcing PIS**; and

– have a minimum distance of 5 mm to a **resistive PIS**.

Smaller distances are allowed provided that the part of the **fire enclosure** or fire barrier within the required separation distance complies with one of the following:

– the **fire enclosure** or fire barrier meets the needle-flame test according to IEC 60695-11-5. Severities are identified in Clause S.2. After the test, the **fire enclosure** or fire barrier material shall not have formed any holes that are bigger than allowed in 6.4.8.3.3 or 6.4.8.3.4 as appropriate; or

– the **fire enclosure** is made of **V-0 class material**; or

– the fire barrier is made of **V-0 class material** or **VTM-0 class material**.

6.4.9 Flammability of an insulating liquid

An **insulating liquid**:

– shall have an auto ignition temperature not less than 300 °C as determined in accordance with ISO 871 or similar national standard (for example ASTM E659-84); and

– shall not flash; or shall have a flashpoint higher than 135 °C determined in accordance with ISO 2719 using Pensky-Martens closed cup method (or a national standard, for example ASTM D93); or by the Small Scale closed cup method in accordance with ISO 3679 (or national standards, for example ASTM D3828 and ASTM D3278).

If transformer oil, silicon oil, mineral oil or other similar oil is used as **insulating liquid**, the oil shall comply with the flash point, fire point or flammability requirements of the applicable IEC standard. See Table 34 for a list of the IEC standards.

The temperature of components in contact with the **insulating liquid** shall not exceed the flashpoint of the **insulating liquid**.

Table 34 – List of applicable IEC standards regarding insulating liquids

IEC 60296	*Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear*
IEC 60836	*Specifications for unused silicone insulating liquids for electrotechnical purposes*
IEC 61039	*Classification of insulating liquids*
IEC 61099	*Insulating liquids – Specifications for unused synthetic organic esters for electrical purposes*
IEC 60076-14	*Power transformers – Part 14: Liquid-immersed power transformers using high-temperature insulation materials*
IEC TS 62332-1	*Electrical insulation systems (EIS) – Thermal evaluation of combined liquid and solid components – Part 1: General requirements*

Compliance is checked by the available data or by inspection and tests as applicable.

6.5 Internal and external wiring

6.5.1 General requirements

In PS2 circuits or PS3 circuits, the insulation on internal or external wiring shall pass the test methods described below, or the equivalent.

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For conductors with a cross-sectional area of 0,5 mm^2 or greater, the test methods in IEC 60332-1-2 and IEC 60332-1-3 shall be used.

For conductors with a cross-sectional area of less than 0,5 mm^2, the test methods in IEC 60332-2-2 shall be used.

For both internal and external wiring, the test method described in IEC TS 60695-11-21 may be used instead of the test methods in IEC 60332-1-2, IEC 60332-1-3 or IEC 60332-2-2.

NOTE Wire complying with UL 2556 VW-1 is considered to comply with these requirements.

~~**6.5.2 Compliance criteria**~~

The insulated conductor or cable shall be acceptable if it complies with the recommended performance requirements of the applicable IEC 60332 standards or with the requirements of IEC TS 60695-11-21.

6.5.2 Requirements for interconnection to building wiring.

Equipment intended to provide power over the wiring system to remote equipment shall limit the output current to a value that does not cause damage to the wiring system, due to overheating, under any external load condition. The maximum continuous current from the equipment shall not exceed a current limit that is suitable for the minimum wire gauge specified in the equipment installation instructions.

NOTE This wiring is not usually controlled by the equipment installation instructions, since the wiring is often installed independent of the equipment installation.

PS2 circuits or PS3 circuits that provide power and that are intended to be compatible with LPS to **external circuits** (see Annex Q) shall have their output power limited to values that reduce the likelihood of ignition within building wiring ~~or external devices located in a different room~~.

~~*Compliance is checked with Clause Q.1.*~~

~~Circuits providing power to devices or external components that are intended for use in the same room as the EUT are not subject to this requirement. See 6.6 for connection to secondary equipment.~~

External paired conductor cable circuits, such as those described in Table 13, ID numbers 1 and 2 having a minimum wire diameter of 0,4 mm, shall have the current limited to 1,3 A.

EXAMPLE Time/current characteristics of type gD and type gN fuses specified in IEC 60269-2 comply with the above limit. Type gD or type gN fuses rated 1 A, would meet the 1,3 A current limit.

~~*Compliance is checked with Clause Q.1.2.*~~

~~**6.5.4 Compliance criteria**~~

Compliance is checked by test, inspection and where necessary by the requirements of Annex Q.

6.5.3 Internal wiring for socket-outlets

Internal wiring for socket-outlets or appliance outlets providing **mains** power to other equipment shall have a nominal cross-sectional area at least as specified in Table G.7, including the condition of footnote [a].

Compliance is checked by inspection.

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6.6 Safeguards against fire due to the connection of additional equipment

~~Where it is unknown that the connected equipment or accessories (for example, a scanner, mouse, keyboard, DVD drive, CD-ROM drive or joystick) are likely to comply with this standard, the delivered power shall be limited to PS2 or shall comply with Clause Q.1.~~

The power delivered to connected equipment or accessories shall be limited to PS2 or shall comply with Clause Q.1, unless it is likely that the connected equipment or accessory also complies with this document.

This requirement does not apply to the audio output of audio amplifiers.

EXAMPLE Connected equipment or accessories that are likely to comply with this document include a scanner, a mouse, a keyboard, a DVD drive, a CD ROM drive or a joystick.

Compliance is checked by inspection or measurement.

7 Injury caused by hazardous substances

7.1 General

To reduce the likelihood of injury due to exposure to **hazardous substances**, equipment shall be provided with the **safeguards** specified in Clause 7.

NOTE 1 These **safeguards** are not intended to be the only means to reduce the likelihood of such injury.

NOTE 2 The classification of other possible **hazardous substances** not addressed in Clause 7 is not covered by this document. In many regions of the world different legislation applies, such as Restriction of Hazardous Substances Directive (RoHS) and Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH).

7.2 Reduction of exposure to hazardous substances

The exposure to **hazardous substances** shall be reduced. Reduction of exposure to **hazardous substances** shall be controlled by using containment of the **hazardous substances**. Containers shall be sufficiently robust and shall not be damaged or degraded by the contents over the lifetime of the product.

Compliance is checked by:

– *the examination of the effects the chemical has on the material of the container; and*

– *any relevant tests of Annex T according to 4.4.3, following which there shall be no leakage from the container.*

7.3 Ozone exposure

For equipment that produces ozone, the installation and operating instructions shall indicate that precaution shall be taken to ensure that the concentration of ozone is limited to a safe value.

NOTE 1 Currently, the typical long term exposure limit for ozone is considered to be $0{,}1 \times 10^{-6}$ ($0{,}2\ mg/m^3$) calculated as an 8 h time-weighted average concentration. Time-weighted average is the average level of exposure over a given time period.

NOTE 2 Ozone is heavier than air.

Compliance is checked by inspection of instructions or accompanying documents.

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7.4 Use of personal safeguards or personal protective equipment (PPE)

Where **safeguards**, such as containment of a chemical, are not practical, a **personal safeguard** and its use shall be specified in the instructions that are provided with the equipment.

Compliance is checked by inspection of instructions or accompanying documents.

7.5 Use of instructional safeguards and instructions

Where a **hazardous substance** is capable of causing an injury, **instructional safeguards** as specified in ISO 7010 and instructions shall be applied to the equipment in accordance with Clause F.5.

Compliance is checked by inspection of instructions or accompanying documents.

7.6 Batteries and their protection circuits

Batteries and their protection circuits shall comply with Annex M.

8 Mechanically-caused injury

8.1 General

To reduce the likelihood of injury due to exposure to mechanical hazards, equipment shall be provided with the **safeguards** specified in Clause 8.

NOTE 1 In some cases, the person is the source of the kinetic energy.

NOTE 2 Where not specifically mentioned in Clause 8, the words “products” and “equipment” also cover carts, stands and carriers used with these products or equipment.

8.2 Mechanical energy source classifications

8.2.1 General classification

Various categories of mechanical energy sources are given in Table 35.

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Table 35 – Classification for various categories of mechanical energy sources

Line	Category	MS1	MS2	MS3
1	Sharp edges and corners	Does not cause pain or injury [b]	Does not cause injury [b] but may be painful	May cause injury [c]
2	Moving parts	Does not cause pain or injury [b]	Does not cause injury [b] but may be painful	May cause injury [c]
3a	Plastic fan blades [a] See Figure 46	$\frac{N}{15\,000} + \frac{K}{2\,400} \leq 1$	~~> MS1; and~~ $\frac{N}{44\,000} + \frac{K}{7\,200} \leq 1$	> MS2
3b	Other fan blades [a] See Figure 45	$\frac{N}{15\,000} + \frac{K}{2\,400} \leq 1$	~~> MS1; and~~ $\frac{N}{22\,000} + \frac{K}{3\,600} \leq 1$	> MS2
4	Loosening, exploding or imploding parts	NA	NA	See [d]
5	Equipment mass [f]	≤ 7 kg	~~7 kg < mass~~ ≤ 25 kg	> 25 kg
6	Wall/ceiling or other structure mount [f]	Equipment mass ≤ 1 kg mounted ≤ 2 m [e]	Equipment mass > 1 kg mounted ≤ 2 m [e]	All equipment mounted > 2 m

[a] The K factor is determined from the formula $K = 6 \times 10^{-7} (m\ r^2\ N^2)$, where m is the mass (kg) of the moving part of the fan assembly (blade, shaft and rotor), r is the radius (mm) of the fan blade from centre line of the motor (shaft) to the tip of the outer area likely to be contacted, N is the rotational speed (rpm) of the fan blade.

In the end product, the fan maximum operational voltage can be different than the **rated voltage** of the fan and this difference should be taken into account.

[b] The phrase “Does not cause injury” means that, according to experience and/or basic safety standards, a doctor or hospital emergency attention is not needed.

[c] The phrase “May cause injury” means that, according to experience and/or basic safety standards, a doctor or hospital emergency attention may be needed.

[d] The following equipment constructions are examples considered MS3:

– CRTs having a maximum face dimension exceeding 160 mm; and

– lamps in which the pressure exceeds 0,2 MPa when cold or 0,4 MPa when operating.

[e] This classification can only be used if the manufacturer’s instructions state that the equipment is only suitable for mounting at heights ≤ 2 m.

[f] Mass of supplies, **consumable materials**, media or the like that may be contained in the equipment shall be included in the calculation of the equipment mass. The additional mass of such items is determined by the manufacturer.

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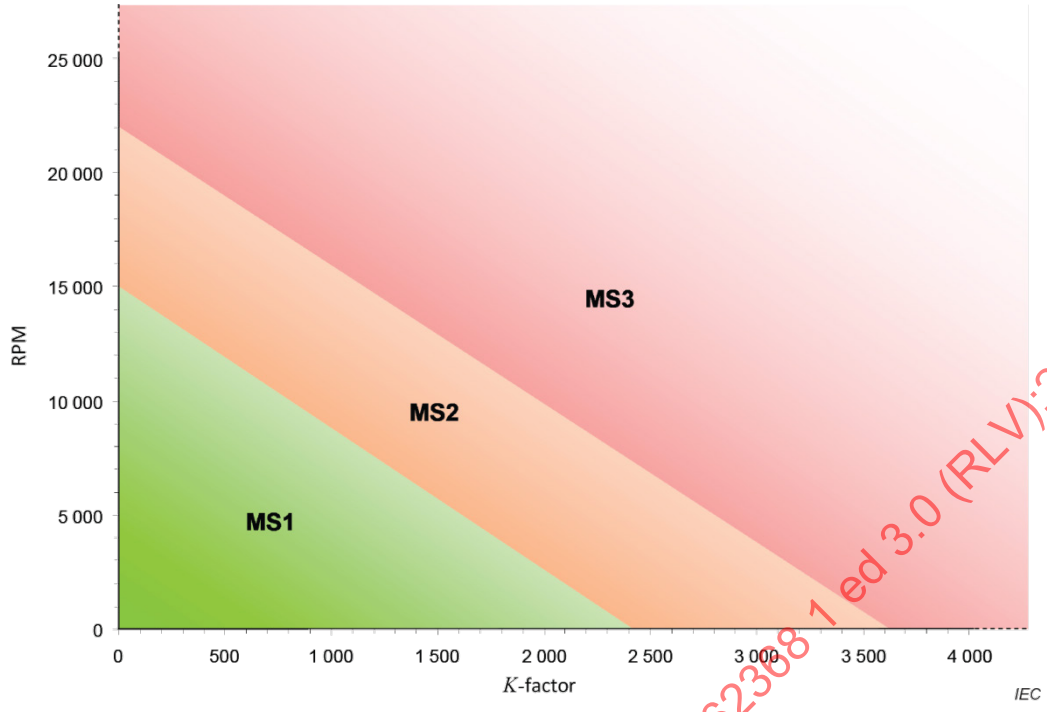


Figure 45 – Limits for moving fan blades made of non-plastic materials

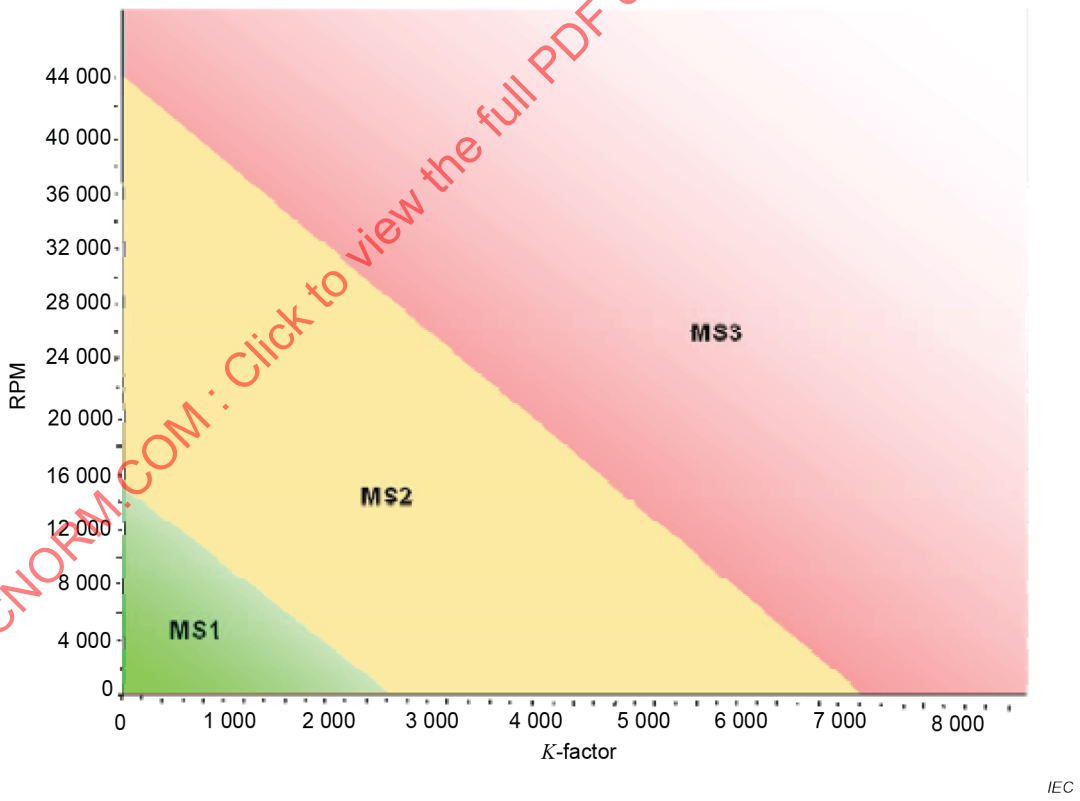


Figure 46 – Limits for moving fan blades made of plastic materials

8.2.2 MS1

MS1 is a class 1 mechanical energy source with levels not exceeding MS1 limits under **normal operating conditions** and **abnormal operating conditions** and not exceeding MS2 under **single fault conditions**.

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8.2.3 MS2

MS2 is a class 2 mechanical energy source with levels not exceeding MS2 limits under **normal operating conditions**, **abnormal operating conditions**, and **single fault conditions**, but is not MS1.

8.2.4 MS3

MS3 is a class 3 mechanical energy source with levels exceeding MS2 limits under **normal operating conditions**, **abnormal operating conditions** or **single fault conditions**, or any mechanical energy source declared to be treated as MS3 by the manufacturer.

8.3 Safeguards against mechanical energy sources

Except as given below, **safeguard** requirements for parts **accessible** to **ordinary persons**, **instructed persons** and **skilled persons** are given in 4.3.

An **instructional safeguard** shall be provided for MS2 that is not obvious to an **instructed person** or for MS3 that is not obvious to a **skilled person**.

Other MS3 parts not actively being serviced shall be located or guarded so that unintentional contact with such parts during service operations is an unlikely result in the **skilled person** involuntary recoiling from class 2 or class 3 energy sources being serviced.

8.4 Safeguards against parts with sharp edges and corners

8.4.1 Requirements

Safeguards that reduce the likelihood of injury by parts with sharp edges and corners in **accessible** areas of the equipment are specified below.

Classification of the energy sources shall be done according to Table 35, line 1.

Where a sharp edge or corner classified as MS2 or MS3 is required to be **accessible** for the function of the equipment:

– any potential exposure shall not be life threatening; and
– the sharp edge or corner shall be obvious to an **ordinary person** or an **instructed person** when exposed; and
– the sharp edge shall be guarded as much as practicable; and
– an **instructional safeguard** shall be provided to reduce the risk of unintentional contact in accordance with Clause F.5, except that element 3 is optional.

The elements of the **instructional safeguard** shall be as follows:

– element 1a:  , IEC 60417-6043 (2011-01)
– element 2: “Sharp edges” or equivalent text
– element 3: optional
– element 4: “Do not touch” or equivalent text

8.4.2 Compliance criteria

*Where a sharp edge or corner is required to be **accessible** for the function of the equipment, compliance is checked by inspection.*

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*Where a sharp edge or corner is not required to be **accessible** for the function of the equipment compliance is checked by the relevant tests of Annex V. During and after the application of the force, the sharp edge or corner shall not be **accessible**.*

8.5 Safeguards against moving parts

8.5.1 Requirements

Safeguards that reduce the likelihood of injury caused by moving parts of the equipment (for example, pinch points, meshing gears and parts that may start moving due to unexpected resetting of a control device) are specified below.

Plastic fan blades are classified according to Table 35, line 3a. Other fan blades are classified according to Table 35, line 3b. Other moving parts are classified according to Table 35, line 2.

NOTE 1 The ability of a part to cause injury is not solely dependent upon the kinetic energy it possesses. Consequently, the classification used in this document can only be based on typical experience and engineering judgement.

NOTE 2 Examples of factors influencing the energy transfer to a body part include shape of the surface that strikes the body part, elasticity, velocity and the mass of equipment and body part.

If a **safety interlock** is used as **safeguard**~~, it shall comply with Annex K. The movement~~ the energy of the moving part shall be reduced to MS1 before the part is **accessible**.

Unless otherwise specified, where the likelihood exists that fingers, jewellery, clothing, hair, etc., can come into contact with moving MS2 or MS3 parts, an **equipment safeguard** shall be provided to prevent entry of body parts or entanglement of such items.

If a moving MS2 part is required to be **accessible** for the function of the equipment to an **ordinary person**~~ or~~, the moving part shall be guarded as much as practicable and an **instructional safeguard** as given in 8.5.2 shall be used.

If a moving MS3 part is required to be **accessible** for the function of the equipment to an **ordinary person** or an **instructed person**:

– any exposure shall not be life threatening; and

– the moving part shall be obvious when exposed; and

– the moving part shall be guarded as much as practicable; and

– an **instructional safeguard** as given in 8.5.2 shall be used; and

– ~~for MS3,~~ a manually activated stopping device shall be clearly visible and placed in a prominent position within 750 mm of the MS3 part.

  Components of the manually activated stopping device shall be of an electromechanical type. A manually activated stopping device may consist of:

  - a switch complying with IEC 61058-1 and that meets the requirements of Annex K and that is provided with a latching type mechanism meeting the requirements of IEC 60947-5-5, or
  - an emergency stop device in accordance with IEC 60947-5-5.

  Restarting of the mechanical system shall only be possible by initiating a start control procedure after the manually activated stopping device has been manually reset.

Moving MS3 parts:

– that are only **accessible** to a **skilled person**; and

– where the MS3 moving part is not obvious (for example, a device having intermittent movement),

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shall have an **instructional safeguard** as given in 8.5.2. Unless the moving part is arranged, located, enclosed or guarded in such a way that the possibility of contact with the moving parts is unlikely, a stopping device shall be placed in a clearly visible and prominent position within 750 mm of the MS3 part.

8.5.2 Instructional safeguard requirements

An **instructional safeguard** shall be provided to reduce the likelihood of unintentional contact with a moving part in accordance with Clause F.5, except that element 3 is optional.

The elements of the **instructional safeguard** shall be as follows:

– element 1a:  IEC 60417-6056 (2011-05) for moving fan blades; or

 IEC 60417-6057 (2011-05) for other moving parts

– element 2: “Moving parts” or “Moving fan blade” as applicable, or equivalent text

– element 3: optional

– element 4: “Keep body parts away from moving parts” or “Keep body parts away from fan blades” or “Keep body parts out of the motion path” as applicable, or equivalent text

During **ordinary person** servicing conditions, where it is necessary to defeat or bypass the **equipment safeguard** preventing access to a moving part classified as MS2, an **instructional safeguard** shall be provided to:

– disconnect the power source prior to defeating or bypassing the **equipment safeguard**; and

– restore the **equipment safeguard** before restoring power.

8.5.3 Compliance criteria

The accessibility of moving parts shall be checked by inspection and, if necessary, be evaluated according to the relevant parts of Annex V.

8.5.4 Special categories of equipment ~~comprising~~ containing moving parts

~~**8.5.4.1 Large data storage equipment**~~

~~The requirements of IEC 60950-23 are additional to the relevant requirements in this standard.~~

~~Large equipment is typically of such a size that a person may enter completely. Systems may also include similar equipment having areas containing moving parts into which only a complete limb or head may enter. These requirements apply to a three-dimensional envelope of 0,75 m^3 or more within reach of the moving part.~~

~~The following references in IEC 60950-23 shall be treated as follows:~~

~~– replace IEC 60950-1:2005, 2.8 by Annex K;~~

~~– replace IEC 60950-1:2005, 2.8.6 by Clause K.4;~~

~~– replace "SERVICE PERSON" by **"skilled person"**;~~

~~– replace "OPERATOR ACCESS AREA" by "areas **accessible** by an **ordinary person** as determined by Annex V".~~

~~NOTE An example of these systems is a self-contained data storage system.~~

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8.5.4.1 General

Clause 8.5.4 applies to large self-contained equipment installed in **restricted access areas** (for example, a data centre), typically of such a size that a person may enter completely, or may insert a complete limb or head into areas containing hazardous moving parts and where a person is expected to enter the area to service or operate the equipment.

Equipment covered by this paragraph are automated information mass storage and retrieval systems that use integral hazardous moving parts for the handling of recorded media (for example, tape cartridges, tape cassettes, optical discs, etc.) and similar functions and large printers.

8.5.4.2 Equipment containing work cells with MS3 parts

8.5.4.2.1 Protection of persons in the work cell

During **normal operating conditions**, no MS3 moving parts shall be **accessible** at the outer **enclosure** of a **work cell.**

The equipment shall be provided with **safeguards** to reduce the risk of injury due to MS3 moving parts in the **work cell**. Other class 3 energy sources within a **work cell** shall not be **accessible** under **normal operating conditions**, **abnormal operating conditions** and **single fault conditions**.

EXAMPLES **Safeguards** include interlocks, barriers and awareness signals, together with designated procedures and training.

NOTE 1 Some authorities may require installation of fire detection and extinguishing systems in **work cells**.

Access to a **work cell** or any of its compartments shall be protected by either of the following methods:

– Method 1 – **Safety interlock** method. No key or **tool** is needed to gain entry to the **work cell**. **Safety interlocks** meeting the requirements of Annex K shall be provided to prevent access to the **work cell** while power is available to the MS3 moving parts in that compartment. Power to the MS3 moving parts shall not be restored until the doors are closed and latched. Opening of the interlocked access door into any compartment of a **work cell** containing MS3 moving parts, or an access door between a compartment containing MS3 moving parts and one that has been disabled, shall automatically initiate disconnection of the supply to such parts, and to reduce to a class 2 energy source within 2 s for an **instructed person** or a **skilled person**. If reduction of the energy source class takes longer than 2 s, then an **instructional safeguard** shall be provided in accordance with Clause F.5.

– Method 2 – Key or **tool** method. A key or **tool** shall be required to gain and control access to the **work cell**, and access to the **work cell** shall be prevented while power is available to the MS3 moving parts in that **work cell**. The operating and servicing instructions, as appropriate, shall specify that the key or **tool** must be carried by the person while in the **work cell**. When the **work cell** can be entered completely closing of the door without the key or **tool** shall not result in the equipment being restarted automatically.

  NOTE 2 The key or **tool** may be used as the means to remove power before access to the **work cell** or compartment.

Except as permitted in 8.5.4.2.2, it shall not be possible to start or restart the system until all relevant access doors are closed and latched.

Where it is possible to enter a **work cell** completely, an automatically activated mechanical interlock shall be provided so that the door cannot be closed inadvertently if this closure would allow the equipment to be restarted. It shall be possible to open any door from inside the **work cell** without the use of a key or **tool**. The means of opening the door from inside the **work cell** shall be readily identifiable and visible, whether the door is open or closed, irrespective of the operating status of the equipment.

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Compliance is checked by inspection.

During servicing of the equipment, there may be a need to energize the equipment to allow for alignment, etc. In such cases, under **single fault conditions** or **abnormal operating conditions**, adequate means shall be provided to limit the movement of the parts so that they do not become MS3, such as by extended travel or by having parts detach and be ejected from the moving assembly. Such means shall be capable of limiting these moving parts to less than MS3 under rated load, maximum speed conditions and at maximum extension.

*Compliance is checked by inspection, and, if necessary, by the tests of B.3 and B.4. The **enclosure** or compartment separation barriers shall contain any part that may become detached during the test.*

8.5.4.2.2 Access Protection Override

8.5.4.2.2.1 General

If it is necessary for a **skilled person** to override a protective mechanism such as a **safety interlock** for access to a **work cell** or compartment, an override system complying with Clause K.4 shall be provided. In addition, when an override system is used, an emergency stop system shall be provided in accordance with 8.5.4.2.3, and shall comply with the operational endurance requirements of 8.5.4.2.4.

Compliance is checked by inspection.

8.5.4.2.2.2 Visual indicator

A set of two or more bright flashing indicators complying with IEC 60073 shall operate under the following conditions:

a) for a **work cell** or compartment that can be entered completely to indicate the equipment is being restored to normal operation and motion is pending; or

b) for any equipment when the interlock is overridden and drive power is available to MS3 moving parts.

The indicators shall be readily visible at any point within the **work cell** or relevant compartment and at the point of entry. For condition a), the indicators shall operate for a minimum of 10 s prior to movement of a MS3 moving part along the most significant axis. If condition a) can occur while condition b) is in effect, there shall be a change of light sequencing such that the change in status will be obvious to persons in or at the point of entry to the **work cell**.

NOTE The most significant axis is the one with the longest travel distance. This is usually the horizontal (X) axis.

Compliance is checked by inspection and test.

8.5.4.2.3 Emergency stop system

This subclause only applies if a **safety interlock** override is provided as specified in 8.5.4.2.2.

An emergency stop system shall override all other controls, remove drive power from MS3 moving parts and employ automatic braking, if necessary, to cause all these moving parts to stop within a reasonable time period such that a level 3 hazard cannot be contacted.

Components of the emergency stop system shall be of an electromechanical type. An emergency stop control may consist of:

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– a switch complying with IEC 61058-1 and that meets the requirements of Annex K and that is provided with a latching type mechanism meeting the requirements of IEC 60947-5-5, or equivalent; or

– an emergency stop device in accordance with IEC 60947-5-5.

NOTE In the United Kingdom, an emergency stop system complying with the requirements of IEC 60204-1 and ISO 13850 is required where there is a risk of personal injury.

Alternatively, the safety function of the emergency stop system shall have a Safety Integrity Level (SIL) per IEC 62061, or a Performance Level (PL) per ISO 13849-1 that is consistent with the results of a risk assessment of the **work cell**.

Restarting of the mechanical system shall only be possible by initiating a start control procedure after the emergency stop control has been manually reset.

For equipment where a person may completely enter the **work cell**, the emergency stop system shall include a minimum of two emergency stop controls, one outside the **work cell** and one within the **work cell**. The system start up procedure shall include a non-hazardous method to ensure no person is present in the **work cell**. If it can be shown, after application of the single fault tests specified in 8.5.4.2.4 to the movement control circuitry or other sensing means, that such tests do not by-pass the non-hazardous start up procedure, the emergency stopping distance test of this subclause is not required.

For equipment where a person may only partially enter a **work cell** or compartment, a minimum of one emergency stop control shall be provided outside of the **work cell**. The emergency stop system shall be operable by the person needing to have access to the **work cell**.

An emergency stop control provided outside the **work cell** shall be readily visible and shall be located on the equipment such that the person operating it can see if the **work cell** is occupied. The installation instructions shall require that space be provided around the control so that an **instructed person** or **skilled person** can easily reach and activate it.

An emergency stop control provided inside the **work cell** shall be readily accessible from anywhere inside the **work cell** and shall be provided with lighting to permit easy identification. It shall consist of a red palm or mushroom head button or be provided with an indirect arrangement, such as an easily identifiable red safety cable, that activates the emergency stop system.

Compliance is checked by inspection and, if necessary, by the following tests.

While the mechanical system is operating at its maximum kinetic energy (carrying maximum load capacity at maximum speed), the emergency stop system is to be activated and the distance to stop measured. The results of the distance measurements shall show that after activation of the emergency stop system, any subsequent motion in any direction would be unlikely to present a risk of injury.

The maximum stopping distance from the point of activation, along the most significant axis, shall be 1 m or less. In addition, if there is an end point along the most significant axis beyond which the MS3 moving part does not operate, there shall be at least 150 mm of empty space available between this end point and the nearest fixed mechanical part, intended to provide sufficient space for a person not to be harmed. The requirements of B.3.8 apply.

8.5.4.2.4 Endurance requirements

Except as referenced in 8.5.4.2.3, this subclause only applies when a **safety interlock** override is provided as specified in 8.5.4.2.2, or if any **instructed person** or **skilled person accessible** cable contains ES3 voltages.

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Movable cable assemblies are tested to ensure that no mechanical damage occurs that could result in any of the following:

– a malfunction of the **safety interlock** system;
– compromise any compartment separation barriers or **mechanical enclosures**;
– expose a person to other hazards.

If the voltage in these cables and movement control circuitry are ES3, mechanical endurance tests shall be applied to ensure that no electric shock hazard results.

For cables that carry only voltages meeting the requirements for ES1, if it can be shown that single open-circuit or short-circuit fault testing of these cables and movement control circuitry would not result in a hazard, they are exempt from the mechanical endurance tests.

Compliance is checked by inspection and, when necessary, by the following mechanical endurance tests.

The mechanical system, including the means (for example, limit switches) that limit movement during normal operation, are subjected to 100 000 cycles of operation at rated load and maximum speed through the maximum length or rotation of travel permitted by the design.

After the cycling:

– *a mechanical function check (for example, MS3 moving parts to operate electromechanical switches; end of travel mechanical stop, etc.) and a visual inspection, are conducted. Mechanical stops and electromechanical switches shall perform as intended. There shall be no evidence of loss of mechanical integrity. All safety-related functions (including emergency stop systems, and the like, as applicable) shall operate normally; and*
– *the assembly cables that control the MS3 moving parts, other than those containing only ES1, are examined for damage that exposes conductors carrying greater than ES1. No conductor shall be broken and no individual strands shall have penetrated the insulation. If damage cannot be determined by inspection, the cable assembly shall pass an electric strength test of 1 000 V, in accordance with 5.4, applied between the conductors carrying greater than ES1 and foil wrapped around the body of the cable.*

8.5.4.3 Equipment having an electromechanical device for destruction of media

8.5.4.3.1 General requirements

Equipment safeguards to protect persons, including children, for equipment intended to mechanically destroy various media by means of moving parts that draw the media into the equipment are specified below. The media destruction device within this equipment is classed as MS3.

~~NOTE 1~~ EXAMPLES Equipment that includes household use and home-office use document shredding and similar media destruction devices, as determined by the nature of their power source.

For equipment for use in locations where children are not likely to be present, see Clause F.4.

NOTE ~~2~~ This equipment design typically applies to commercial or industrial equipment expected to be installed in locations where only adults are normally present.

Equipment shall be provided with **safeguards** so that MS3 moving parts are not **accessible** to the appropriate jointed test probe of Annex V and the wedge probe of Figure V.4. Requirements for **safety interlocks** are according to ~~Annex K~~ 4.4.5, except that where a moving part cannot be reduced to the appropriate energy class within 2 s, the **safety interlock** shall continue to prevent access.

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8.5.4.3.2 Instructional safeguards against moving parts

For equipment installed where children may be present, an **instructional safeguard** shall be provided in accordance with Clause F.5, except that element 3 is optional.

The elements of the **instructional safeguard** shall be as follows:

– element 1a:  , IEC 60417-6057 (2011-05)

– element 2: optional

– element 3: optional

– element 4: “This equipment is not intended for use by children” and “Avoid touching the media feed opening with the hands, clothing or hair” and “Unplug this equipment when not in use for an extended period of time” or equivalent text

8.5.4.3.3 Disconnection from the supply

An isolating switch complying with Annex L shall be provided to disconnect power to MS3 moving parts. A switch with an “OFF” position, that removes all power from the MS3 moving part is acceptable. The switch shall be located where it is easily **accessible** to the user whose body part or clothes may be caught.

The ”ON" and "OFF" positions of a two-position switch shall be marked in accordance with F.3.5.2.

For a multi-position switch, the "OFF" position of the switch shall be marked in accordance with F.3.5.2, and the other positions shall be marked with appropriate words or symbols.

8.5.4.3.4 Test method

The media destruction device is tested with the wedge probe of Figure V.4 applied in any direction relative to the opening:

– *with a force up to 45 N for a strip-cut type device; and*

– *with a force up to 90 N for a cross-cut type device.*

NOTE Media destruction devices are typically identified as either strip-cut type or cross-cut type. A strip-cut media destruction device shreds the media into long strips using a motor-based shredding mechanism. A cross-cut media destruction device shreds the media two or more ways into tiny particles, typically using a more powerful motor and more complex shredding mechanism.

*Any **enclosure** or guard that can be removed or opened by an **ordinary person** or an **instructed person** shall be removed or opened prior to application of the probes.*

8.5.4.3.5 Compliance criteria

Compliance is checked in accordance with V.1.2 and V.1.5. The wedge probe shall not contact any moving part.

*Where the equipment is provided with a **safety interlock**, compliance is checked according to ~~Annex K~~ 4.4.5, except where a moving part cannot be reduced to the appropriate energy class within 2 s, the **safety interlock** shall continue to prevent access.*

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8.5.5 High pressure lamps

8.5.5.1 General

The containment mechanism for high pressure lamps that are considered MS3 according to Line 4 of Table 35 shall have adequate strength to contain an **explosion** of the lamp so as to reduce the likelihood of injury to an **ordinary person** or **instructed person** during normal use, or lamp assembly replacement, as appropriate.

8.5.5.2 Test method

For the protection against the effects of a high pressure lamp failure, the following test is performed as follows:

- *lamp assemblies considered MS3 parts during field replacement are tested separate from the equipment;*
- *lamp assemblies only considered MS3 parts during operation, may be tested separately, or as normally installed in the equipment, or both.*

*An **explosion** of the lamp is stimulated by mechanical impact, electronic pulse generator or similar method. The lamp shall operate for at least 5 min to obtain operational temperature and pressure. To evaluate the rupture results for potential debris area and particle size, the equipment or lamp assembly is placed on a horizontal surface, and a dark sticky mat (or another adequate method) of adequate size to capture the particles is placed near the exhaust vent of the equipment. The equipment opening shall be oriented to maximize potential for particles to be expelled from the product horizontally across the dark sticky mat. After the rupture, the glass particles generated are measured using a magnified glass piece with a 0,1 mm resolution. The test shall be conducted to simulate the worst case operating position specified in the instructions.*

NOTE It is easier for the inspection of potential glass debris if the sticky mat has a dark blue colour.

An example of an electronic pulse generator method is given in Figure D.3.

The charge is increased in steps of 5 J until the lamp ruptures are repeatable.

8.5.5.3 Compliance criteria

Compliance is checked by physical inspection or, if necessary, by the tests of 8.5.5.2.

When tested in accordance with 8.5.5.2, inspect the dark sticky mat for glass particles, and:

- *glass particles less than 0,8 mm in the longest axis shall not be found beyond 1 m of the **enclosure** opening; and*
- *glass particles equal to or greater than 0,8 mm in the longest axis shall not be found.*

*For **professional equipment**, where it is unlikely that the particles will be within reach of an **ordinary person**, the value of 0,8 mm may be replaced with 5 mm.*

8.6 Stability of equipment

8.6.1 Requirements

Classification of products for the purposes of assessing equipment stability is to be done according to Table 35, line 5.

In case units are fixed together, the MS class is determined by the total weight of the units. If units are intended to be separated for relocation, the MS class is determined by the individual weight.

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Individual units that are designed to be mechanically fixed together on site and are not used individually, or **stationary equipment**, shall be assessed by inspection after installation according to the manufacturer's instructions and, if necessary, tested according to 8.6.2.2.

Equipment shall comply with the requirements and tests given in 8.6.2, 8.6.3, 8.6.4 and 8.6.5 according to Table 36. Where an "x" is given, it means that the test is applicable.

Table 36 – Overview of requirements and tests

Equipment type		Type of test				
		Static stability	Downward force	Relocation	Glass slide [b]	Horizontal force
		8.6.2.2	8.6.2.3	8.6.3	8.6.4	8.6.5
MS1	All equipment	No stability requirements				
MS2	Floor standing			x		
	Non-floor standing	x				
	Controls or display [a]	x			x	~~x~~
	Fixed equipment [b]	No stability requirements				
MS3	Floor standing	x	x	x		
	Non-floor standing	x				
	Controls or display [a]	x			x	x
	Fixed equipment	No stability requirements				

[a] Equipment with front mounted **accessible** user controls and equipment having displays with moving images likely to be used in the home or similar installation environments where the equipment may be **accessible** to children.

[b] ~~Where equipment is expected to be installed by an **ordinary person**, equipment having a screw hole or other means to secure the equipment, such as for securement to a table or for earth quake protection, is not considered to be fixed. Such securements are considered to be **supplementary safeguards**.~~

The glass slide test is not applicable to floor standing equipment, even though the equipment may have controls or a display.

Where thermoplastic materials ~~are involved in~~ have an influence on the ~~construction~~ stability of the equipment, the relevant stability tests shall be conducted after the stress relief test in Clause T.8 when the equipment has cooled to room temperature.

MS2 and MS3 television sets shall have an **instructional safeguard** in accordance with Clause F.5, except that the **instructional safeguard** may be included in the installation instructions or equivalent document accompanying the equipment.

The elements of the **instructional safeguard** shall be as follows:

– element 1a: not available
– element 2: "Stability Hazard" or equivalent word
– element 3: "The television set may fall, causing serious personal injury or death" or equivalent text
– element 4: the text below or equivalent text

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~~Never place a television set in an unstable location.~~ A television set may fall, causing serious personal injury or death. Many injuries, particularly to children, can be avoided by taking simple precautions such as:

- ~~Using~~ ALWAYS use cabinets or stands or mounting methods recommended by the manufacturer of the television set.
- ~~Only using~~ ALWAYS use furniture that can safely support the television set.
- ~~Ensuring~~ ALWAYS ensure the television set is not overhanging the edge of the supporting furniture.
- ALWAYS educate children about the dangers of climbing on furniture to reach the television set or its controls.
- ALWAYS route cords and cables connected to your television so they cannot be tripped over, pulled or grabbed.
- NEVER place a television set in an unstable location.
- ~~Not placing~~ NEVER place the television set on tall furniture (for example, cupboards or bookcases) without anchoring both the furniture and the television set to a suitable support.
- ~~Not placing~~ NEVER place the television set on cloth or other materials that may be located between the television set and supporting furniture.
- ~~Educating children about the dangers of climbing on furniture to reach the television set or its controls.~~
- NEVER place items that might tempt children to climb, such as toys and remote controls, on the top of the television or furniture on which the television is placed.

If the existing television set is going to be retained and relocated, the same considerations as above should be applied.

8.6.2 Static stability

8.6.2.1 Test setup

The equipment shall be blocked, if necessary, by means of a stop of the smallest dimensions possible to keep it from sliding or rolling during the test. During the tests, containers, if any, are to contain the amount of substance within their rated capacity that will result in the most disadvantageous condition.

*All doors, drawers, casters, adjustable feet and other appurtenances~~, if used by~~ that are **accessible** to an **ordinary person**, are arranged in any combination that results in the least stability. Equipment provided with multi-positional features shall be tested in the least favourable position based on the equipment construction. However, if the casters are intended only to transport the unit, and if the installation instructions require adjustable feet to be lowered after installation, then the adjustable feet (and not the casters) are used in this test.*

*Where equipment is subject to periodic maintenance or routinely serviced or repaired at its intended use location, the doors, drawers, etc. or any other adjustment means **accessible** to an **instructed person** or **skilled person** shall be arranged in any combination specified by the servicing instructions that results in the least stability.*

The tests of 8.6.2.2 and 8.6.2.3 shall be performed as indicated in Table 36.

8.6.2.2 Static stability test

~~*Equipment shall not tip over when a force equal to 20 % of the weight of the unit, but not more than 250 N, is applied in any direction, except upwards, to any point on the equipment in such a way as to produce the maximum overturning moment. The test may be applied at any height not exceeding 1,5 m from the base of the equipment. The test force shall be discontinued if the equipment remains stable after being tilted 10° from vertical. Alternatively, the equipment shall be tipped at any angle from the vertical up to and including 10°.*~~

The equipment shall be subjected to one of the following tests:

- *The equipment is tilted in all directions such that the base of the equipment is at an angle up to and including 10°; or*

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– *The equipment is placed on a plane at an angle of 10° from the horizontal and rotated slowly through an angle of 360° about its normal vertical axis; or*

– *The equipment is placed on a horizontal non-skid surface and subjected to a force equal to:*

  - *50 % of the weight of the unit vertical downwards, but not more than 100 N. If, during the test, the supporting surface prevents the equipment from overturning, the test shall be repeated such that the supporting surface is not used to pass the test; and*
  - *13 % of the weight in all horizontal directions but not more than 250 N,*

  that is applied to the worst case positions on the equipment by means of a suitable test apparatus having a flat surface of approximately 125 mm by 200 mm, in such a way as to produce the maximum overturning moment. The test may be applied at any height not exceeding 1,5 m from the base of the equipment. The test force shall be discontinued if the equipment remains stable after being tilted 10° from vertical.

8.6.2.3 Downward force test

Equipment shall not tip over when a constant downward force of 800 N is applied at the point of leverage for a maximum moment to any point of any surface within 10° of horizontal of at least 125 mm by at least 200 mm, at any height up to 1 m from the base of the equipment. The 800 N force is applied by means of a suitable test apparatus having a flat surface of approximately 125 mm by 200 mm. The downward force is applied with the complete flat surface of the test apparatus in contact with the equipment, however the test apparatus need not be in full contact with uneven surfaces (for example, corrugated or curved surfaces).

Equipment having a shape or a flexibility of the surface that is not likely to be used as a step or a ladder are exempt from the test.

~~NOTE~~ EXAMPLE Products in combination with a cart or stand or products with protrusion or recess where the construction is obviously not to be used as a step or ladder.

8.6.2.4 Compliance criteria

During the tests, the equipment shall not tip over.

8.6.3 Relocation stability ~~test~~

8.6.3.1 Requirements

Equipment shall be stable when it is being relocated. Equipment shall:

– be equipped with wheels having a minimum diameter of 100 mm; or

– comply with the test of 8.6.3.2.

~~*Compliance is checked by the test of 8.6.3.2. The equipment shall not tip over during the test. Equipment with wheels having a minimum diameter of 100 mm is considered to comply with the above requirements without test.*~~

8.6.3.2 Test method and compliance criteria

The equipment is tilted to an angle of 10° from its normal upright position in any direction. If the equipment is such that when it is tilted through an angle of 10° when standing on a horizontal plane, a part of the equipment not normally in contact with the supporting surface would touch the horizontal plane, the equipment is placed on the edge of the horizontal support during the test so that the contact is not made. Alternatively, the equipment may be placed on a plane and is rotated through an angle of 360° about its normal vertical axis while tilted at 10°.

Equipment expected to be moved or relocated by ***ordinary persons*** *shall have:*

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– *all doors and drawers not having a positive means of retention and that can be opened inadvertently; and*

– *casters, adjustable feet and the like*

arranged in any combination that results in the least stability.

*Equipment expected to be moved or relocated by an **instructed person** or a **skilled person**, shall have all doors, drawers, etc., positioned in accordance with the manufacturer's instructions.*

A unit provided with multi-positional features shall be tested in the least favourable position based on the equipment construction.

The equipment shall not tip over during the test.

8.6.4 Glass slide test

~~**8.6.4.1 Requirements**~~

~~Equipment shall be so constructed that it will not slide or tip over on a supporting surface made of glass.~~

~~**8.6.4.2 Test method and compliance criteria**~~

The equipment is placed on a clean, dry, glass covered horizontal surface so that only the supporting feet are in contact with the glass. The glass-covered surface is then tilted in the most unfavourable direction through an angle of 10°.

During the test, the equipment shall not slide or tip over.

8.6.5 Horizontal force test and compliance criteria

The equipment is to be placed on a horizontal non-skid surface with all doors, drawers, casters, adjustable feet and other movable parts arranged in any combination that results in the least stable condition. The equipment shall be blocked, if necessary, by means of a stop of the smallest dimensions possible, to keep it from sliding or rolling when subjected to one of the following tests:

– *an external horizontal force of ~~13~~ 20 % of the weight of the equipment or ~~100~~ 250 N, whichever is less, is applied to that point on the equipment that will result in the least stability. The force shall not be applied more than 1,5 m above the supporting surface; or*

– *the equipment shall be moved through any angle of tilt up to and including 15° from the vertical; or*

– *the equipment is placed on a plane and is rotated through an angle of 360° about its normal vertical axis while tilted at an angle of 15°.*

During the test, the equipment shall not tip over.

8.7 Equipment mounted to a wall, ceiling or other structure

8.7.1 Requirements

Classification of equipment for the purposes of assessing ~~wall~~ mounting means for attachment to a wall, ceiling or other fixed structure (for example, a pole or tower) is done according to Table 35, line 6.

For MS2 or MS3 equipment:

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– If the manufacturer ~~specifies a specific wall or ceiling mount~~ defines specific mounting means, the combination of the mounting means and the equipment shall comply with 8.7.2, Test 1. The hardware used to fix the mounting means to the equipment shall either be provided with the equipment, or described in detail in the user instructions (for example, length of screws, diameter of the screws, etc.).

– If the manufacturer does not ~~specify a specific wall or ceiling mount~~ define specific mounting means, but the equipment is provided with any part (for example, a hook or threaded hole) which facilitates attaching such ~~a~~ mounting means to the equipment, such parts shall comply with 8.7.2, Test 2, as appropriate. The user instruction shall advise on the safe use of such parts (for example, screw size including thread size and length, number of screws, etc.).

– If the equipment is provided with threaded parts for attachment of the mounting means, the threaded parts without the mounting means shall additionally comply with 8.7.2, Test 3.

NOTE The tests are meant to test the fixing of the mounting means to the equipment and not to test the fixing to the wall, ceiling or other structure.

8.7.2 Test methods

If the construction involves ~~polymeric~~ thermoplastic materials that have an influence on the strength of the mounting system, the tests shall be performed after the stress relief test of Clause T.8.

Test 1

The equipment is mounted in accordance with the manufacturer's instructions and the mounting means positioned, when possible, to represent the most severe stress on the supports.

A force in addition to the weight of the equipment is applied downwards through the centre of gravity of the equipment, for 1 min. The additional force shall be:

– *three times the weight of the equipment; or*

– *the weight of the equipment plus 880 N,*

whichever is less.

~~In addition~~ Afterwards, for ~~wall mounted~~ equipment mounted to a wall or another structure, a horizontal force of 50 N is applied laterally for 1 min.

Test 2

The test force shall be equivalent to the least of the following divided by the number of attachment points in the mounting system:

– *four times the weight of the equipment; or*

– *two times the weight of the equipment plus 880 N.*

~~*Each point in the mounting system shall be subjected to a shear force perpendicular to its centre axis for 1 min. The force shall be applied in four directions, one direction at a time, separated by 90°.*~~

~~*Each point in the mounting system, one at a time, shall be subjected to an inward directed push force parallel to its centre axis for 1 min.*~~

~~*Each point in the mounting system, one at a time, shall be subjected to an outward directed pull force parallel to its centre axis for 1 min.*~~

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Each individual representative point in the mounting system, one at a time, shall be subjected to the following six test forces:

- *a shear force perpendicular to its centre axis for 1 min. The force shall be applied in four directions, one direction at a time, separated by 90°.*
- *an inward directed push force parallel to its centre axis for 1 min.*
- *an outward directed pull force parallel to its centre axis for 1 min.*

Test 3

If the mounting system design relies upon threaded parts, ~~a torque according to Table 37 shall be applied to each threaded part, one at a time~~ each threaded part, one at a time, shall be subjected to the following test.

The screw is tightened with a torque according to Table 37 and then loosened, for a total of 5 times. The torque shall be applied gradually.

If a corresponding screw fastener is supplied by the manufacturer, it shall be used for the test. If no corresponding screw fastener is supplied by the manufacturer, even though a screw type may be recommended in the user instructions, any screw with the same diameter shall be used for the test.

Table 37 – Torque to be applied to screws

Nominal diameter of screw mm		Torque Nm
	up to and including 2,8	0,4
over 2,8	up to and including 3,0	0,5
over 3,0	up to and including 3,2	0,6
over 3,2	up to and including 3,6	0,8
over 3,6	up to and including 4,1	1,2
over 4,1	up to and including 4,7	1,8
over 4,7	up to and including 5,3	2,0
over 5,3	up to and including 6,0	2,5

8.7.3 Compliance criteria

Compliance is checked by inspection and by the tests of 8.7.2, as applicable. The equipment or its associated mounting means shall not become dislodged and shall remain mechanically intact and secure during the test. Threaded parts shall remain mechanically intact.

8.8 Handle strength

8.8.1 General

~~A handle that is declared by the manufacturer for the purpose of lifting or carrying the equipment shall comply with the tests as specified in 8.8.2.~~

A part of the equipment used for lifting or carrying the equipment, regardless of its shape or location or whether the part is intended for lifting or carrying by hand or via mechanical means, is considered to be a handle and shall have adequate strength.

The equipment is classified according to Table 35, line 5.

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If equipment having handles is designed, or provided with instructions, for lifting or carrying multiple units together, the class is determined taking into account the weight that may be carried.

Compliance is checked by inspection or by available data, or, where necessary, by the test of 8.8.2. As a result of the test, the handle, its securing means, or that portion of the ***enclosure*** *to which it is secured, shall not break, crack, or detach from the equipment.*

8.8.2 Test method ~~and compliance criteria~~

~~*The equipment shall pass the following test:*~~

A weight shall be uniformly applied over a 75 mm width at the centre of the handle, without clamping.

The weight shall be the equipment weight plus an additional weight as specified below:

– *for MS1 equipment with two or more handles, a weight that exerts a force of three times the weight of the equipment;*

NOTE No tests apply to MS1 equipment having only one handle.

– *for MS2 equipment, a weight that exerts a force of three times the weight of the equipment;*

– *for MS3 equipment with a mass 50 kg or less, a weight that exerts a force of two times the weight of the equipment or 75 kg, whichever is greater; and*

– *for MS3 equipment with a mass greater than 50 kg, a weight that exerts a force of the weight of the equipment or 100 kg, whichever is greater.*

The additional weight shall be started at zero and gradually increased so that the test value is attained in 5 s to 10 s and maintained for 60 s. When more than one handle is provided, the force shall be distributed between the handles. The distribution of the forces shall be determined by measuring the percentage of the equipment's weight sustained by each handle with the equipment in the intended carrying position. When MS2 equipment is furnished with more than one handle, and it can be considered capable of being carried by only one handle, each handle shall be capable of sustaining the total force.

~~*As a result of the test, the handle, its securing means, or that portion of the* ***enclosure*** *to which it is secured, shall not break, crack, or detach from the equipment.*~~

8.9 Wheels or casters attachment requirements

8.9.1 General

The equipment is classified according to Table 35, line 5. When equipment is intended to be used with carts, stands and similar carriers provided with wheels or casters, the classification is applied using the combined mass.

The likelihood of MS3 ~~and some MS2~~ equipment, including carts, stands and similar carriers that support the equipment, from tipping over during movement shall be reduced. ~~The equipment is classified according to Table 35, line 5.~~

8.9.2 Test method

Wheels or casters on MS3 equipment, or their supporting cart, stand or similar carrier, intended to be moved as part of its ***normal operating conditions****, shall be capable of withstanding a pull of 20 N. The pull force is to be applied by a weight, or a steady pull, to the wheel or caster for a period of 1 min in any direction made possible by the construction.*

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During the test, the wheels or casters shall not be damaged or pull free from its securing means.

8.10 Carts, stands, and similar carriers

8.10.1 General

The equipment shall be stable with the cart, stand or similar carrier. The classifications of Table 35, line 5 are applied using the combined mass of both the equipment and the carts or stands specified with the equipment.

All carts and stands specified for use with the equipment shall be subjected to the applicable tests described in the following subclauses. A cart, stand or carrier shall be subjected to the applicable tests alone and again with the equipment specified by the manufacturer placed on the cart or stand.

MS3 equipment, including their supporting carts, stands and similar carriers that support the equipment, that are not moved as part of its **normal operating conditions**, shall comply with the horizontal force test of 8.6.5.

MS2 or MS3 equipment more than 1 m in height, including equipment mounted on their specified cart, stand or carrier, shall comply with the relocation stability test in 8.6.3 except that the tip angle becomes 15°. If equipment is provided with wheels or casters that allow the equipment to only move in limited directions, the test is only applied in those directions (for example, an electronic white board).

8.10.2 Marking and instructions

A cart, stand or similar carrier that is specified by the manufacturer for use with specific equipment, but is packaged and marketed separately from the equipment, shall be provided with an **instructional safeguard** in accordance with Clause F.5.

The elements of the **instructional safeguard** shall be as follows:

– element 1a: not available
– element 2: “Caution” or equivalent text
– element 4: “This (cart, stand, or carrier) is intended for use only with (manufacturer's name), (model number or series), (equipment name).” or equivalent text
– element 3: “Use with other equipment may result in instability causing injury” or equivalent text

The elements shall be in the order 2, 4, and 3.

The **instructional safeguard** shall be affixed to the cart, stand or carrier, or included in the installation instructions or equivalent document accompanying the equipment.

Equipment only intended and shipped for use with a specific cart, stand or similar carrier, shall be provided with an **instructional safeguard** in accordance with Clause F.5 and be comprised of:

– element 1a: not available
– element 2: “Caution” or equivalent word or text
– element 4: “This (equipment name) is for use only with (manufacturer's name), (model number or series), (cart, stand, or carrier)” or equivalent text
– element 3: “Use with other (carts, stands, or carriers) may result in instability causing injury” or equivalent text

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The elements shall be in the order 2, 4, and 3.

The **instructional safeguard** shall be affixed to the equipment or included in the installation instructions or equivalent document accompanying the equipment.

8.10.3 Cart, stand or carrier loading test and compliance criteria

*A cart, stand or carrier shall be constructed so that permanent deformation or damage that is capable of resulting in injury to a person, does not occur when it is subjected to a force of 220 N applied for 1 min to any grippable or leverage point **accessible** to a child.*

To determine compliance, the force is applied through the end of a 30 mm diameter circular cylinder. The force is to be applied to a shelf drawer, dowel rung support, or equivalent part that is within 750 mm from the floor and will support some or all of a child's weight. The force is to be applied for 1 min with the cart or stand at room temperature. The part shall not collapse or break so as to expose sharp edges or produce pinch points that are capable of resulting in injury.

In addition, a cart, stand or other carrier shall be constructed so that permanent deformation or damage that is capable of resulting in injury to persons does not occur when each supporting surface is individually loaded with:

- *the manufacturer's intended load plus 440 N for the surface intended to support a display with moving images; or*
- *four times the manufacturer's intended load or 100 N, whichever is greater but not to exceed 440 N, is applied to all applicable surfaces.*

A dedicated storage area intended to accommodate specific accessories such as media tapes, discs, etc. shall be fully loaded to the rated load.

The weight is to be applied for 1 min on each supporting surface, with the other supporting surfaces unloaded.

8.10.4 Cart, stand or carrier impact test

When tested as described below, a cart, stand or carrier shall not produce a risk of injury to persons.

A single ~~7 J~~ impact is to be applied to any part of the cart or stand and the test method is to be as described in Clause T.6. However, a cart, stand or carrier made of glass shall instead be tested according to 4.4.3.6.

8.10.5 Mechanical stability

A cart, stand or carrier, including floor standing types, shall be subjected to the applicable tests described in 8.6.3 and 8.6.5 by itself, and where applicable in combination with its intended MS2 or MS3 equipment.

For the purposes of these tests, the weight shall be considered as the total weight of the equipment plus the weight of the cart, stand or carrier. The equipment shall be installed according to the manufacturer's instructions and the horizontal force shall be applied to either the cart, stand or carrier or intended equipment to produce a maximum overturning moment on the equipment at a point up to a maximum height of 1,5 m above the floor level.

If during the tests of 8.6.3 and 8.6.5 the equipment starts to slide or tip relative to the cart, stand or carrier, only the horizontal force test shall be repeated by reducing the force to 13 % of the weight of the equipment alone, or 100 N, whichever is less.

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The equipment and cart or stand shall not tip over.

8.10.6 Thermoplastic temperature stability

An equipment, cart, stand or carrier using thermoplastic materials in its construction shall withstand the test of Clause T.8 without any shrinkage, warpage, or other distortion of the thermoplastic materials that results in the equipment failing to comply with 8.10.3, 8.10.4 and 8.10.5.

8.11 Mounting means for ~~rack mounted equipment~~ slide-rail mounted equipment (SRME)

8.11.1 General

This subclause specifies requirements for horizontally mounted slide-rails to reduce the likelihood of injury by retaining the SRME in a stable position and not allowing the slide-rails to buckle, the means of attachment to break, or the SRME to slide past the end of the slide-rails.

The requirements below apply to the mounting means of MS2 and MS3 SRME that is:

– installed in a rack and that is intended to be extended on slide-rails away from the rack for installation, use or service; and

– SRME that extends the full width of the rack; and

– having a top installation position more than 1 m in height from the supporting surface.

The requirements do not apply to:

– equipment subassemblies; or

– other equipment fixed in place in the rack; or

– equipment that is not intended to be serviced while extended on slide-rails.

The mechanical mounting means for the SRME are referred to as slide-rails. The SRME may be the actual product configured in its worst case mechanical loading, or a representative **enclosure** with weights to simulate worst case loading.

NOTE 1 Slide-rails include bearing slides, friction slides or other equivalent mounting means.

NOTE 2 Subassemblies of the end product (for example, removable modules, component drawers, pull out paper/heater trays in copiers/printers) are not considered to be SRME.

8.11.2 Requirements

Classification of products for the purposes of assessing equipment stability is to be done according to Table 35, line 5.

NOTE For assessing equipment stability, see 8.6.

Slide-rails shall retain the SRME and have end stops that prevent the SRME from unintentionally sliding off the mounting means.

The slide-rails shall be installed in a representative rack with the SRME, or in an equivalent setup in accordance with the manufacturer's instructions.

~~Slide-rails and their mounting means shall meet the mechanical strength tests of 8.11.3 and 8.11.4. Following each test, the slide-rails and the SRME may be replaced before conducting the next test.~~

Slide rails with a single extended position shall comply with the downward force test of 8.11.3.1 in the extended position.

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Slide rails having a service position and an installation position shall comply with the downward force test of 8.11.3.1 in the service position.

All slide rails shall comply with the tests of 8.11.3.2 and 8.11.3.3 in both the service position and the installation position.

Following each test, the slide-rails and the SRME may be replaced before conducting the next test.

A multi position slide rail shall not extend automatically to any of the extended positions. The SRME shall only be able to go to the service position when pulled out. A latch or other means shall be provided to stop the SRME in the service position. Any service position and installation position shall be explained. An **instructional safeguard** shall be provided for the installer. The elements of the **instructional safeguard** shall be as follows:

– element 1a: not available
– element 2: Stability hazard
– element 3: “The rack may tip over causing serious personal injury”
– element 4: the text below or equivalent text

Before extending the rack to the installation position, read the installation instructions. Do not put any load on the slide-rail mounted equipment in the installation position. Do not leave the slide-rail mounted equipment in the installation position.

8.11.3 Mechanical strength test

8.11.3.1 Downward force test

With the SRME in its extended position, a force in addition to the weight of the SRME is to be applied downwards through the centre of gravity for 1 min.

The additional force applied to the SRME shall be equal to the greater of the following two values, with a maximum of 800 N:

– *50 % of the SRME weight plus a force of 330 N; or*
– *50 % of the SRME weight, plus an additional weight, where the additional weight is equal to the SRME weight or a force of 530 N, whichever is less.*

NOTE This additional force is intended to take into account other items or devices that are stacked on top of the installed SRME while in the extended position during installation of other SRME.

For slide-rail mounted shelves, the shelf shall be tested with a weight of 125 % of the maximum weight that is intended to be placed on the shelf.

A marking shall be provided on the shelf to indicate the maximum weight that can be added to the shelf.

8.11.3.2 Lateral push force test

A 250 N static push force is applied laterally, in both directions at or near the end of the SRME with the slide rails in their fully extended (service) position for a period of 1 min. The applied weight need not be in full contact with uneven surfaces (for example, corrugated or curved surfaces) but shall be concentrated within 30 mm of the end of the SRME.

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8.11.3.3 Integrity of slide rail end stops

To test the integrity of the end stops, a 250 N static pull force is applied at the front of the fully extended rail on the SRME for a period of 1 min, in an attempt to cause the SRME to come off the slide-rail. The SRME is then returned to the (installed) use position and then placed back in the fully extended position. The test is performed 10 times.

~~**8.11.4 Mechanical strength test, 250 N, including end stops**~~

~~*A 250 N static push force is applied laterally, in both directions at or near the end of the SRME with the slide rails in their fully extended (service) position for a period of 1 min. The applied weight need not be in full contact with uneven surfaces (for example, corrugated or curved surfaces) but shall be concentrated within 30 mm of the end of the SRME.*~~

~~*To test the integrity of the end stops, a 250 N pull and push force is applied at the front of the SRME in an attempt to cause the SRME to come off the slide-rail. The test is performed with the SRME in both the fully extended (service) position and the installed (use) position.*~~

~~NOTE Additional requirements for a dynamic force test on end stops are being considered at this time.~~

8.11.4 Compliance criteria

Compliance is checked by inspection and available manufacturer's data. If data is not available, then the tests according to 8.11.3 ~~and 8.11.4~~ are conducted.

Following each test, the SRME and its associated slide-rails shall remain secure for one complete cycle of travel on its slide-rails. If the mounting means is not able to perform one complete cycle without binding, a force of 100 N shall be applied horizontally to the front of the SRME at its centre point with the intent to completely retract the SRME into the rack.

The mounting means shall not bend or buckle to any extent that could introduce an injury. End stops shall retain the SRME in a safe position and shall not allow the SRME to slide past the end of the slide-rails.

8.12 Telescoping or rod antennas

A telescoping or rod antenna shall be provided with a minimum 6,0 mm diameter button or ball on the end. An antenna end piece and the sections of a telescoping antenna shall be secured in such a manner as to prevent removal.

Compliance is checked by inspection and the test of Clause T.11.

9 Thermal burn injury

9.1 General

To reduce the likelihood of painful effects and injury due to thermal burns, ~~equipment~~ **accessible** parts shall be classified and when necessary provided with the **safeguards** specified in Clause 9.

NOTE Electric burns due to radio frequency (RF) energy sources are a special case in this document. They are controlled by limiting accessibility above a specified frequency. These limits and conditions are defined in the notes [d] and [e] defined in Table 4.

9.2 Thermal energy source classifications

~~**9.2.1 General**~~

~~The different thermal energy sources and their limits under **normal operating conditions**, **abnormal operating conditions** and **single fault conditions** at a normal room ambient of~~

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~~25 °C are specified below. Touch temperature limits and classifications for various **accessible** parts are given in Table 38.~~

9.2.1 TS1

TS1 is a class1 thermal energy source with temperature levels:

– not exceeding TS1 limits under **normal operating conditions**; and
– not exceeding TS2 limits under:
  • **abnormal operating conditions**; or
  • **single fault conditions**.

9.2.2 TS2

TS2 is a class 2 thermal energy source where:

– the temperature exceeds the TS1 limits; and
– under **normal operating conditions**, **abnormal operating conditions** or **single fault conditions** the temperature does not exceed the TS2 limits.

Where the malfunction of the equipment is evident, no limits apply.

9.2.3 TS3

TS3 is a class 3 thermal energy source where the temperature exceeds the TS2 limits in Table 38 under **normal operating conditions** or under **abnormal operating conditions**, or under **single fault conditions**.

9.3 Touch temperature limits

9.3.1 Requirements

Except as noted below, touch temperatures of **accessible** parts shall comply with Table 38.

An **accessible** part that, while in contact with the body, is likely to drop in temperature upon touch can be evaluated under the limits of Annex A in IEC Guide 117:2010. An appropriate and reproducible test methodology is determined by the manufacturer with due regard to the test method in IEC Guide 117.

9.3.2 Test method and compliance criteria

The temperature tests are run with the room ambient conditions as defined in B.1.5 and B.2.3, except that the room ambient temperature shall be ~~25~~ $^{-5}_{+0}$ ~~°C~~ 25 °C ± 5 °C.

If the test is performed at a temperature ~~deviating from~~ between 20 °C and 25 °C, the results are adjusted to reflect a value of 25 °C.

NOTE 1 For an explanation of why the test is done at 25 °C without adjusting results for higher ambient temperatures, see IEC TR 62368-2.

*The equipment shall be operated in a manner the manufacturer determines likely to result in elevated thermal conditions of **accessible** surfaces and parts.*

NOTE 2 This may not be the condition of maximum input current or wattage but the condition that delivers the highest thermal level to the part in question.

*Compliance is checked by measuring the steady state temperature of **accessible** surfaces.*

~~**9.2.6 Touch temperature levels**~~

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Table 38 – Touch temperature limits for accessible parts

	Accessible parts [a]	Maximum temperature (T_{max}) °C			
		Metal [f]	Glass, porcelain and vitreous material	Plastic and rubber	Wood
TS1	Handles, knobs, grips, etc., and external surfaces either held, touched or worn against the body in normal use (> 1 min) [b, c]	48	48	48	48
	Handles, knobs, grips, etc., and external surfaces held for short periods of time or touched occasionally (> 10 s and < 1 min) [e]	51	56	60	60
	Handle, knobs, grips etc., and external surfaces touched occasionally for very short periods (>1 s and < 10 s) [e]	60	71	77	107
	External surfaces that need not be touched to operate the equipment (<1 s) [e]	70 [d]	80 [d]	94 [d]	140
TS2	Handles, knobs, grips, etc., and external surfaces held in normal use (> 1 min) [c]	58	58	58	58
	Handles, knobs, grips, etc., and external surfaces held for short periods of time or touched occasionally (> 10 s and < 1 min) [d]	61	66	70	70
	Handle, knobs, grips etc., and external surfaces touched occasionally for very short periods (> 1 s and < 10 s) [d]	70	81	87	117
	External surfaces that need not be touched to operate the equipment (< 1 s) [d]	80 (100) [e]	90 (100) [e]	104	150

[a] Except for handles, knobs, grips etc., the following parts inside the equipment need not comply with this table provided an **instructional safeguard** in accordance with Clause F.5 is provided on or near the hot part (see 9.4.2):

- a part that does not need to be touched to operate the equipment and if unintentional contact with the part is unlikely;
- internal parts of the equipment requiring heat for the intended function (for example, a document laminator, thermal print head, fuser heater, etc.) provided the parts are unlikely to be touched by an **ordinary person** under **normal operating conditions**.

[b] For parts in continuous contact with the skin, lower temperatures should be considered, see IEC Guide 117.

[c] Examples of these surfaces include a telephone handset, a headset, the palm rest surface of a notebook computer and surfaces that need to be touched for disconnection.

[d] Time of contact shall be determined by the manufacturer and shall be consistent with the intended use in accordance with the equipment instructions

For outside parts of metal that are covered with plastic material of at least 0,3 mm thick, a temperature rise which corresponds to the temperature limit of the plastic and rubber is allowed.

[e] The values in parentheses may be used for the following areas and external surfaces:

- an area on the external surface of the equipment that has no dimension exceeding 50 mm, and that is not likely to be touched in normal use; or
- **accessible** surfaces of the equipment requiring heat for the intended function (for example, equipment that contains a document laminator, thermal print head, fuser heater, etc.), and that are not likely to be touched in normal use; or
- heatsinks and metallic parts directly covering heatsinks, except those on surfaces incorporating switches or controls handled during normal use.

For these areas and parts, an **instructional safeguard** in accordance with Clause F.5 shall be provided on or near the hot part.

Under **abnormal operating conditions** and **single fault conditions**, for other areas and external surfaces of the equipment, an **equipment basic safeguard** is required.

[f] For external metal parts that are covered with plastic or rubber material of at least 0,3 mm thick, the temperature limit of plastic and rubber is allowed.

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	Accessible parts [b]	Maximum temperature (T_{max}) °C			
		Metal [d]	Glass, porcelain and vitreous material	Plastic and rubber	Wood
TS1	Devices worn on the body (in direct contact with the skin) in normal use (> 8 h) [e]	43 to 48	43 to 48	43 to 48	43 to 48
	Handles, knobs, grips, etc., and surfaces either held or touched in normal use (> 1 min and < 8 h) [a]	48	48	48	48
	Handles, knobs, grips, etc., and surfaces held for short periods of time or touched occasionally (> 10 s and < 1 min)	51	56	60	60
	Handle, knobs, grips etc., and surfaces touched occasionally for very short periods (> 1 s and < 10 s) [f]	60	71	77	107
	Surfaces that need not be touched to operate the equipment (< 1 s)	70	85	94	140
TS2	Handles, knobs, grips, etc., and surfaces held in normal use (> 1 min) [a]	58	58	58	58
	Handles, knobs, grips, etc., and surfaces held for short periods of time or touched occasionally (> 10 s and < 1 min)	61	66	70	70
	Handle, knobs, grips etc., and surfaces touched occasionally for very short periods (> 1 s and < 10 s) [f]	70	81	87	117
	Surfaces that need not be touched to operate the equipment (< 1 s)	80 (100) [c]	95 (100) [c]	104	150
TS3	Higher than the TS2 limits				

[a] Examples of these surfaces include a telephone handset, a mobile phone or another handheld device, and the palm rest surface of a notebook computer. Limits for > 1 s and < 10 s may be used for local hotspots where touching can be easily avoided by changing the way the device is held.

[b] Where necessary, time of contact shall be determined by the manufacturer and shall be consistent with the intended use in accordance with the equipment instructions.

[c] The values in parentheses may be used for the following areas and surfaces:

– an area on the surface of the equipment that has no dimension exceeding 50 mm, and that is not likely to be touched in normal use; or

– heatsinks and metallic parts directly covering heatsinks, except those on surfaces incorporating switches or controls handled during normal use.

For these areas and parts, an **instructional safeguard** in accordance with Clause F.5 shall be provided on or near the hot part.

Under **abnormal operating conditions** and **single fault conditions**, for other areas and surfaces of the equipment, an **equipment basic safeguard** is required.

[d] For metal parts that are covered with plastic or rubber material of at least 0,3 mm thick, the covering is considered suitable for use as a **safeguard** and the temperature limit of plastic and rubber is allowed.

[e] Examples include portable lightweight devices such as watches, headsets, personal music players and sports monitoring equipment. For larger devices or devices in direct contact with vital areas of the face (e.g. the airways), lower limits may apply. For contact durations less than 8 hours based on its intended normal use, apply limits between 48 °C/1 min and 43 °C/8 h. Calculations shall be rounded down to the nearest whole number. An example is a headset with a limited **battery** charge of 2 h.

[f] Examples include surfaces that need to be touched for disconnection.

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9.4 Safeguards against thermal energy sources

Except as given below, **safeguard** requirements for parts **accessible** to **ordinary persons**, **instructed persons** and **skilled persons** are given in 4.3.

For protection of an **ordinary person** against TS2, an **instructional safeguard** in accordance with 9.5.2 may be used as the **basic safeguard** ~~(see condition e of Table 38)~~.

~~For protection of an **ordinary person** or an **instructed person** against TS3, the **supplementary safeguard** may be replaced with an **instructional safeguard** in accordance with 9.4.2. Parts and surfaces classed TS3 shall be provided with an **equipment safeguard** or provided with an **instructional safeguard** so that unintentional contact with such parts and surfaces during service operations is unlikely to cause the **skilled person** to recoil into other class 3 energy sources (see Figure 19).~~

Accessible parts (internal and external) classified as TS2 or TS3 that require heat for the intended function (for example, a document laminator, thermal print head, fuser heater, etc.) shall comply with all of the following:

– the part does not need to be touched to operate the equipment (for example, a part also serving a handle, knob, or grip function);
– it is unlikely that an **ordinary person** will touch the part intentionally under **normal operating conditions**;
– unintentional contact with the part is unlikely by an **ordinary person** during maintenance not involving the part;
– the part is provided with an **instructional safeguard** on or near the part in accordance with 9.5.2; and
– it is unlikely that the part will be touched by children.

For protection of a **skilled person**, parts and surfaces classed TS3 shall be provided with an **equipment safeguard** or provided with an **instructional safeguard** so that unintentional contact with such parts and surfaces during service operations is unlikely to cause the **skilled person** to recoil into other class 3 energy sources (see Figure 19).

9.5 Requirements for safeguards

9.5.1 Equipment safeguard

An **equipment safeguard** shall limit the transfer of thermal energy (source temperature) under **normal operating conditions**, **abnormal operating conditions** and **single fault conditions** or limit accessibility to a thermal energy source to a touch temperature as classified in Table 38.

Temperature limits are applied only for those **abnormal operating conditions** or **single fault conditions** where the equipment continues to operate ~~in accordance with the manufacturer's instructions~~ as intended and, hence, the **abnormal operating condition** or **single fault condition** is not obvious. If ~~the equipment stops functioning~~ a malfunction is evident, then the limits are not applicable.

9.5.2 Instructional safeguard

An **instructional safeguard** shall be provided in accordance with Clause F.5, except that element 3 is optional.

The elements of the **instructional safeguard** shall be as follows:

– element 1a:  , IEC 60417-5041 (2002-10)
– element 2: "CAUTION" and "Hot surface" or equivalent word or text
– element 3: optional
– element 4: "Do not touch" or equivalent text

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9.6 Requirements for wireless power transmitters

9.6.1 General

Wireless power transmitters for near field wireless power transfer can warm up foreign metallic objects that may be placed close to or on such a transmitter. To avoid a burn due to high temperatures of the foreign metallic objects, the transmitter is tested as specified in 9.6.3.

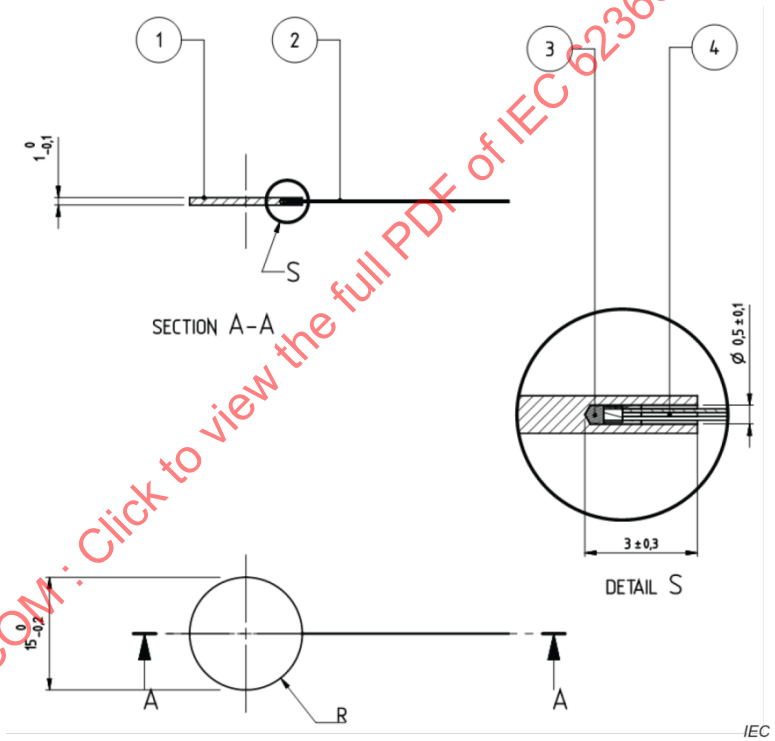
9.6.2 Specification of the foreign objects

The following foreign objects are used:

– a steel disc, see Figure 47;
– an aluminium ring, see Figure 48; and
– an aluminium foil, see Figure 49.

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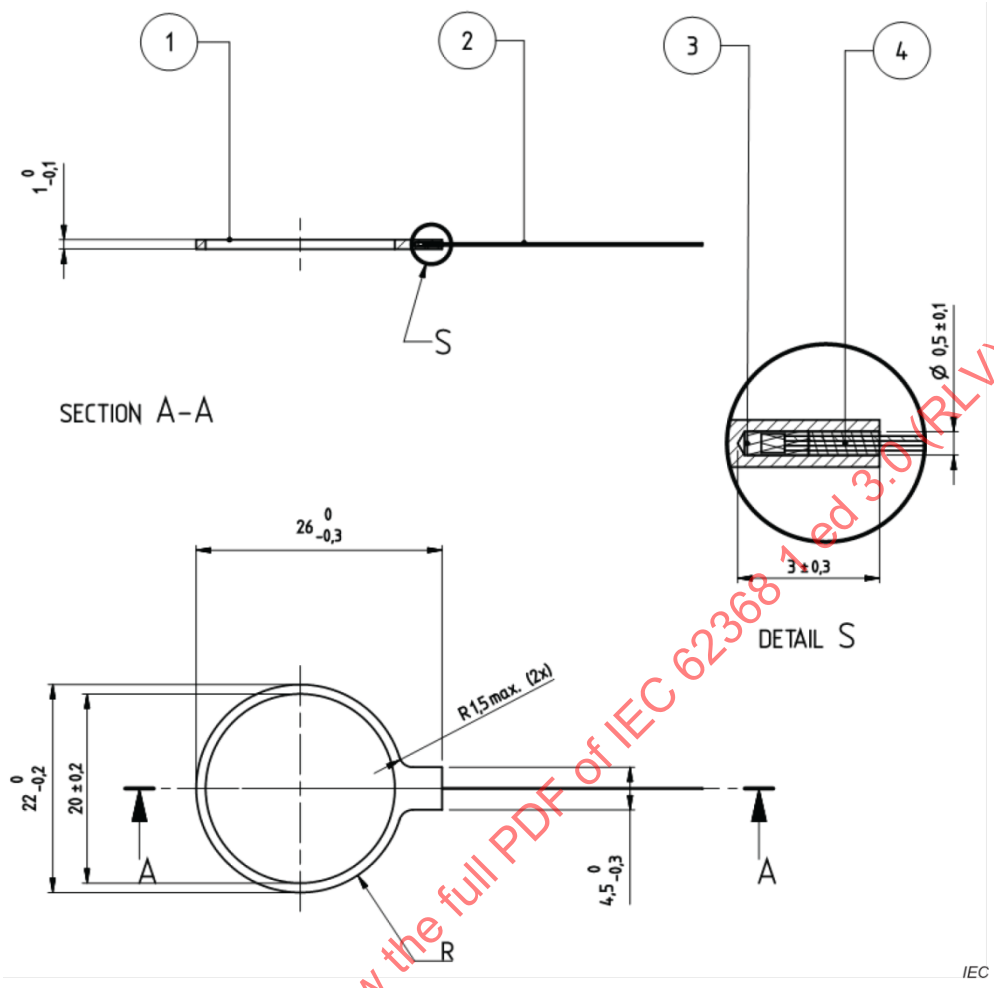
Dimensions in millimetres



No	Name	Remarks
1	Disc	Steel 1,1011/ RFe 160
2	Thermocouple	Any suitable type
3	Heatsink compound	Heat transport
4	Silicon tubing	Strain relief

Figure 47 – Steel disc

Dimensions in millimetres

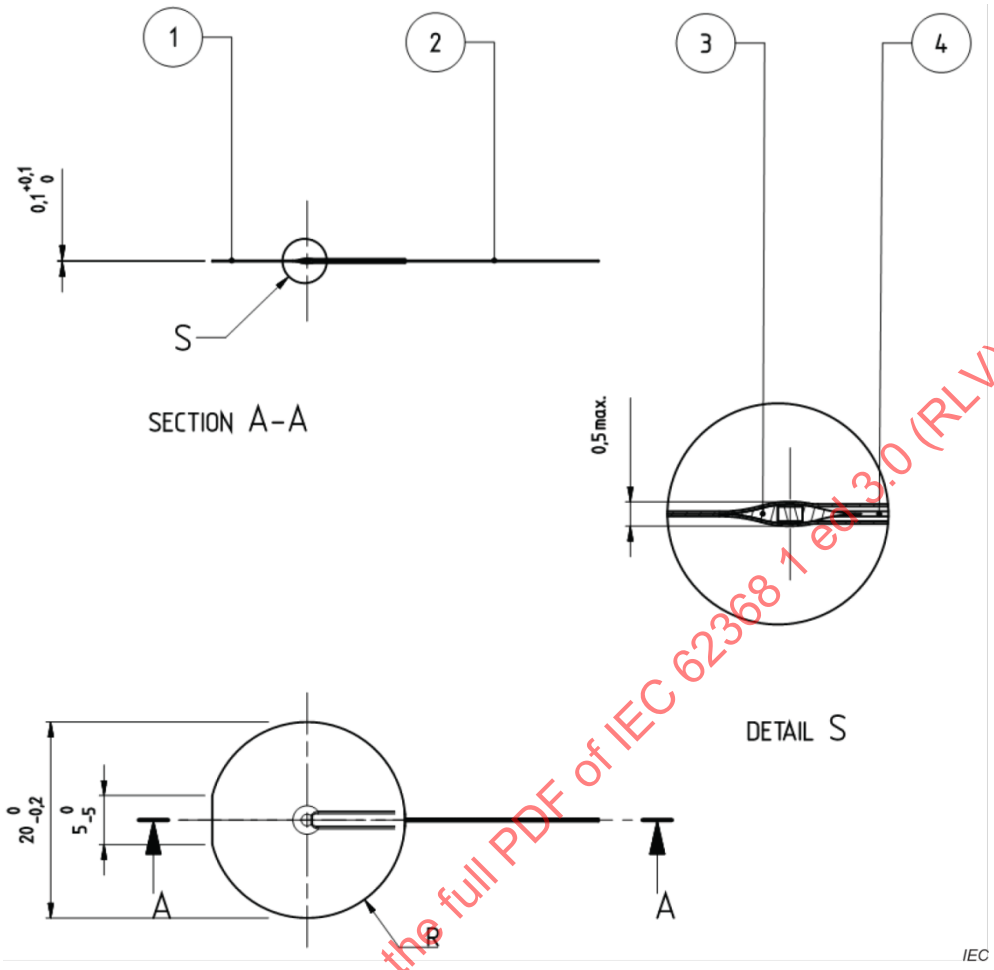


No	Name	Remarks
1	Ring	Aluminium (for example AlSiMg1Mn 100 Hv)
2	Thermocouple	Any suitable type
3	Heatsink compound	Heat transport
4	Silicon tubing	Strain relief

Figure 48 – Aluminium ring

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Dimensions in millimetres



No	Name	Remarks
1	Foil	Al 99,5 %
2	Thermocouple	Any suitable type
3	Heatsink compound	Heat transport
4	Silicon tubing	Strain relief (or use of glue layer on the foil)

Figure 49 – Aluminium foil

9.6.3 Test method and compliance criteria

*The **wireless power transmitter** is placed in a room under the temperature conditions as specified in 9.3.2.*

The test is performed once with each of the foreign objects specified in 9.6.2 placed in direct contact with the transmitter. Each test has four cycles:

- *one without a receiver present and with the foreign object in direct contact with the transmitter; and*
- *one with a receiver placed in direct contact with the foreign object; and*
- *one with a receiver placed at a distance of 2 mm from the foreign object; and*
- *one with a receiver placed at a distance of 5 mm from the foreign object.*

The transmitter is operated to transmit its maximum power.

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NOTE The test is not meant to test the temperature of the receiver, therefore any compatible receiver that can draw the maximum power from the **wireless power transmitter** can be used and the temperature of the receiver does not have to be monitored.

During each cycle, the foreign object can be moved on the transmitter in order to find the location where the highest temperature occurs.

During the tests, the temperature of the foreign object shall not exceed 70 °C.

10 Radiation

10.1 General

To reduce the likelihood of painful effects and injury due to ~~laser, visible, infra-red, ultraviolet,~~ optical energy (visible, IR, UV), X-ray, and acoustic energy, equipment shall be provided with the **safeguards** specified in this clause.

10.2 Radiation energy source classifications

10.2.1 General classification

Radiation energy source classifications are given in Table 39.

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Table 39 – Radiation energy source classifications

Line	Category	RS1	RS2	
1	Lasers	Class 1 [a]	Class 1M, Class 2, Class 2M, and Class 3R (visible) [a]	
2	Lamps and LEDs	Exempt group, RG-1 and RG-2 [b]		
3	X-Ray	≤ 36 pA/kg at 50 mm [c]	> RS1 and ≤ 185 pA/kg at 100 mm [d]	
4	Acoustic	≤ 85 dB(A)	> RS1 and ≤ 100 dB(A)	

[a] The different classes are defined in IEC 60825-1.

[b] The different classes are defined in IEC 62471. Low power application of LEDs are in the exempt group.

UV radiation from general purpose incandescent and fluorescent lamps, with ordinary glass envelopes, are taken as RS1.

EXAMPLE RS1 LEDs are those used as:

- indicating lights;
- infra-red devices such as used in home entertainment devices;
- infra-red devices for data transmission such as used between computers and computer peripherals;
- optocouplers; and
- other similar low power devices.

NOTE 1 If optical radiation is broadband visible and IR-A radiation and the luminance of the source does not exceed 10^4 cd/m^2, it is expected that the radiation does not exceed the exposure limits given in 4.3 of IEC 62471:2006 (see 4.1 of IEC 62471:2006).

For UV-C limits (wavelengths between 180 nm and 200 nm), the value of IEC 62471 for 200 nm is used.

[c] 36 pA/kg equals 5 µSv/h or 0,5 mR/h. This value is consistent with International Commission on Radiation Protection (ICRP) Publication 60.

[d] 185 pA/kg equals 25 µSv/h or 2,5 mR/h.

Measurement is made with any part of the cabinet, case, and chassis removed per maintenance instructions (CRT exposed) at the maximum test voltage applicable and under the conditions as specified below.

NOTE 2 In the member countries of CENELEC, the amount of ionizing radiation is regulated by European Council Directive 96/29/Euratom of 13 May 1996. This Directive requires that at any point 100 mm from the surface of the equipment, the dose rate shall not exceed 1 µSv/h (0,1 mR/h) taking account of the background level. For complete requirements refer to the above Directive.

NOTE 3 In the USA, the measuring conditions in the U.S. Code of Federal Regulations Title 21 Part 1020 are as given below (for complete requirements, refer to the above regulations).

Measurements are made with the EUT connected to the following source of supply:

- 130 V if the **rated voltage** is between 110 V and 120 V;
- 110 % of the **rated voltage**, if the **rated voltage** is not between 110 V and 120 V.

During the measurements:

- all user and service **accessible** controls are adjusted to combinations that produce maximum x-radiation emissions; and
- **abnormal operating conditions** of any component or circuit malfunction causing an increase of x-radiation emissions are to be simulated.

NOTE 4 In Canada, the measuring conditions in the Consolidated Regulations of Canada, c.1370 are as given below (for complete requirements refer to the above regulations).

Measurements are made with the EUT connected to the following source of supply:

- 127 V if the **rated voltage** is between 110 V and 120 V;
- 110 % of the **rated voltage**, if the **rated voltage** is not between 110 V and 120 V.

During the measurements all user and service **accessible** controls are adjusted to combinations that produce maximum x-radiation emissions.

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Source		RS1	RS2	RS3
Lasers	optical fibre communication systems (OFCS)	According to IEC 60825-2		
	free space optical communication systems for transmission of information	According to IEC 60825-12		
	Other lasers, except those used in image projectors	According to IEC 60825-1 [a]		
Lamps and lamp systems (including LEDs), except those used in image projectors		According to IEC 62471:2006 [b]		
Image projectors (beamers)	Image projectors with lasers	According to IEC 60825-1 [a] or IEC 62471-5:2015 if applicable		
	Image projectors with lamps or LEDs	According to IEC 62471-5:2015		
X-Ray		≤ 36 pA/kg at 50 mm [c]	≤ 185 pA/kg at 100 mm [d]	> RS2
PMP Acoustic Maximum sound pressure [e]	sound output	≤ 85 dB(A)	≤ 100 dB(A)	> RS2
	analogue output	≤ 27 mV	≤ 150 mV	> RS2
	digital output	≤ –25 dBFS	≤ –10 dBFS	> RS2
PMP Acoustic Maximum dose exposure [e]	sound output	100 % CSD = ≤ 80 dB(A) / 40 h	≤ 100 dB(A)	> RS2
	analogue output	≤ 15 mV	≤ 150 mV	> RS2
	digital output	≤ –30 dBFS	≤ –10 dBFS	> RS2

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[a] Additional considerations for laser products designed to function as conventional lamps (such as laser image projector), see Note 2 of 10.3.

NOTE 1 For example, in IEC 60825-1:2014, Class 1, Class 1C, Class 1M, Class 2, Class 2M, Class 3R, Class 3B and Class 4 are defined. These are not classifications of radiation energy source itself.

[b] To classify the risk group, **abnormal operating conditions** and **single fault conditions** shall be taken into account.

In general, the radiation of the following low power application of a lamp is classified as Exempt Group. Also, classification according to IEC 62471 (all parts) is not required for:

– indicating lights;

– infra-red devices such as used in home entertainment devices;

– infra-red devices for data transmission such as used between computers and computer peripherals;

– optocouplers;

– UV radiation from general purpose incandescent and fluorescent lamps, with ordinary glass envelopes; and

– other similar low power devices.

NOTE 2 If optical radiation is broadband visible and IR-A radiation and the luminance of the source does not exceed 10^4 cd/m^2, it is expected that the radiation does not exceed the exposure limits given in 4.3 of IEC 62471:2006 (see 4.1 of IEC 62471:2006).

For UV-C limits (wavelengths between 180 nm and 200 nm), the value of IEC 62471 for 200 nm is used.

[c] 36 pA/kg equals 5 μSv/h or 0,5 mR/h. This value is consistent with International Commission on Radiation Protection (ICRP) Publication 60.

[d] 185 pA/kg equals 25 μSv/h or 2,5 mR/h.

Measurement is made with any part of the cabinet, case, and chassis removed per maintenance instructions (CRT exposed) at the maximum test voltage applicable and under the conditions as specified below.

NOTE 3 In the member countries of CENELEC, the amount of ionizing radiation is regulated by European Council Directive 96/29/Euratom of 13 May 1996. This Directive requires that at any point 100 mm from the surface of the equipment, the dose-rate shall not exceed 1 μSv/h (0,1 mR/h) taking account of the background level. For complete requirements refer to the above Directive.

NOTE 4 In the USA, the measuring conditions in the U.S. Code of Federal Regulations Title 21 Part 1020 are as given below (for complete requirements, refer to the above regulations).

Measurements are made with the EUT connected to the following source of supply:

– 130 V if the **rated voltage** is between 110 V and 120 V; or

– 110 % of the **rated voltage**, if the **rated voltage** is not between 110 V and 120 V.

During the measurements:

– all user and service **accessible** controls are adjusted to combinations that produce maximum X-radiation emissions; and

– **abnormal operating conditions** of any component or circuit malfunction causing an increase of X-radiation emissions are to be simulated.

NOTE 5 In Canada, the measuring conditions in the Consolidated Regulations of Canada, c.1370 are as given below (for complete requirements refer to the above regulations).

Measurements are made with the EUT connected to the following source of supply:

– 127 V if the **rated voltage** is between 110 V and 120 V; or

– 110 % of the **rated voltage**, if the **rated voltage** is not between 110 V and 120 V.

During the measurements all user and service **accessible** controls are adjusted to combinations that produce maximum X-radiation emissions.

[e] Fault testing measurements are not required for listening devices and personal music players.

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10.2.2 RS1

For X-radiation sources, RS1 is a class 1 radiation energy source that does not exceed RS1 limits under:

- **normal operating conditions**, and

- **abnormal operating conditions** that do not lead to a **single fault condition**, and
- **single fault conditions** ~~for laser, visible, infra-red, ultra-violet and x-radiation; and~~

~~– does not exceed RS2 limits under~~

- ~~**single fault conditions** for acoustic radiation.~~

For acoustic radiation sources, RS1 is a class 1 radiation energy source that does not exceed RS1 limits under:

– **normal operating conditions**; and
– **abnormal operating conditions**.

10.2.3 RS2

RS2 is a class 2 radiation energy source that does not exceed RS2 limits under:

– **normal operating conditions**; and
– **abnormal operating conditions**; and
– **single fault conditions**, except for acoustic radiation sources, and

is not RS1.

10.2.4 RS3

RS3 is a class 3 radiation energy source that exceeds RS2 limits under:

– **normal operating conditions**; or
– **abnormal operating conditions**; or
– **single fault conditions**.

10.3 Safeguards against laser radiation

~~**10.3.1 Requirements**~~

~~Equipment containing one or more lasers (including laser diodes) shall comply with IEC 60825-1, IEC 60825-2 or IEC 60825-12 as applicable.~~

~~Diodes emitting coherent light shall be threated as laser radiation.~~

~~NOTE In IEC 60825-1 such diodes are identified as "laser diodes".~~

~~Unless RS2 is required to be **accessible** for the function of the equipment, laser radiation that exits the equipment shall not exceed RS1 under **normal operating conditions**, **abnormal operating conditions**, and **single fault conditions**. If RS2 is required to be **accessible** for the function of the equipment, the equipment shall be provided with an **instructional safeguard** in accordance with IEC 60825-1.~~

~~Unless the equipment complies with IEC 60825-2, where an RS3 laser is present, a **tool** shall be required to gain access.~~

~~**10.3.2 Compliance criteria**~~

~~*Compliance is determined by measurement or by checking the available manufacturer's data sheet.*~~

Equipment containing laser(s) shall comply with the requirements as indicated in Table 39.

When applying the IEC 60825 series, the requirements of this document shall be considered, in particular those for:

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– the robustness of a **safeguard** (see 4.4.3);
– operating conditions (see Annex B); and
– **safety interlocks** (see Annex K).

Laser equipment intended for use by an **ordinary person** or an **instructed person** shall not be Class 3B or Class 4.

NOTE 1 National and regional legislation regarding occupational safety and health (OSH) and regarding the general public, for example for consumer products, may contain additional or different requirements.

NOTE 2 For laser products designed to function as conventional lamps (such as laser image projector), see 4.4 of IEC 60825-1:2014. For additional consideration for such equipment, see 10.4.

Compliance is checked by evaluation of available data sheets, by inspection and, if necessary, by measurement.

NOTE 3 For guidance on measuring techniques, see the IEC 60825 series.

10.4 Safeguards against ~~visible, infra-red, and ultra-violet radiation~~ optical radiation from lamps and lamp systems (including LED types)

10.4.1 General requirements

~~Except as given below, protection requirements for parts **accessible** to **ordinary persons**, **instructed persons**, and **skilled persons** are given in 4.3.~~

~~For an **ordinary person** or an **instructed person**, RS3 shall be contained by the **enclosure** of the lamps and lamp system or the **enclosure** of the equipment.~~

~~If RS3 is **accessible** to a **skilled person**, then a **personal safeguard** (PPE) shall be required, and an **instructional safeguard** in accordance with 10.4.2 shall be provided.~~

~~Unless RS2 is required to be **accessible** for the function of the equipment, visible, infra-red, and ultra-violet radiation **accessible** to an **ordinary person** or an **instructed person** shall not exceed RS1 under **normal operating conditions**, **abnormal operating conditions** and **single fault conditions**. If RS2 is required to be **accessible** for the function of the equipment, the equipment shall be provided with an **instructional safeguard** in accordance with IEC/TR 62471-2.~~

~~**Enclosure** material used as a **safeguard** shall be opaque to the radiation. An opaque **enclosure** that complies with the test of Annex T according to 4.4.4 is taken as a **reinforced safeguard**.~~

~~UV radiation emitted through glass having a 90 % UV attenuation up to 400 nm is taken as RS1. Glass with a thickness of 2 mm is considered to have such attenuation.~~

~~Materials that comprise a **safeguard** and are exposed to UV radiation from a lamp in the equipment shall be sufficiently resistant to degradation to the extent that the **safeguard** function remains effective for the equipment lifetime. Metal, glass and ceramic materials do not need to be assessed.~~

~~Equipment with optical energy sources in excess of the limits specified in IEC 62471 in the wavelength range 200 nm to 3 000 nm impinging on the human body shall be provided with the **safeguards** specified in this subclause.~~

~~In general, optical radiation from the equipment shall either:~~

~~– be contained by the **enclosure** of the lamps and lamp system or the **enclosure** of the equipment; or~~

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~~– not exceed the relevant limits for RS1 for **normal operating conditions**.~~

Equipment emitting optical radiation shall comply with the requirements as indicated in Table 39.

Electronic light effect equipment does not have to comply with the requirements of 10.4. However, IEC TR 62471-2 should be considered and proper installation instructions shall be provided.

For lamps used in other equipment, the following applies:

NOTE 1 National legislation regarding occupational safety and health (OSH) may contain additional or different requirements.

Radiation not needed to be **accessible** for the correct functioning of the equipment shall not exceed the level specified in Table 40. When the **accessible** radiation level for the correct functioning of the equipment needs to exceed the levels in Table 40, the equipment shall be provided with an **instructional safeguard** in accordance with 10.4.3.

Table 40 – Allowable radiation level according to IEC 62471 (all parts) for each hazard type

Hazard type	Allowed radiation level
Ultraviolet hazard 200 nm to 400 nm	Exempt Group
Retinal blue light hazard 300 nm to 700 nm	Exempt Group or Risk Group 1
Retinal thermal hazard 380 nm to 1400 nm	Exempt Group or Risk Group 1
Cornea/lens infrared hazard 780 nm to 3 000 nm	Exempt Group
Retinal thermal hazard, weak visual stimulus 780 nm to 1 400 nm	Exempt Group

Lamps and lamp systems intended for use by an **ordinary person** or an **instructed person** shall not emit Risk Group 3 energy.

The risk group, based on the classification according to IEC 62471 series, shall be marked on the equipment. If the size or design of the product makes marking impractical, the marking shall be included in the packaging and included in the user instructions. If the **accessible** radiation level does not exceed the level specified in Table 40, marking is not required.

If a **safety interlock** is used for reducing the radiation level, it shall reduce the radiation to the allowable radiation levels specified in Table 40.

When equipment emits optical radiation in more than one hazard type, see also 10.4.3.

The following information should be provided in the user manual for safe operation and installation. This information shall also be provided for safe operation by a **skilled person** who may be exposed to Risk Group 3 energy levels.

– Adequate instructions for proper assembly, installation, maintenance and safe use, including clear warnings concerning precautions to avoid possible exposure to hazardous optical radiation; and

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– Advice on safe operating procedures and warnings concerning **reasonably foreseeable misuse**, malfunctions and hazardous failure modes. Where servicing and maintenance procedures are detailed, they should, wherever possible, include explicit instructions on safe procedures to be followed; and

– The marking on the equipment should be reproduced in the user manual. A yellow background is not required in the user manual.

NOTE 2 See IEC TR 62471-2 for more information including the terms and definitions used in this subclause.

10.4.2 Requirements for enclosures

The **enclosure** protecting against optical radiation not needed to be **accessible** for the correct functioning of the equipment and that exceeds the level specified in Table 40 shall comply with 4.4.3 and is considered to be a **reinforced safeguard**.

Materials that comprise a **safeguard** and are exposed to UV radiation from a lamp in the equipment shall be sufficiently resistant to degradation to the extent that the **safeguard** function remains effective for the equipment lifetime. Metal, glass and ceramic materials are considered to be resistant to degradation.

10.4.3 Instructional safeguard

~~Where required, an **instructional safeguard** shall be in accordance with Clause F.5.~~

~~The elements of the **instructional safeguard** shall be as follows:~~

~~– element 1a: the UV radiation symbol~~  ~~, IEC 60417-6040 (2010-08), or~~

~~the visible radiation symbol~~  ~~, IEC 60417-6041 (2010-08), or~~

~~the infrared radiation symbol~~  ~~, IEC 60417-6151 (2012-02)~~

~~– element 2: "UV light" "Bright light" or "Infrared light" as applicable, or equivalent text~~

~~– element 3: "Possible skin or eye damage" or equivalent text~~

~~– element 4: "Disconnect power before servicing" or equivalent text~~

~~Alternatively, the cautionary statement for Risk Groups RG-1 and RG-2 specified in IEC/TR 62471-2 may be used as an **instructional safeguard**.~~

~~If the **safeguard** is a **safety interlock**, then an **instructional safeguard** is not required.~~

For image projectors, the **instructional safeguard** shall comply with the requirements of 6.5.4 and 6.5.5 of IEC 62471-5:2015 for Risk Group 2 and Risk Group 3, respectively.

For image projectors with lamps, the cautionary statement defined in IEC 62471-5:2015 shall be used as an **instructional safeguard**.

For all other equipment with lamps, an **instructional safeguard** in accordance with Clause F.5 shall be used. The elements of the **instructional safeguard** shall be as follows:

– element 1a: the UV radiation symbol  , IEC 60417-6040:2010-08 for ultraviolet hazard; or

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the visible radiation symbol  , IEC 60417-6041:2010-08 for retinal blue light hazard and Retinal thermal hazard; or

the IR radiation symbol  , IEC 60417-6151:2012-02 for cornea/lens infrared hazard and retinal thermal hazard, weak visual stimulus

– element 2: According to Table 41 or equivalent text

– element 3 and 4: According to Table 42 or equivalent text

The elements 1a and 2 shall be black on a yellow background.

Table 41 – Hazard-related risk group marking of equipment

Hazard	Exempt Group	Risk Group 1	Risk Group 2	Risk Group 3
Ultraviolet hazard 200 nm to 400 nm	Not required	NOTICE UV emitted from this product	CAUTION UV emitted from this product.	WARNING UV emitted from this product.
Retinal blue light hazard 300 nm to 700 nm	Not required	Not required	CAUTION Possibly hazardous optical radiation emitted from this product	WARNING Possibly hazardous optical radiation emitted from this product
Retinal thermal hazard 380 nm to 1400 nm	Not required	Not required	CAUTION Possibly hazardous optical radiation emitted from this product	WARNING Possibly hazardous optical radiation emitted from this product
Cornea/lens infrared hazard 780 nm to 3 000 nm	Not required	NOTICE IR emitted from this product	CAUTION IR emitted from this product	WARNING IR emitted from this product.
Retinal thermal hazard, weak visual stimulus 780 nm to 1 400 nm	Not required	CAUTION IR emitted from this product	CAUTION IR emitted from this product.	WARNING IR emitted from this product.

Table 42 – Explanation of marking information and guidance on control measures

Hazard	Exempt Group	Risk Group 1	Risk Group 2	Risk Group 3
Ultraviolet hazard 200 nm to 400 nm	Not required	Minimize exposure to eyes or skin. Use appropriate shielding.	Eye or skin irritation may result from exposure. Use appropriate shielding.	Avoid eye and skin exposure to unshielded product.
Retinal blue light hazard 300 nm to 700 nm	Not required	Not required	Do not stare at operating lamp. May be harmful to the eyes.	Do not look at operating lamp. Eye injury may result.
Retinal thermal hazard 380 nm to 1400 nm	Not required	Not required	Do not stare at operating lamp. May be harmful to the eyes.	Do not look at operating lamp. Eye injury may result.
Cornea/lens infrared hazard 780 nm to 3 000 nm	Not required	Use appropriate shielding or eye protection.	Avoid eye exposure.Use appropriate shielding or eye protection.	Avoid eye exposure. Use appropriate shielding or eye protection.

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Retinal thermal hazard, weak visual stimulus 780 nm to 1 400 nm	Not required	Do not stare at operating lamp.	Do not stare at operating lamp.	Do not look at operating lamp.

When equipment emits optical radiation in more than one hazard spectral region, the equipment shall be classified for the most restrictive case. If the optical radiation in any spectral region requires a marking per Table 41 or Table 42, all relevant warnings shall be included. For example, for a lamp assigned to Risk Group 3 on the basis of a retinal IR hazard and emitting UV to the level of Risk Group 2, the legend of the marking shall indicate Risk Group 3, with the appropriate 'Warning' text; and show the 'Caution' text for Risk Group 2 for the UV, but shall not mention Risk Group 2 explicitly, as illustrated in Figure 50.

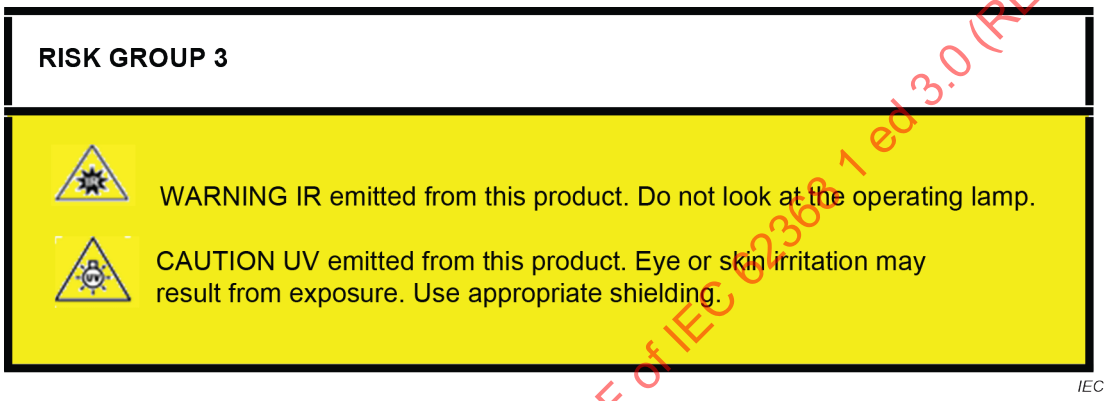


Figure 50 – Example of a warning label for a lamp with multiple hazard spectral regions

10.4.4 Compliance criteria

Compliance is checked by evaluation of available data sheets, by inspection and, if necessary, by measurement.

NOTE For guidance on measuring techniques, see the relevant part of the IEC 62471 series.

Compliance against material degradation from UV radiation is checked by the relevant tests in Annex C.

10.5 Safeguards against X-radiation

10.5.1 Requirements

Equipment X-radiation that exits the equipment shall not exceed RS1 under **normal operating conditions**, **abnormal operating conditions**, and **single fault conditions**.

An **equipment safeguard** is required between RS2 or RS3 and all persons.

Doors and covers acting as a **safeguard** that, when open, would allow access to RS2 or RS3 for a **skilled person** shall be provided with an **instructional safeguard** in accordance with Clause F.5.

10.5.2 Compliance criteria

Compliance is checked by inspection and, where necessary, by the test of 10.5.3.

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10.5.3 Test method

Equipment that is likely to produce ionizing radiation is checked by measuring the amount of radiation. Account is taken of the background level.

The amount of radiation is determined by means of a radiation monitor of the ionizing chamber type with an effective area of 1 000 mm^2 or by measuring equipment of other types giving equivalent results.

*Measurements are made with the EUT operating at the most unfavourable supply voltage (see B.2.3) and with controls for an **ordinary person** and an **instructed person**, and controls for a **skilled person** that are not locked in a reliable manner, adjusted so as to give maximum radiation whilst maintaining the equipment operative for normal use.*

NOTE 1 Soldered joints and fixing by application of paint, epoxy, or similar materials are considered reliable locking means.

*Moreover, the measurement shall be made under any **abnormal operating condition** and **single fault conditions** that can cause an increase of the high-voltage, provided an intelligible picture is maintained for 5 min, at the end of which the measurement is made and averaged over 5 min.*

During the measurements, an intelligible picture is to be maintained.

A picture is considered to be intelligible if the following conditions are met:

- *a scanning amplitude of at least 70 % of the usable screen for both width and height;*
- *a minimum luminance of 50 cd/m^2 with locked blank raster provided by a test generator;*
- *not more than 12 flashovers in a 1 h period; and*
- *a horizontal resolution corresponding to at least 1,5 MHz in the centre with a similar vertical degradation.*

NOTE 2 In the USA and Canada, an intelligible picture is in synchronization while covering 60 % of the viewable screen area.

10.6 Safeguards against acoustic energy sources

10.6.1 General

Safeguard requirements for protection against long-term exposure to excessive sound pressure levels from personal music players closely coupled to the ear are specified below. Requirements for earphones and headphones intended for use with personal music players are also covered.

A personal music player (PMP) is a portable equipment intended for use by an **ordinary person**, that:

- is designed to allow the user to listen to audio or audiovisual content / material; and
- uses a listening device, such as headphones or earphones that can be worn in or on or around the ears; and
- has a player that can be body worn (of a size suitable to be carried in a clothing pocket) and is intended for the user to walk around with while in continuous use (for example, on a street, in a subway, at an airport, etc.).

~~NOTE 1~~ EXAMPLES Portable CD players, MP3 audio players, mobile phones with MP3 type features, PDAs or similar equipment.

Personal music players shall comply with the requirements ~~below~~ of either 10.6.2 or 10.6.3.

NOTE ~~2~~ 1 Protection against acoustic energy sources from telecom applications is referenced to ITU-T P.360.

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NOTE 2 It is the intention of the Committee to allow the alternative methods for now, but to only use the dose measurement method as given in 10.6.3 in future. Therefore, manufacturers are encouraged to implement 10.6.3 as soon as possible.

Listening devices sold separately shall comply with the requirements of 10.6.6.

These requirements are valid for music or video mode only.

For equipment that is clearly designed or intended primarily for use by children, additional limits of the relevant toy standards may apply.

NOTE 3 In Europe, the relevant requirements are given in EN 71-1:2011, 4.20 and the related tests methods and measurement distances apply.

The requirements do not apply to:

– **professional equipment**;

~~NOTE 3 Professional equipment is equipment sold through special sales channels. All products sold through normal electronics stores are considered not to be professional equipment.~~

– hearing aid equipment and other devices for assistive listening; and
– the following type of analogue personal music players:
  - long distance radio receiver (for example, a multiband radio receiver or world band radio receiver, an AM radio receiver), and
  - cassette player/recorder; and

  NOTE ~~4~~ 2 This exemption has been allowed because this technology is falling out of use and it is expected that within a few years it will no longer exist. This exemption will not be extended to other technologies.
– a player while connected to an external amplifier that does not allow the user to walk around while in use.

10.6.2 Classification

10.6.2.1 RS1 limits

RS1 is a class 1 acoustic energy source that does not exceed the following:

~~– for equipment provided as a package (player with its listening device), the $L_{Aeq,T}$ acoustic output shall be ≤ 85 dB(A) when playing the fixed "programme simulation noise" described in EN 50332-1.~~

~~– for equipment provided with an electrical output socket for a listening device, the unweighted r.m.s. output voltage shall be ≤ 27 mV or 25 dB below full scale when playing the fixed "programme simulation noise" described in EN 50332-1.~~

~~NOTE 1 Unless otherwise specified, wherever the term acoustic output is used in 10.6, $L_{Aeq,T}$ is the A-weighted equivalent sound pressure level over a 30 s period.~~

~~For music where the average sound pressure (long term $L_{Aeq,T}$) measured over the duration of the song is lower than the average produced by the programme simulation noise, the warning does not need to be given as long as the average sound pressure of the song does not exceed the basic limit of 85 dB(A). In this case, T becomes the duration of the song.~~

~~NOTE 2 Classical music typically has an average sound pressure (long term $L_{Aeq,T}$) which is much lower than the average programme simulation noise. Therefore, if the player is capable to analyse the song and compare it with the programme simulation noise, the warning does not need to be given as long as the average sound pressure of the song does not exceed the basic limit of 85 dB(A).~~

~~For example, if the player is set with the programme simulation noise to 85 dB(A), but the average music level of the song is only 65 dB(A), there is no need to give a warning or ask an acknowledgeme~~

~~nt as long as the average sound level of the song is not above the basic limit of 85 dB(A).~~

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~~For equipment that is clearly designed or intended for use by children, the limits of the relevant toy standards may apply.~~

~~NOTE 3 In Europe, the relevant requirements are given in EN 71-1:2011, 4.20 and the related tests methods and measurement distances apply.~~

– for equipment provided as a package (player with its listening device), and with a proprietary connector between the player and its listening device, or where the combination of player and listening device is known by other means such as setting or automatic detection, the $L_{\mathrm{Aeq},T}$ acoustic output shall be lower or equal to the relevant RS1 sound output value of Table 39 when playing the fixed "programme simulation noise" described in EN 50332-1.

– for equipment provided with a standardized connector (for example, a 3,5 mm phone jack) that allows connection to a listening device for general use, the unweighted RMS output voltage shall be lower or equal to the relevant RS1 analogue output value of Table 39 when playing the fixed "programme simulation noise" described in EN 50332-1.

– for equipment provided with a digital output, the output signal shall be lower or equal to the relevant RS1 digital output value of Table 39 when playing the fixed "programme simulation noise" described in EN 50332-1.

NOTE 1 Unless otherwise specified, wherever the term acoustic output is used in 10.6.2, $L_{\mathrm{Aeq},T}$ is the A-weighted equivalent sound pressure level over a 30 s period.

If the player is able to analyse a song, and where the average sound pressure (long term $L_{\mathrm{Aeq},T}$) measured over the duration of the song is lower than the average produced by the programme simulation noise, the output is considered RS1 as long as the average sound pressure of the song does not exceed the basic limit of 85 dB(A). In this case, T becomes the duration of the song.

NOTE 2 Classical music typically has an average sound pressure (long term $L_{\mathrm{Aeq},T}$) which is much lower than the average programme simulation noise.

For example, if the player is set with the programme simulation noise to 85 dB(A), but the average sound pressure of the song is only 65 dB(A), the output is considered to be RS1 as long as the average sound level of the song is not above the basic limit of 85 dB(A).

10.6.2.2 RS2 limits

RS2 is a class 2 acoustic energy source that does not exceed the following:

~~– for equipment provided as a package (player with its listening device), the $L_{\mathrm{Aeq},T}$ acoustic output shall be ≤ 100 dB(A) when playing the fixed "programme simulation noise" as described in EN 50332-1.~~

~~– for equipment provided with an electrical output socket for a listening device, the unweighted r.m.s. output voltage shall be ≤ 150 mV or 10 dB below full scale when playing the fixed "programme simulation noise" as described in EN 50332-1.~~

– for equipment provided as a package (player with its listening device), and with a proprietary connector between the player and its listening device, or where the combination of player and listening device is known by other means such as setting or automatic detection, the $L_{\mathrm{Aeq},T}$ acoustic output shall be lower or equal to the relevant RS2 sound output value of Table 39 when playing the fixed "programme simulation noise" described in EN 50332-1.

– for equipment provided with a standardized connector (for example, a 3,5 mm phone jack) that allows connection to a listening device for general use, the unweighted RMS output voltage shall be lower or equal to the relevant RS2 analogue output value of Table 39 when playing the fixed "programme simulation noise" described in EN 50332-1.

– for equipment provided with a digital output, the output signal shall be lower or equal to the relevant RS2 digital output value of Table 39 when playing the fixed "programme simulation noise" described in EN 50332-1.

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10.6.2.3 RS3 limits

RS3 is a class 3 acoustic energy source that exceeds RS2 limits.

10.6.3 Requirements for dose-based systems

10.6.3.1 General requirements

Personal music players shall give the warnings as provided below when tested according to EN 50332-3.

The manufacturer may offer optional settings to allow the users to modify when and how they wish to receive the notifications and warnings to promote a better user experience without defeating the **safeguards**. This allows the users to be informed in a method that best meets their physical capabilities and device usage needs. If such optional settings are offered, an administrator (for example, parental restrictions, business/educational administrators, etc.) shall be able to lock any optional settings into a specific configuration.

The personal music player shall be supplied with easy to understand explanation of the dose management system and how to use it. The user should be made aware that other sources may significantly contribute to the **sound exposure** (for example work, transportation, concerts, clubs, cinema, car races, etc.).

10.6.3.2 Dose-based warning and automatic decrease

When a dose of 100 % CSD is reached (RS2), and at least at every 100 % further increase of CSD, the device shall warn the user and require an acknowledgement. In case the user does not acknowledge, the output level shall automatically decrease to RS1.

NOTE 100 % CSD is based on 80 dB(A) for 40 h.

The warning shall at least clearly indicate that listening above 100 % CSD leads to the risk of hearing damage or loss.

10.6.3.3 Exposure-based warning and requirements

The purpose of the dose-based only requirement is to inform and educate users about safe listening practice.

In addition to dose-based requirements, a system shall therefore either:

– Limit the 30 s integrated exposure level (MEL30) to the relevant RS2 limit of Table 39. The limiter setting time shall be 20 s or faster. The measurement of such limiting functionality is, after allowing the 20 s settling time of the PMP limiter, conducted according to EN 50332-1 or EN 50332-2 as applicable.

– Warn the user in case **momentary exposure level (MEL)** equals or exceeds 100 dB(A). The warning may be given visually or audibly. If the warning is given visually, it shall remain visible for at least 5 s. If the warning is given audibly, it shall interrupt the programme clearly and unmistakingly for at least 1 s.

10.6.4 Measurement methods

All volume controls shall be turned to maximum during tests.

Measurements shall be made in accordance with EN 50332-1 or EN 50332-2 as applicable.

10.6.5 Protection of persons

Except as given below, protection requirements for parts **accessible** to **ordinary persons**, **instructed persons** and **skilled persons** are given in 4.3.

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NOTE 1 Volume control is not considered a **safeguard.**

~~Between RS2 and an **ordinary person**, the **basic safeguard** may be replaced by an **instructional safeguard** in accordance with Clause F.5, except that the **instructional safeguard** shall be placed on the equipment, or on the packaging, or in the instruction manual. Alternatively, the **instructional safeguard** may be given through the equipment display during use.~~

An **equipment safeguard** shall prevent exposure of an **ordinary person** to an RS2 source unless all of the following are met:

– an **instructional safeguard** is provided as given below; and

– the **instructional safeguard** is acknowledged by the user. The output level shall not be higher than RS1 until the acknowledgment is made. The acknowledgement does not need to be repeated more than once every 20 h of cumulative listening time.

NOTE ~~3~~ 2 The 20 h listening time is the accumulative listening time, independent of how often and how long the personal music player has been switched off.

The output level shall automatically return to an output level not exceeding RS1 when the power is switched off.

A **skilled person** shall not unintentionally be exposed to RS3.

When required, an **instructional safeguard** in accordance with Clause F.5 shall be used, except that the **instructional safeguard** shall be placed on the equipment, on the packaging, or in the instruction manual. Alternatively, the **instructional safeguard** may be given through the equipment display during use. The elements of the **instructional safeguard** shall be as follows:

– element 1a: the symbol  , IEC 60417-6044 (2011-01)

– element 2: “High sound pressure” or equivalent wording

– element 3: “Hearing damage risk” or equivalent wording

– element 4: “Do not listen at high volume levels for long periods.” or equivalent wording

~~An **equipment safeguard** shall prevent exposure of an **ordinary person** to RS2 power source without intentional physical action from the **ordinary person** and shall automatically return to an output level not exceeding RS1 when the power is switched off.~~

~~The equipment shall provide a means to actively inform the user of the increased sound pressure when the equipment is operated with an acoustic output exceeding RS1. Any means used shall be acknowledged by the user before activating a mode of operation which allows for an acoustic output exceeding RS1. The acknowledgement does not need to be repeated more than once every 20 h of cumulative listening time.~~

~~NOTE 2 Examples of means include visual or audible signals. Action from the user is always needed.~~

10.6.6 Requirements for listening devices (headphones, earphones, etc.)

10.6.6.1 Corded ~~passive~~ listening devices with analogue input

~~With 94 dB(A) L_{Aeq} acoustic pressure output, the input voltage of the fixed “programme simulation noise” as described in EN 50332-1 shall be ≥ 75 mV.~~

~~This requirement is applicable in any music play mode where the headphones can operate, including any available setting (for example, a built-in volume level control, an additional sound feature like equalization, etc.).~~

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With 94 dB(A) L_{Aeq} acoustic pressure output of the listening device, and with the volume and sound settings in the listening device (for example, built-in volume level control, additional sound feature like equalization, etc.) set to the combination of positions that maximize the measured acoustic output, the input voltage of the listening device when playing the fixed "programme simulation noise" as described in EN 50332-1 shall be ≥ 75 mV.

NOTE The values of 94 dB(A) and 75 mV correspond with 85 dB(A) and 27 mV or 100 dB(A) and 150 mV.

10.6.6.2 Corded listening devices with digital input

With any playing device playing the fixed "programme simulation noise" described in EN 50332-1, and with the volume and sound settings in the listening device (for example, built-in volume level control, additional sound feature like equalization, etc.) set to the combination of positions that maximize the measured acoustic output, the $L_{Aeq,T}$ acoustic output of the listening device shall be ≤ 100 dB(A) with an input signal of –10 dBFS.

~~This requirement is applicable in any music play mode where the headphones can operate, including any available setting (for example, a built-in volume level control, an additional sound feature like equalization, etc.).~~

10.6.6.3 Cordless listening devices

In cordless mode,

– with any playing and transmitting device playing the fixed programme simulation noise described in EN 50332-1; and

– respecting the cordless transmission standards, where an air interface standard exists that specifies the equivalent acoustic level; and

– with volume and sound settings in the receiving device (for example, built-in volume level control, additional sound feature like equalization, etc.) set to the combination of positions that maximize the measured acoustic output for the above mentioned programme simulation noise,

– the $L_{Aeq,T}$ acoustic output of the listening device shall be ≤ 100 dB(A) with an input signal of –10 dBFS.

10.6.6.4 Measurement method

Measurements shall be made in accordance with EN 50332-2 as applicable.

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Annex A
(informative)

Examples of equipment within the scope of this document

Some examples of equipment within the scope of this document are:

Generic product type	Specific example of generic type
Banking equipment	Monetary processing machines including automated teller (cash dispensing) machines (ATM)
Consumer electronic equipment (including professional audio, video and musical instrument equipment)	Receiving equipment and amplifiers for sound and/or vision, supply equipment intended to supply other equipment covered by the scope of this document, electronic musical instruments, and electronic accessories such as rhythm generators, tone generators, music tuners and the like for use with electronic or non-electronic musical instruments, audio and/or video educational equipment, video projectors, video cameras and video monitors, network surveillance cameras, video games, juke boxes, record and optical disc players, tape and optical disc recorders, antenna signal converters and amplifiers, antenna positioners, Citizen's Band equipment, equipment for imagery, electronic light effect equipment, intercommunication equipment using low voltage mains as the transmission medium, cable head-end receivers, multimedia equipment, electronic flash equipment
Data and text processing machines and associated equipment	Data preparation equipment, data processing equipment, data storage equipment, personal computers, tablets, smartphones, wearable devices, plotters, printers (including 3D printers), scanners, text processing equipment, visual display units
Data network equipment	Bridges, data circuit terminating equipment, data terminal equipment, routers
Electrical and electronic retail equipment	Cash registers, point of sale terminals including associated electronic scales
Electrical and electronic office machines	Calculators, copying machines, dictation equipment, document shredding machines, duplicators, erasers, micrographic office equipment, motor-operated files, paper trimmers (punchers, cutting machines, separators), paper jogging machines, pencil sharpeners, staplers, typewriters
Other information technology equipment	Photoprinting equipment, public information terminals, electronic kiosks, multimedia equipment
Postage equipment	Mail processing machines, postage machines
Telecommunication network infrastructure equipment	Billing equipment, multiplexers, network powering equipment, network terminating equipment, radio base stations, repeaters, transmission equipment, telecommunication switching equipment
Telecommunication terminal equipment	Facsimile equipment, key telephone systems, modems, PABXs, pagers, telephone answering machines, telephone sets (wired and wireless)

This list is not intended to be all-inclusive, and equipment that is not listed is not necessarily excluded from the scope.

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Annex B
(normative)

Normal operating condition tests, abnormal operating condition tests and single fault condition tests

B.1 General

B.1.1 ~~Introduction~~ Test applicability

This annex specifies various tests and test conditions applicable to the equipment.

If it is evident that a particular test is not applicable, or not necessary after inspection of available data, the test shall not be made. Tests in this document shall be conducted only if safety is involved.

In order to establish whether or not a test is applicable, the circuits and construction shall be carefully investigated to take into account the consequences of possible faults. The consequence of a fault may or may not require the use of a **safeguard** to reduce the likelihood of injury or fire.

B.1.2 Type of test

Except where otherwise stated, tests specified are **type tests**.

B.1.3 Test samples

Unless otherwise specified, the sample under test shall be representative of the actual equipment or shall be the actual equipment.

As an alternative to conducting tests on the complete equipment, tests may be conducted separately on circuits, components or sub-assemblies outside the equipment, provided that inspection of the equipment and circuit arrangements ensure that such testing will indicate that the assembled equipment would conform to the requirements of this document. If any such test indicates the likelihood of non-conformance in the complete equipment, the test shall be repeated in the equipment.

If a test could be destructive, a model may be used to represent the condition to be evaluated.

B.1.4 Compliance by inspection of relevant data

Where in this document compliance of materials, components or subassemblies is checked by inspection or by testing of properties, compliance may be confirmed by reviewing any relevant data or previous test results that are available instead of carrying out the specified **type tests**.

B.1.5 Temperature measurement conditions

The test measurement set-up shall reproduce the most severe equipment installation conditions. Where a maximum temperature (T_{max}) is specified for compliance with tests, it is based on the assumption that the room ambient air temperature will be 25 °C when the equipment is operating. However, the manufacturer may specify a different maximum ambient air temperature.

~~Measurements are made with the EUT operating at the most unfavourable supply voltage (see B.2.3).~~

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Unless otherwise specified, it is not necessary to maintain the ambient temperature (T_{amb}) at a specific value during tests, but it shall be monitored and recorded.

With reference to those tests that are to be continued until steady state temperatures are attained, steady state is considered to exist if the temperature rise does not exceed 3 K in 30 min. If the measured temperature is at least 10 % less than the specified temperature limit, steady state is considered to exist if the temperature rise does not exceed 1 K in 5 min.

Unless a particular method is specified, temperatures of windings shall be determined either by the thermocouple method or by any other method giving the average temperature of the winding wires such as the resistance method.

B.2 Normal operating conditions

B.2.1 General

Except where specific test conditions are stated elsewhere and where it is clear that there is a significant impact on the results of the test, the tests shall be conducted under the most unfavourable **normal operating conditions** taking into account the following parameters:

– supply voltage;

– supply frequency;

– environmental conditions (for example, the manufacturer's rated maximum ambient temperature);

– physical location of equipment and position of movable parts, as specified by the manufacturer;

– operating mode, including external loading due to interconnected equipment; and

– adjustment of a control.

For audio amplifiers and equipment containing an audio amplifier, additional test conditions apply, see Annex E.

B.2.2 Supply frequency

In determining the most unfavourable supply frequency for a test, different frequencies within the **rated frequency** range shall be taken into account (for example, 50 Hz and 60 Hz) but consideration of the tolerance on a **rated frequency** (for example, 50 Hz ± 0,5 Hz) is not necessary.

B.2.3 Supply voltage

In determining the most unfavourable supply voltage for a test, the following variables shall be taken into account:

– multiple **rated voltages**;

– extremes of **rated voltage ranges**; and

– tolerance on **rated voltage** as declared by the manufacturer.

Unless the manufacturer declares a wider tolerance, the minimum tolerance shall be taken as +10 % and −10 % for AC **mains** and +20 % and −15 % for DC **mains**. Equipment intended by the manufacturer to be restricted to connection to a conditioned power supply system (for example, a UPS) may be provided with a narrower tolerance if the equipment is also provided with instructions specifying such restriction.

~~Where a test subclause does not require the most unfavourable supply voltage (by not making a specific reference to B.2.3), the supply voltage is the value of the **rated voltage** or any value in the **rated voltage range**.~~

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B.2.4 Normal operating voltages

The following voltages shall be considered:

– normal operating voltages generated in the equipment, including repetitive peak voltages such as those associated with switch mode power supplies; and

– normal operating voltages generated external to the equipment, including ringing signals received from **external circuits** as indicated in Table 13, ID numbers 1 and 2.

Externally generated **mains transient voltages** and **external circuit** transient voltages shall not be considered:

– when determining **working voltages**, because such transients have been taken into account in the procedures for determining minimum **clearances** (see 5.4.2); and

– when classifying circuits in the equipment as ES1, ES2 and ES3 (see 5.2).

B.2.5 Input test

In determination of the input current or input power, the following variables shall be considered:

– *loads due to optional features, offered or provided for by the manufacturer for inclusion in or with the EUT;*

– *loads due to other units of equipment intended by the manufacturer to draw power from the EUT;*

– *loads that could be connected to any standard supply outlet on the equipment that is **accessible** to an **ordinary person**, up to the value specified by the manufacturer;*

– *for equipment containing an audio amplifier, see Clause E.1;*

– *for ~~displays with~~ equipment where the primary function is to display moving images, the following settings shall apply:*

- *the 'Three vertical bar signal' shall be used as defined in 3.2.1.3 of IEC 60107-1:1997; and*
- *user **accessible** picture controls shall be adjusted so as to obtain the maximum power consumption; and*
- *sound settings shall be as defined in Clause E.1 of this document.*

Artificial loads may be used to simulate such loads during testing.

In each case, the readings are taken when the input current or input power has stabilized. If the current or power varies during the normal operating cycle, the steady state current or power is taken as the mean indication of the value, measured on a recording RMS ammeter or power meter, during a representative period.

*The measured input current or input power under **normal operating conditions**, but at the **rated voltage** or at each end of each **rated voltage range**, shall not exceed the **rated current** or **rated power** by more than 10 %.*

Compliance is checked by measuring the input current or input power of the equipment under the following conditions:

– *where equipment has more than one **rated voltage**, the input current or input power is measured at each **rated voltage**; and*

– *where equipment has one or more **rated voltage ranges**, the input current or input power is measured at each end of each **rated voltage range**:*

- *where a single value of **rated current** or **rated power** is marked, it is compared with the higher value of input current or input power measured in the associated **rated voltage range**; and*

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- *where two values of **rated current** or **rated power** are marked, separated by a hyphen, they are compared with the two values measured in the associated **rated voltage range**.*

B.2.6 Operating temperature measurement conditions

B.2.6.1 General

Temperatures measured on the equipment shall conform to B.2.6.2 or B.2.6.3, as applicable, all temperatures being in degrees Celsius (°C); where:

T is the temperature of the given part measured under the prescribed test conditions;

T_{max} is the maximum temperature specified for compliance with the test;

T_{amb} is the ambient temperature during test;

T_{ma} is the maximum ambient temperature specified by the manufacturer, or 25 °C, whichever is greater.

B.2.6.2 Operating temperature dependent heating/cooling

For equipment where the amount of heating or cooling is designed to be dependent on temperature (for example, the equipment contains a fan that has a higher speed at a higher temperature), the temperature measurement is made at the least favourable ambient temperature within the manufacturer's specified operating range. In this case, T shall not exceed T_{max}.

NOTE 1 In order to find the highest value of T for each component, it can be useful to conduct several tests at different values of T_{amb}.

NOTE 2 The least favourable value of T_{amb} can be different for different components.

Alternatively, the temperature measurement may be made under ambient conditions with the heating/cooling device at its least effective setting or with the device defeated.

B.2.6.3 Operating temperature independent heating/cooling

For equipment where the amount of heating or cooling is not designed to be dependent on ambient temperature, the method in B.2.6.2 may be used. Alternatively, the test is performed at any value of T_{amb} within the manufacturer's specified operating range. In this case, T shall not exceed $(T_{max} + T_{amb} - T_{ma})$.

During the test, T_{amb} should not exceed T_{ma} unless agreed by all parties involved.

B.2.7 Battery charging and discharging under normal operating conditions

Under **normal operating conditions**, **battery** charging and discharging conditions shall comply with the requirements of Annex M as applicable.

B.3 Simulated abnormal operating conditions

B.3.1 General

When applying simulated **abnormal operating conditions**, parts, supplies, and media shall be in place if they are likely to have an effect on the outcome of the test.

Each **abnormal operating condition** shall be applied in turn, one at a time.

Faults that are the direct consequence of the **abnormal operating condition** are deemed to be a **single fault condition**.

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The equipment, installation, instructions, and specifications shall be examined to determine those **abnormal operating conditions** that might reasonably be expected to occur.

As a minimum, the following examples of **abnormal operating conditions** shall be considered, as applicable, in addition to those mentioned in B.3.2 to B.3.7:

– for paper handling equipment: a paper jam;
– for equipment with controls **accessible** to an **ordinary person**: adjustment of the controls, both individually and collectively, for worst-case operating conditions;
– for audio amplifiers with controls **accessible** to an **ordinary person**: adjustment of the controls, both individually and collectively, for worst-case operating conditions, without applying the conditions specified in Annex E;
– for equipment with moving parts **accessible** to an **ordinary person**: a moving parts jam;
– for equipment with media: incorrect media, incorrect size media, and incorrect media quantity;
– for equipment with replenishable liquids or liquid cartridges, or replenishable materials: liquids or materials spilled into the equipment; and
– for equipment that uses an **insulating liquid** described in 5.4.12.1: loss of liquid.

Before introducing any of the above **abnormal operating conditions**, the equipment shall be operating under **normal operating conditions**.

B.3.2 Covering of ventilation openings

The top, sides and the back of equipment, if such surfaces have ventilation openings, shall be covered one at a time with a ~~piece of~~ card (thick, stiff paper or thin cardboard) with a minimum density of 200 g/m^2, with dimensions not less than each tested surface, covering all openings.

Openings on different surfaces on top of the equipment (if any) are covered simultaneously by separate pieces of card.

Openings on top of the equipment, on a surface inclined at an angle greater than 30° and smaller than 60° to the horizontal, from which an obstruction is free to slide, are excluded.

On the back and the sides of the equipment, the card is attached to the upper edge and allowed to hang freely.

Except as specified below, there are no requirements for blocking openings in the bottom of the equipment.

In addition, equipment with ventilation openings likely to be used on a soft support (like bedding, blankets etc.), shall comply with one of the following:

– Openings in the bottom, sides and back of the equipment are to be covered simultaneously. External surfaces shall not exceed the TS2 limits in Table 38.
– An **instructional safeguard** shall be provided in accordance with Clause F.5, except that element 3 is optional.

  The elements of the **instructional safeguard** shall be as follows:

  - element 1a: not available
  - element 2: “Do not cover ventilation openings” or equivalent wording
  - element 3: optional
  - element 4: “This equipment is not intended to be used on soft support (like beddings, blankets etc.).” or equivalent wording

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B.3.3 DC mains polarity test

If the connection to the DC **mains** is not polarized and the connection is **accessible** to an **ordinary person**, then the possible influence of polarity shall be taken into account when testing equipment designed for DC.

B.3.4 Setting of voltage selector

Equipment to be supplied from the **mains** and provided with a voltage setting device to be set by the **ordinary person** or an **instructed person**, is tested with the **mains** voltage setting device at the most unfavourable position.

B.3.5 Maximum load at output terminals

Output terminals of equipment supplying power to other equipment, except socket-outlets and appliance outlets directly connected to the **mains**, are connected to the most unfavourable load impedance, including short-circuit.

B.3.6 Reverse battery polarity

If it is possible for an **ordinary person** to insert replaceable **batteries** with reversed polarity, the equipment is tested in all possible configurations with one or more **batteries** reversed (see also Annex M).

B.3.7 Audio amplifier abnormal operating conditions

Abnormal operating conditions for audio amplifiers are specified in Clause E.3.

B.3.8 Compliance criteria during and after abnormal operating conditions

*During an **abnormal operating condition** that does not lead to a **single fault condition**, all **safeguards** shall remain effective. After restoration of **normal operating conditions**, all **safeguards** shall comply with applicable requirements.*

*If an **abnormal operating condition** leads to a consequential fault, the compliance criteria of B.4.8 apply.*

B.4 Simulated single fault conditions

B.4.1 General

When applying simulated **single fault conditions**, parts, supplies, and media shall be in place if they are likely to have an effect on the outcome of the test.

The introduction of any **single fault condition** shall be applied in turn one at a time. Faults, that are the direct consequence of the **single fault condition**, are deemed to be part of that **single fault condition**.

The equipment construction, circuit diagrams, component specifications, including **functional insulation** are examined to determine those **single fault conditions** that might reasonably be expected and that:

– might bypass a **safeguard**; or

– cause the operation of a **supplementary safeguard**; or

– otherwise affect the safety of the equipment.

The following **single fault conditions** shall be considered:

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– an **abnormal operating condition** that results in a **single fault condition** (for example, an **ordinary person** overloading external output terminals, or an **ordinary person** incorrectly setting a selector switch);
– a **basic safeguard** failure or a **supplementary safeguard** failure;
– except for integrated circuit current limiters complying with Clause G.9, a component failure simulated by short-circuiting any two leads and open-circuiting any one lead of the component one at a time; and
– when required by B.4.4, a failure of **functional insulation**.

B.4.2 Temperature controlling device

Except for temperature controlling **safeguards**, according G.3.1 to G.3.4, any single device or component of a circuit controlling the temperature during temperature measurement shall be open-circuited or short-circuited, whichever is more unfavourable.

Temperatures shall be measured according to B.1.5.

B.4.3 Motor tests

B.4.3.1 Blocked motor test

Motors are blocked or the rotor is locked in the end product if it is obvious that such an action will result in an increase in internal ambient temperature of the equipment (for example, locking the rotor of the fan motor to stop air flow).

B.4.3.2 Compliance criteria

Compliance is checked by inspection and examination of the available data or by testing according to G.5.4.

B.4.4 Functional insulation

B.4.4.1 Clearances for functional insulation

Unless the **clearance** for **functional insulation** complies with:

– the **clearance** for **basic insulation** as specified in 5.4.2; or
– for ES1 and PS1 circuits used in **pollution degree** 1 and **pollution degree** 2 environments, the **clearance** for **basic insulation** for printed wiring boards as specified in IEC 60664-1:2007, Table F.4; or
– the electric strength test of ~~Table 26~~ 5.4.9.1 for **basic insulation**,

a **clearance** for **functional insulation** shall be short-circuited.

B.4.4.2 Creepage distances for functional insulation

Unless the **creepage distance** for **functional insulation** complies with:

– the **creepage distance** for **basic insulation** as specified in 5.4.3; or
– for ES1 and PS1 circuits used in **pollution degree** 1 and **pollution degree** 2 environments, the **clearance** for **basic insulation** for printed wiring boards as specified in IEC 60664-1:2007, Table F.4; or
– the electric strength test of 5.4.9.1 for **basic insulation**,

a **creepage distance** for **functional insulation** shall be short-circuited.

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B.4.4.3 Functional insulation on coated printed boards

Unless the **functional insulation** complies with:

– the separation distance of Table G.13; or

– the electric strength test of 5.4.9.1 for **basic insulation**,

a **functional insulation** on a coated printed board shall be short-circuited.

B.4.5 Short-circuit and interruption of electrodes in tubes and semiconductors

Electrodes in electronic tubes and leads of semiconductor devices shall be short-circuited, or if applicable, interrupted. One lead at a time is interrupted or any two leads connected together in turn. ~~See B.4.1 for exceptions to this test.~~

B.4.6 Short-circuit or disconnection of passive components

Resistors, capacitors, windings, loudspeakers, VDRs and other passive components shall be short-circuited or disconnected, whichever is more unfavourable.

These **single fault conditions** do not apply to:

– PTC thermistors complying with IEC 60730-1:~~2010~~ 2013, Clauses 15, 17, J.15 and J.17;

– a PTC providing IEC 60730-1 Type 2.AL action;

– resistors complying with the tests of 5.5.6;

– capacitors complying with IEC 60384-14 and assessed according to 5.5.2 of this document;

– isolating components (for example, optocouplers and transformers) complying with the relevant component requirements in Annex G for **reinforced insulation**; and

– other components that serve as a **safeguard** complying with the relevant requirements of Annex G or with the safety requirements of the relevant IEC component standard.

B.4.7 Continuous operation of components

*Motors, relay coils or the like, intended for **short–time operation** or **intermittent operation**, are operated continuously if this can occur during operation of the equipment.*

*For equipment rated for **short–time operation** or **intermittent operation**, the test is repeated until steady state conditions are reached, irrespective of the operating time. For this test, the **thermostats**, **temperature limiters** and **thermal cut-offs** are not short-circuited.*

*In circuits not directly connected to the **mains** and in circuits supplied by a DC power distribution system, electromechanical components normally energized intermittently, except for motors, a fault shall be simulated in the drive circuit to cause continuous energizing of the component.*

The duration of the test shall be as follows:

– *for equipment or components whose failure to operate is not evident to an **ordinary person**, as long as necessary to establish steady conditions or up to the interruption of the circuit due to other consequences of the simulated fault condition, whichever is the shorter; and*

– *for other equipment and components: 5 min or up to interruption of the circuit due to a failure of the component (for example, burn-out) or to other consequences of the simulated fault condition, whichever is shorter.*

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B.4.8 Compliance criteria during and after single fault conditions

*During and after a **single fault condition**, an **accessible** part shall not exceed the relevant energy class as specified in 5.3, 8.3, 9.4, 10.3, 10.4.1, 10.5.1 and 10.6.5 for the related person depending on the hazard involved. During and after **single fault conditions**, any flame inside the equipment shall extinguish within 10 s and no surrounding parts shall have ignited. Any part showing flames shall be regarded as a **PIS**.*

*After a **single fault condition** that might impact an insulation used as a **safeguard**, the insulation shall withstand the electric strength test of 5.4.9.1 for the relevant insulation.*

*During and after a **single fault condition**, the opening of a conductor on a printed board shall not be used as a **safeguard**, except for the following situations, in which case the fault condition shall be repeated 3 times:*

– *Conductors of a printed board of **V-1 class material** or **VTM-1 class material** may open under overload condition provided that the open circuit is not an **arcing PIS**. Conductors on a printed board material that has no **material flammability class** or is classed lower than **V-1 class material** shall not open.*

– *Under a **single fault condition**, the peeling of conductors on a printed board shall not result in the failure of any **supplementary safeguard** or **reinforced safeguard**.*

B.4.9 Battery charging and discharging under single fault conditions

*Under **single fault conditions**, **battery** charging and discharging conditions shall comply with the requirements of Annex M as applicable.*

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Annex C
(normative)

UV radiation

C.1 Protection of materials in equipment from UV radiation

C.1.1 General

This annex defines the test requirements and test procedures for materials that have ~~safety~~ **safeguard** properties and that are subject to UV radiation exposure.

C.1.2 Requirements

~~The following requirements apply only to equipment containing lamps that produce significant UV radiation in the spectrum 180 nm to 400 nm, as specified by the lamp manufacturer.~~

The following requirements apply to equipment, or parts of equipment, that are exposed to lamps that produce significant UV radiation in the spectrum 180 nm to 400 nm and to outdoor equipment exposed to sunlight.

NOTE 1 General-purpose incandescent and fluorescent lamps, with ordinary glass envelopes, are not considered to emit significant UV radiation.

NOTE 2 Filters and/or lenses usually act as a **safeguard** and can serve as part of the **enclosure**.

Table C.1 – Minimum property retention limits after UV exposure

Parts to be tested	Property	Standard for the test method	Minimum retention after test
Parts providing mechanical support	Tensile strength [a]	ISO 527 series	70 %
	or flexural strength [a b]	ISO 178	70 %
Parts providing impact resistance	Charpy impact [c] or	ISO 179-1	70 %
	Izod impact [c] or	ISO 180	70 %
	Tensile impact [c]	ISO 8256	70 %
All parts	**Material flammability class**	See Clause S.4 of this document	[d]

[a] Tensile strength and flexural strength tests are to be conducted on specimens no thicker than the actual thicknesses.

[b] The side of the sample exposed to UV radiation is to be in contact with the two loading points when using the three point loading method.

[c] Tests conducted on 3,0 mm thick specimens for Izod impact and tensile impact tests and 4,0 mm thick specimens for Charpy impact tests are considered representative of other thicknesses, down to 0,75 mm.

[d] The **material flammability class** may change as long as it does not fall below that specified in Clause 6 of this document.

C.1.3 Test method and compliance criteria

Compliance is checked by examination of the construction and of available data regarding the UV resistance characteristics of the parts exposed to UV radiation in the equipment. If such data is not available, the tests in Table C.1 are carried out on the parts.

Samples taken from the parts, or consisting of identical material, are prepared according to the standard for the test to be carried out. They are then ~~exposed to UV radiation (~~conditioned~~)~~ according to Clause C.2. After conditioning, the samples shall show no signs of significant deterioration, such as crazing or cracking. They are then kept at room ambient

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conditions for not less than 16 h and not more than 96 h, after which they are tested according to the standard for the relevant test.

In order to evaluate the percentage retention of properties after test, samples that have not been conditioned according to Clause C.2 are tested at the same time as the conditioned samples.

The retention shall be as specified in Table C.1.

C.2 UV light conditioning test

C.2.1 Test apparatus

Samples are exposed to UV light by using one of the following apparatus:

- *a twin enclosed carbon-arc (see C.2.3) with continuous exposure for a minimum of 720 h. The test apparatus shall operate with a black-panel temperature of 63 °C ± 3 °C in a relative humidity of (50 ± 5) %; or*
- *a xenon-arc (see C.2.4) with continuous exposure for a minimum of 1 000 h. The test apparatus shall operate with a 6 500 W, water-cooled xenon-arc lamp, a spectral irradiance of 0,35 W/m^2 at 340 nm, a black-panel temperature of 63 °C ± 3 °C in a relative humidity of (50 ± 5) %.*

C.2.2 Mounting of test samples

The samples are mounted vertically on the inside of the cylinder of the light exposure apparatus, with the widest portion of the samples facing the arcs. They are mounted so that they do not touch each other.

C.2.3 Carbon-arc light-exposure test

The apparatus described in ISO 4892-4, or equivalent, is used in accordance with the procedures given in ISO 4892-1 and ISO 4892-4 using a type 1 filter, ~~without~~ with water spray.

~~NOTE The wording "without water spray" indicates that the samples are not sprayed with water during the test. Do not confuse water spray with water cooling that is necessary for operation of the apparatus.~~

~~*Materials are exposed to the light continuously for a minimum of 720 h.*~~

~~*Materials tested with water spray are also considered acceptable.*~~

C.2.4 Xenon-arc light-exposure test

The apparatus described in ISO 4892-2:2013, or equivalent, is used in accordance with the procedures given in ISO 4892-1 and ISO 4892-4 using cycle ~~2~~ 1 of method A of Table 3, without water spray.

~~NOTE The wording "without water spray" indicates that the samples are not sprayed with water during the test. Do not confuse water spray with water cooling that is necessary for operation of the apparatus.~~

~~*Materials are exposed to the light continuously for a minimum of 1 000 h.*~~

~~*Materials tested with water spray are also considered acceptable.*~~

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Annex D
(normative)

Test generators

D.1 Impulse test generators

These circuits produce test pulses as referenced in Table D.1. In this table:

– the circuit 1 impulse is typical of voltages induced into telephone wires and coaxial cables in long outdoor cable runs due to lightning strikes to their earthing shield;

– the circuit 2 impulse is typical of earth potential rises due to either lightning strikes to power lines or power line faults; and

– the circuit 3 impulse is typical of voltages induced into antenna system wiring due to nearby lightning strikes to earth.

NOTE During the tests, use extreme care due to the high electric charge stored in the capacitor C_1.

The circuit in Figure D.1, using the component values in circuits 1 and 2 of Table D.1, is used to generate impulses, the C_1 capacitor being charged initially to a voltage U_c.

Circuit 1 of Table D.1 generates 10/700 μs impulses (10 μs virtual front time, 700 μs virtual time to half value) to simulate transients in **external circuits** as indicated in Table 13, ID numbers 1, 2, 3, 4 and 5.

Circuit 2 of Table D.1 generates 1,2/50 μs impulses (1,2 μs virtual front time, 50 μs virtual time to half value) to simulate transients in power distribution systems.

The impulse wave shapes are under open-circuit conditions and can be different under load conditions.

During the test, the peak voltage of the applied impulse shall not be less than the peak impulse test voltage (for example, see Table 14) and the pulse shape (for example, 1,2 μs virtual front time, 50 μs virtual time to half value for the 1,2/50 μs impulse) shall remain substantially the same as under open-circuit conditions. Components in parallel with the ***clearance*** *may be disconnected during this test.*

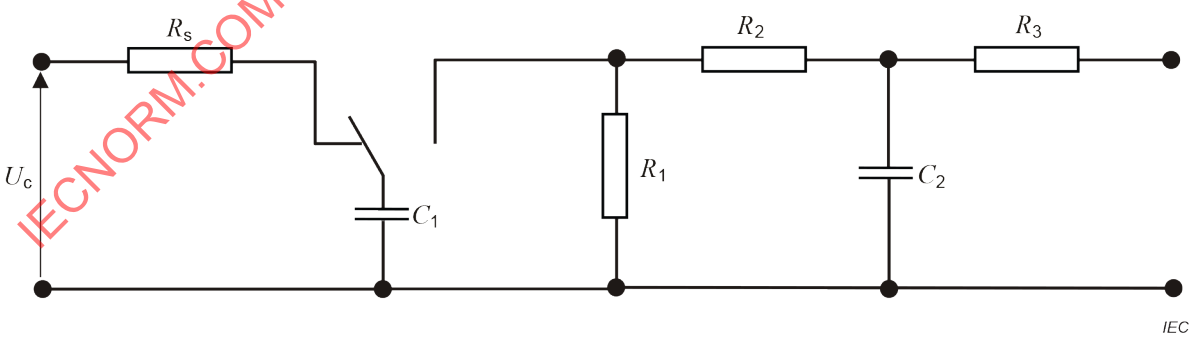


Figure D.1 – 1,2/50 μs and 10/700 μs voltage impulse generator

D.2 Antenna interface test generator

The circuit in Figure D.2 using the component values of circuit 3 in Table D.1, is used to generate impulses, the C_1 capacitor being charged initially to a voltage U_c.

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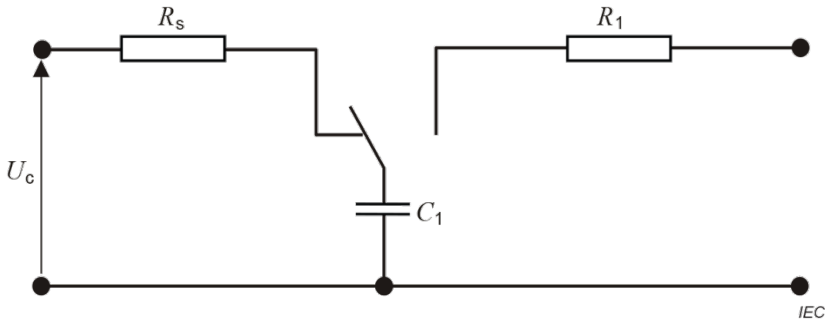
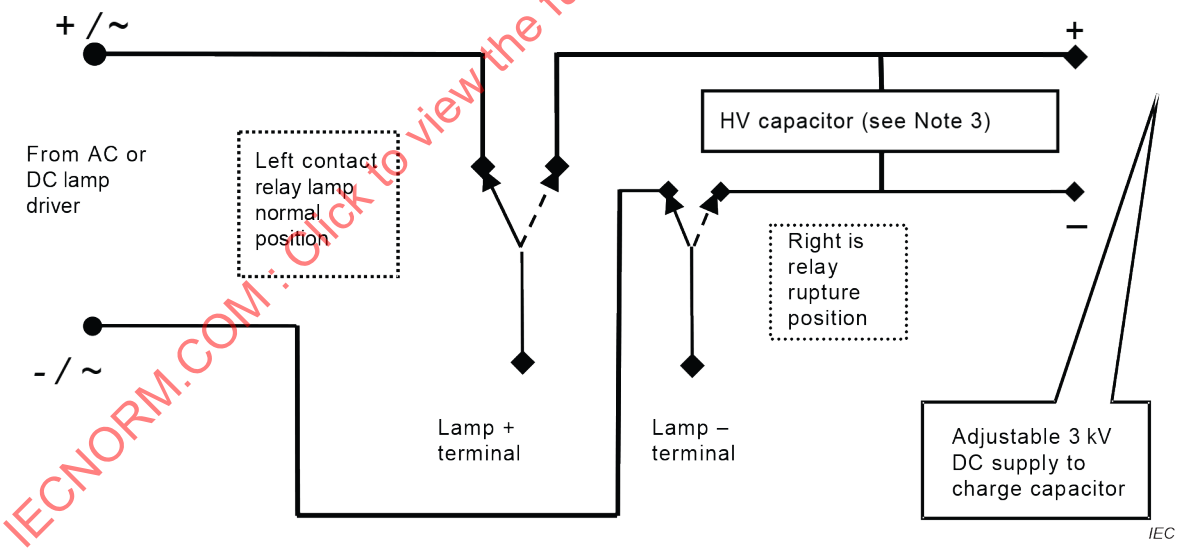


Figure D.2 – Antenna interface test generator circuit

Table D.1 – Component values for Figure D.1 and Figure D.2

	Test impulse	Figure	R_S	C_1	C_2	R_1	R_2	R_3
Circuit 1	10/700 µs	D.1	-	20 µF	0,2 µF	50 Ω	15 Ω	25 Ω
Circuit 2	1,2/50 µs	D.1	-	1 µF	30 nF	76 Ω	13 Ω	25 Ω
Circuit 3	-	D.2	15 MΩ	1 nF	-	1 kΩ	-	-
Alternative test generators may be used provided they give the same result. NOTE Circuits 1 and 2 are based on ITU-T Recommendation K.44.								

D.3 Electronic pulse generator



NOTE 1 The operating pressure of the lamp can be converted to energy (Joules). The operating energy level can typically be used as the starting point for the test charge.

NOTE 2 The relay is a 5 kV double pole defibrillator type, nitrogen filled. A defibrillator qualified relay is sufficient. See IEC 60601-2-4.

NOTE 3 The HV capacitor is rated 0,42 µF 5 kV.

Figure D.3 – Example of an electronic pulse generator

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Annex E
(normative)

Test conditions for equipment containing audio amplifiers

E.1 Electrical energy source classification for audio signals

When classifying audio signals as an electrical energy source (see Table E.1), the equipment shall be operated to deliver maximum **non-clipped output power** into its **rated load impedance**. The load is removed and the electrical energy source class is determined from the resulting open-circuit output voltage.

Tone controls are to be set at mid-range.

Table E.1 – Audio signal electrical energy source classes and safeguards

Class	Audio signal voltage V RMS	Examples of safeguards between energy source and ordinary person	Example of safeguards between energy source and instructed person
ES1	0 up to 71	No **safeguard** necessary	No **safeguard** necessary
ES2	Above 71 and up to 120	Insulated terminals [a] marked with ISO 7000, symbol  0434a (2004-01) or symbol  0434b (2004-01)	No **safeguard** necessary
		Instructional safeguard for uninsulated parts of terminals and bare wiring [b]	
ES3	Above 120	Connectors conforming to the requirements of IEC 61984 and marked with the symbol of IEC 60417-6042 (2010-11) 	

[a] Terminals that have no conductive parts **accessible** after wiring are installed according to instructions.

[b] An **instructional safeguard** indicating that touching uninsulated terminals or wiring may result in an unpleasant sensation.

E.2 Audio amplifier normal operating conditions

Equipment containing an audio amplifier shall be operated using a sine wave audio signal source at a frequency of 1 000 Hz. In the case where an amplifier is not intended for operation at 1 000 Hz, the **peak response frequency** shall be used.

The equipment shall be operated in such a way as to deliver 1/8 **non-clipped output power** to the **rated load impedance**. Alternatively, a band-limited pink noise signal may be used for operation after **non-clipped output power** is established using a sine wave. The noise bandwidth of the pink noise test signal shall be limited by a filter of a characteristic as shown in Figure E.1.

If visible clipping cannot be established, the maximum attainable power shall be considered as the **non-clipped output power**.

~~When classifying audio signals (see Table E.1), the equipment shall be operated to deliver maximum **non-clipped output power** into its **rated load impedance**. The load is removed and the electrical energy source class is determined from the resulting open-circuit output voltage.~~

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~~Tone controls are to be set at mid-range.~~

In addition, all of the following conditions shall be considered under **normal operating conditions**:

– The most unfavourable **rated load impedance** or the actual loudspeaker, when provided, is connected to the amplifier output.

– All amplifier channels are operated simultaneously.

– Organs or similar instruments that have a tone-generator unit shall not be operated with the 1 000 Hz signal, but instead be operated with any combination of two bass pedal keys, if present, and ten manual keys depressed. All stops and tabs that can increase the output power shall be activated and the equipment shall be adjusted to deliver 1/8 of the maximum attainable output power.

– Where the intended amplifier function depends on phase difference between two channels, there shall be a phase difference of 90° between signals applied to the two channels.

– For equipment containing multi-channel amplifiers, where some channels cannot be operated independently, those channels shall be operated using the **rated load impedance** at the output power level that corresponds, by design, to 1/8 of the **non-clipped output power** of the adjustable amplifier channel(s).

– Where continuous operation is not possible, the amplifier shall be operated at the maximum output power level that allows continuous operation.

The temperature measurements shall be carried out with the equipment positioned in accordance with the instruction manual provided by the manufacturer, or, in the absence of instructions, the equipment shall be positioned 5 cm behind the front edge of an open-fronted wooden test box with 1 cm free space along the sides and top and 5 cm depth behind the equipment.

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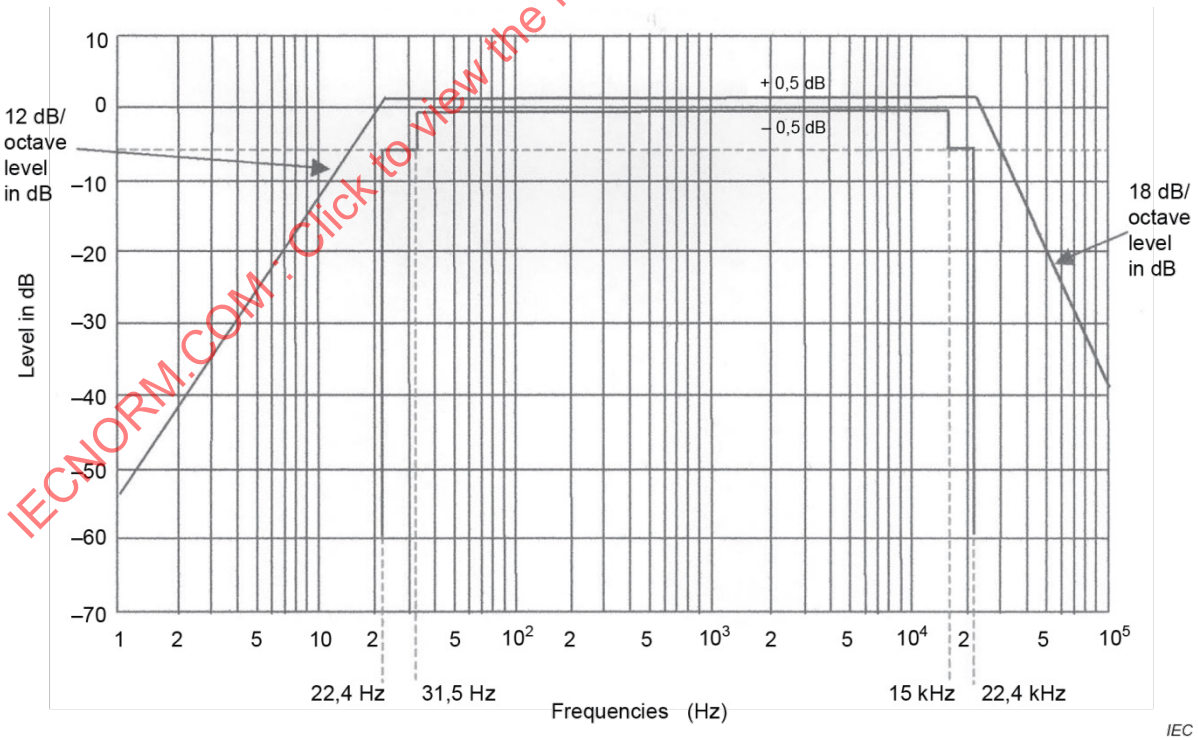


Figure E.1 – Band-pass filter for wide-band noise measurement

E.3 Audio amplifier abnormal operating conditions

Abnormal operating conditions shall be simulated by adjusting the controls to the most unfavourable output power from zero up to the maximum attainable output power into the most unfavourable **rated load impedance** connected to the output terminals. Short-circuit of the output terminals is also considered to be an **abnormal operating condition**.

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Annex F
(normative)

Equipment markings, instructions, and instructional safeguards

F.1 General

This annex specifies equipment markings, equipment instructions, and **instructional safeguards** necessary for equipment installation, operation, maintenance, and servicing in accordance with the requirements of this document.

Unless symbols are used, safety related equipment marking, instructions and **instructional safeguards** shall be in a language accepted in the respective countries.

This annex does not apply to markings on components. Markings on components are specified in the relevant component standard.

This annex may apply to sub-assemblies such as power supplies.

NOTE 1 Where the term marking is used in this document, it also applies to instructions and required elements of an **instructional safeguard**.

NOTE 2 See Table F.1 for examples of markings.

Care shall be taken so that additional markings and instructions not required by this document do not contradict the markings and instructions required by this document.

F.2 Letter symbols and graphical symbols

F.2.1 Letter symbols

Letter symbols for quantities and units shall be in accordance with IEC 60027-1.

F.2.2 Graphical symbols

Graphical symbols placed on the equipment for safety purposes, whether required by this document or not, shall be in accordance with IEC 60417, ISO 3864-2, ISO 7000 or ISO 7010, if available. In the absence of suitable symbols, the manufacturer may design specific graphical symbols.

F.2.3 Compliance criteria

Compliance is checked by inspection.

F.3 Equipment markings

F.3.1 Equipment marking locations

In general, equipment markings shall be located near or adjacent to the part or region that is the subject of the marking.

Unless otherwise specified, equipment markings ~~specified~~ required in F.3.2, F.3.3, F.3.6 and F.3.7 shall be on the exterior of the equipment, excluding the bottom. However, these markings may be in an area that is easily **accessible** by hand, for example:

– under a lid; or

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– on the exterior of the bottom of:
  - **direct plug-in equipment**, **hand-held equipment**, **transportable equipment**; or
  - **movable equipment** with a mass not exceeding 18 kg, provided that the location of the marking is given in the instructions.

Markings shall not be put on parts that can be removed without the use of a **tool**, unless they apply to that part.

For **permanently connected equipment**, installation instructions shall be provided either as markings on the equipment, or in the instructions, or in a separate installation instruction document.

~~For rack or panel mounted equipment exceeding 18 kg, markings may be on any surface that becomes visible after removal of the equipment from the rack or panel.~~

For equipment intended to be mounted on a supporting structure (for example, a rack, panel, wall, ceiling, etc.) and where the external surface of the equipment becomes partially invisible after installation, markings may be on any surface, including the bottom, that becomes visible after removal of the equipment from the supporting structure.

Unless the meaning of the marking is obvious, the marking shall be explained in the instructions.

Compliance is checked by inspection.

F.3.2 Equipment identification markings

F.3.2.1 Manufacturer identification

The manufacturer or responsible vendor shall be identified by means of a marking on the equipment. Identification may be the manufacturer's name, the responsible vendor's name, trademark, or other equivalent identification.

Compliance is checked by inspection.

F.3.2.2 Model identification

The model number, model name, or equivalent shall be identified by means of a marking on the equipment.

Compliance is checked by inspection.

F.3.3 Equipment rating markings

F.3.3.1 Equipment with direct connection to mains

If a unit is provided with a means for direct connection to the **mains**, it shall be marked with an electrical rating, as specified in F.3.3.3 to F.3.3.6.

F.3.3.2 Equipment without direct connection to mains

If a unit is not provided with a means for direct connection to the **mains**, it need not be marked with any electrical rating. However, any **rated power** or **rated current** marking on the equipment shall comply with B.2.5.

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F.3.3.3 Nature of the supply voltage

The nature of the supply voltage, DC, AC, or three-phase AC, shall be marked on the equipment and shall immediately follow the equipment voltage rating. If a symbol is used

– the symbol ~, IEC 60417-5032 (2002-10) shall be used for AC;
– the symbol ⎓, IEC 60417-5031 (2002-10) shall be used for DC;
– the symbol 3~, IEC 60417-5032-1 (2002-10) shall be used for three-phase AC;
– the symbol 3N~, IEC 60417-5032-2 (2002-10) shall be used for three-phase AC with a neutral conductor; or
– the symbol ≂, IEC 60417-5033 (2002-10) shall be used for combined AC and DC.

Three-phase equipment may be identified with “3-phase” or “3Ø” or any other arrangement that clearly indicates the phase of the supply voltage of the equipment.

F.3.3.4 Rated voltage

The **rated voltage** of the equipment shall be marked on the equipment. The voltage rating marking shall be immediately followed by the nature of the supply marking.

The **rated voltage** may be:

– a single, nominal value; or
– a single nominal value and a tolerance percentage of the nominal value; or
– two or more nominal values separated by a solidus (/); or
– a range indicated by minimum and maximum values separated by a hyphen; or
– any other arrangement that clearly indicates the voltage of the equipment.

If the equipment has more than one nominal voltage, all such voltages may be marked on the equipment. However, the voltage for which the equipment is set shall be clearly indicated (see F.3.4). If the equipment is installed by a **skilled person**, this indication may be in the installation instructions or at any location on the equipment, including inside the equipment.

Three-phase equipment shall be marked with the phase-to-phase voltage, a symbol indicating power supply system in accordance with IEC 61293, a solidus (/), the phase-to-neutral voltage, the symbol for voltage (*V*) and the number of phases, in that order. Any other arrangement that clearly indicates the three-phase **rated voltage** of the equipment is also acceptable.

NOTE The solidus (/) represents the word “or” and the hyphen (-) represents the word “to”.

F.3.3.5 Rated frequency

The **rated frequency** of the equipment shall be marked on the equipment.

The **rated frequency** may be:

– a single, nominal value; or
– a single nominal value and a tolerance percentage of the nominal value; or
– two or more nominal values separated by a solidus (/); or
– a range indicated by minimum and maximum values separated by a hyphen; or
– any other arrangement that clearly indicates the **rated frequency** of the equipment.

F.3.3.6 Rated current or rated power

The **rated current** or **rated power** of the equipment shall be marked on the equipment.

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For three-phase equipment, ~~the **rated current** or **rated power** is the current or power of one phase~~ the **rated current** is the current of one phase and the **rated power** is the total power of the three phases.

NOTE 1 B.2.5 establishes criteria for the way in which **rated current** or **rated power** are measured.

NOTE 2 The **rated current** or **rated power** need not be stated to more than one significant digit.

NOTE 3 In some countries, for markings on equipment, a period is ~~required~~ used as the decimal designator.

If the equipment has a socket-outlet for providing **mains** power to other equipment, the **rated current** or **rated power** of the equipment shall include the assigned current or power of the socket-outlet.

See F.3.5.1 for marking requirements for a **mains** socket-outlet.

If the equipment has more than one **rated voltage**, the **rated current** or **rated power** for each **rated voltage** shall be marked on the equipment. The arrangement of the markings shall clearly indicate the **rated current** or **rated power** associated with each **rated voltage** of the equipment.

Equipment with a **rated voltage range** may be marked with either the maximum **rated current** or with the current range.

F.3.3.7 Equipment with multiple supply connections

If the equipment has multiple supply connections, each connection shall be marked with its **rated current** or **rated power**.

Where the multiple **mains** supplies are identical, they may have one marking indicating the number of supplies.

EXAMPLE "240 V ~ / 10 A × N" where N is the number of identical **mains** supply connections.

If the equipment has multiple supply connections, and if each connection has a different **rated voltage** than the other supply connections, each connection shall be marked with its **rated voltage**.

The overall system electrical rating need not be marked.

F.3.3.8 Compliance criteria

Compliance is checked by inspection.

F.3.4 Voltage setting device

If the equipment uses a voltage setting device that is operable by an **ordinary person** or an **instructed person**, the act of changing the voltage setting shall also change the indication of the voltage for which the equipment is set. The setting shall be ~~readily discernable~~ readable when the equipment is ready for use.

If the equipment uses a voltage-setting device that is operable only by a **skilled person**, and if the act of changing the voltage setting does not also change the indication of the voltage rating, an **instructional safeguard** shall state that, when changing the voltage setting, the indication of the voltage setting shall also be changed.

Compliance is checked by inspection.

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F.3.5 Markings on terminals and operating devices

F.3.5.1 Mains appliance outlet and socket-outlet markings

If a **mains** appliance outlet ~~in accordance with IEC 60320-2-2~~ is provided on the equipment, the **rated voltage** and assigned current or power shall be marked adjacent to the appliance outlet.

If the **mains** socket-outlet is configured in accordance with IEC TR 60083 or a relevant national standard, the assigned current or power shall be marked. If the voltage of the socket-outlet is the same as the **mains** voltage, the voltage need not be marked.

F.3.5.2 Switch position identification marking

The position of a disconnect switch or circuit-breaker shall be identified. Such identification may be comprised of words, symbols, or an indicator.

If a symbol is used, the symbol shall be in accordance with IEC 60417.

F.3.5.3 Replacement fuse identification and rating markings

If a fuse is replaceable by an **ordinary person** or an **instructed person**, identification of a suitable replacement fuse shall be marked adjacent to the fuseholder. Identification shall include the fuse current rating and the following as appropriate:

– if the fuse needs a special breaking capacity which is necessary for the **safeguard** function, the appropriate symbol that indicates the breaking capacity;

– if the fuse can be replaced with a fuse of a different voltage rating, the fuse voltage rating;

– if the fuse is a time-delay fuse, and the time-delay is necessary for the **safeguard** function, the appropriate symbol that indicates the time-delay.

If a fuse is replaceable by an **ordinary person**, the codings of the relevant fuses shall be explained in the user instructions.

If a fuse is not replaceable by an **ordinary person** or an **instructed person**:

– identification of a suitable replacement fuse shall be marked adjacent to the fuse or shall be provided in the service instructions; and

– if the fuse is, or could be, in the neutral of the **mains** supply and after operation of the fuse, parts of the equipment that remain energized are at ES3 level during servicing, an **instructional safeguard** shall state that the fuse ~~is~~ may be in the neutral, and that the **mains** shall be disconnected to de-energize the phase conductors.

If a fuse is not intended to be replaceable, fuse ratings need not be marked.

F.3.5.4 Replacement battery identification marking

If a **battery** can be replaced by an incorrect type of replaceable **battery**, an **instructional safeguard** shall be provided in accordance with Clause ~~F.5~~ M.10.

F.3.5.5 Neutral conductor terminal

For **permanently connected equipment**, the terminal, if any, intended exclusively for connection of the **mains** neutral conductor shall be identified by the capital letter “N”.

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F.3.5.6 Terminal marking location

The terminal markings specified in F.3.5.5, F.3.6.1 and F.3.6.3 shall not be placed on screws, removable washers, or other parts that can be removed when conductors are being connected.

F.3.5.7 Compliance criteria

Compliance is checked by inspection.

F.3.6 Equipment markings related to equipment classification

F.3.6.1 Class I equipment

F.3.6.1.1 Protective earthing conductor terminal

The terminal intended for connection of **class I equipment** to the installation **protective earthing conductor** shall be identified with the symbol  , IEC 60417-5019 (2006-08).

A terminal intended for connection of a class I sub-assembly (for example, a power supply), or a component (for example, a terminal block) to the equipment **protective earthing conductor** may be identified with either symbol  , IEC 60417-5019 (2006-08), or with symbol , IEC 60417-5017 (2006-08).

~~**F.3.6.1.2 Neutral conductor terminal**~~

~~For **permanently connected equipment**, the terminal, if any, intended exclusively for connection of the **mains** neutral conductor shall be identified by the capital letter "N".~~

F.3.6.1.2 Protective bonding conductor terminals

Terminals for **protective bonding conductors** need not be identified.

If such terminals are identified, they shall be marked with the earth symbol  , IEC 60417-5017 (2006-08). However, a component terminal or a terminal for bonding wiring from the appliance inlet already marked with the symbol  , IEC 60417-5019 (2006-08), is acceptable as identification of a **protective bonding conductor** terminal.

~~**F.3.6.2 Class II equipment**~~

~~**F.3.6.2.1 Equipment class marking**~~

~~**Class II equipment** without **functional earth** connection shall bear the symbol~~  ~~, IEC 60417-5172 (2003-02).~~

~~**Class II equipment** with **functional earth** connection shall bear the symbol~~  ~~, IEC 60417-6092 (2011-10).~~

~~The above symbols shall not be used for **class I equipment**.~~

~~Equipment providing protective earthing to other equipment cannot be regarded as **class II equipment**.~~

~~For **class II equipment** provided with a **mains** cord having a conductor with green-and-yellow insulation that is used only to provide a connection to **functional earth**, there are no~~

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~~requirements other than those in 4.6 regarding the termination of this conductor at the equipment end.~~

F.3.6.2 Equipment class marking

Class II equipment with a **functional earthing** connection shall bear the symbol  , IEC 60417-6092 (2013-03).

All other **class II equipment** shall bear the symbol  , IEC 60417-5172 (2003-02).

The above symbols shall not be used for **class I equipment**.

Equipment providing **protective earthing** to other equipment shall not be classified as **class II equipment**.

F.3.6.3 Functional earthing terminal marking

Wiring terminals to be used only for the connection of **functional earthing** shall be marked with the symbol ~~  , IEC 60417-5020 (2002-10)~~  , IEC 60417-5018 (2011-07). These terminals shall not be marked with the symbol  , IEC 60417-5017 (2006-08) or with the symbol  , IEC 60417-5019 (2006-08).

However, these symbols may be used for a wiring terminal provided on a component (for example, a terminal block) or subassembly.

F.3.6.4 Compliance criteria

Compliance is checked by inspection.

F.3.7 Equipment IP rating marking

If the equipment is intended for other than IPX0, the equipment shall bear the IP number according to the degree of protection against ingress of water in accordance with IEC 60529.

Compliance is checked by inspection.

F.3.8 External power supply output marking

The DC output of an external power supply shall be marked with the voltage rating, the current rating and the polarity. Polarity marking is not required when the pin configuration prevents reversed polarity. The AC output of an external power supply shall be marked with the voltage rating, the current rating and the frequency if it is different from the input frequency.

Compliance is checked by inspection and measurement.

F.3.9 Durability, legibility and permanence of markings

In general, all markings required to be on the equipment shall be durable and legible, and shall be easily discernable under normal lighting conditions.

Unless otherwise specified, **instructional safeguards** do not have to be in colour. If an **instructional safeguard** is in colour to indicate hazard severity, the colour shall be in

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accordance with the ISO 3864 series. Markings that are engraved or moulded need not be in contrasting colours provided that they are legible and readily discernable under normal lighting conditions.

Printed or screened markings shall also be permanent.

Compliance is checked by inspection. Permanency is determined by the tests of F.3.10.

F.3.10 Test for the permanence of markings

F.3.10.1 General

Each required printed or screened marking shall be tested. However, if the data sheet for a label confirms compliance with the test requirements, the test need not be performed.

F.3.10.2 Testing procedure

The test is conducted by rubbing the marking by hand without appreciable force for 15 s with a piece of cloth soaked with water and at a different place or on a different sample for 15 s with a piece of cloth soaked with the petroleum spirit specified in F.3.10.3.

F.3.10.3 Petroleum spirit

Petroleum spirit is a reagent grade hexane with a minimum of 85 % n-hexane.

NOTE The designation “n-hexane” is chemical nomenclature for a "normal" or straight chain hydrocarbon. ~~This petroleum spirit is further identified as a certified ACS (American Chemical Society) reagent grade hexane (CAS#110-54-3).~~ The CAS (American Chemical Society) number of n-hexane is CAS#110-54-3.

F.3.10.4 Compliance criteria

After each test, the marking shall remain legible. If the marking is on a separable label, the label shall show no curling and shall not be removable by hand.

F.4 Instructions

When information with regard to safety is required according to this document, this information shall be given in an instruction for installation or instruction for initial use. This information shall be available prior to installation and initial use of the equipment.

Equipment for use in locations where children are not likely to be present and that is evaluated using the jointed test probe of Figure V.2 shall have the following or equivalent statement in the user instructions.

NOTE 1 This equipment design typically applies to commercial or industrial equipment expected to be installed in locations where only adults are normally present.

This equipment is not suitable for use in locations where children are likely to be present.

NOTE 2 See also ISO/IEC Guide 37, instructions for use of products of consumer interest.

The instructions shall include the following as far as applicable:

– Instructions to ensure correct and safe installation and interconnection of the equipment.

– For equipment intended only for use in a **restricted access area**, the instructions shall so state.

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- If the equipment is intended to be fastened in place, the instructions shall explain how to securely fasten the equipment.
- For audio equipment with terminals classified as ES3 in accordance with Table E.1, and for other equipment with terminals marked in accordance with F.3.6.1, the instructions shall require that the external wiring connected to these terminals shall be installed by a **skilled person**, or shall be connected by means of ready-made leads or cords that are constructed in a way that would prevent contact with any ES3 circuit.
- If **protective earthing** is used as a **safeguard**, the instructions shall require connection of the equipment **protective earthing conductor** to the installation **protective earthing conductor** (for example, by means of a power cord connected to a socket-outlet with earthing connection).
- For equipment with **protective conductor current** on the **protective earthing conductor** exceeding the ES2 limits of 5.2.2.2, the equipment shall bear an **instructional safeguard** in accordance with 5.7.6.
- Graphical symbols placed on the equipment and used as an **instructional safeguard** shall be explained.
- If a **permanently connected equipment** is not provided with an all-pole **mains** switch, the instructions for installation shall state that an all-pole **mains** switch in accordance with Annex L shall be incorporated in the electrical installation of the building.
- If a replaceable component or module provides a **safeguard** function, identification of a suitable replacement component or module shall be provided in the **ordinary person** instructions or **instructed person** instructions, or **skilled person** instructions, as applicable.
- For equipment containing an **insulating liquid**, safety instructions shall be provided where applicable, including the use of PPE if needed, taking into account the manufacturer's data for the **insulating liquid** and the information in the material safety data sheet.
- The installation instructions for **outdoor equipment** shall include details of any special features needed for protection from conditions in the **outdoor location**.

Compliance is checked by inspection.

F.5 Instructional safeguards

Unless otherwise specified, an **instructional safeguard** is comprised of element 1a or element 2, or both, together with element 3 and element 4. If a suitable symbol for element 1a is not available, then element 1b may be used instead.

Unless otherwise specified, the location of the **instructional safeguard** shall be as follows:

- the complete **instructional safeguard** shall be marked on the equipment; or
- element 1a or element 2, or both, shall be marked on the equipment and the complete **instructional safeguard** shall be in the text of an accompanying document. If only element 2 is used, the text shall be preceded by the word “Warning” or “Caution” or similar wording.

Any **instructional safeguard** element placed on the equipment shall be visible to the person prior to potential exposure to the class 2 energy source or class 3 energy source parts and as close as reasonably possible to the energy source parts.

Elements 1a, 1b, 2, 3, and 4 are specified in Table F.1.

A single **instructional safeguard** may be related to several parts, provided those parts are closely located near each other. An accompanying document or the instruction manual shall show the locations of these parts, if these parts are not easily identifiable, or not located adjacent to the **instructional safeguard**.

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Table F.1 – Instructional safeguard element description and examples

Element	Description	Example
1a	A symbol that identifies the nature of the class 2 or class 3 energy source or the consequences that can be caused by the class 2 or class 3 energy source.	
1b	A symbol such as ISO 7000-0434 (2004-01) or a combination of this symbol and ISO 7000-1641 (2004-01) to refer to text in an accompanying document. These symbols may be combined.	
2	Text that identifies the nature of the class 2 or class 3 energy source or the consequences that can be caused by the energy source, and the location of the energy source.	**Hot parts!**
3	Text that describes the possible consequences of energy transfer from the energy source to a body part.	Burned fingers when handling the parts
4	Text that describes the **safeguard** action necessary to avoid energy transfer to a body part.	Wait one-half hour after switching off before handling parts
The symbols for elements 1a and 1b shall be from IEC 60417, ISO 3864-2, ISO 7000, ISO 7010 or the equivalent.		

Figure F.1 illustrates one example of the arrangement of the four elements that comprise a complete **instructional safeguard**. Other arrangements in the positioning of the elements are also acceptable.

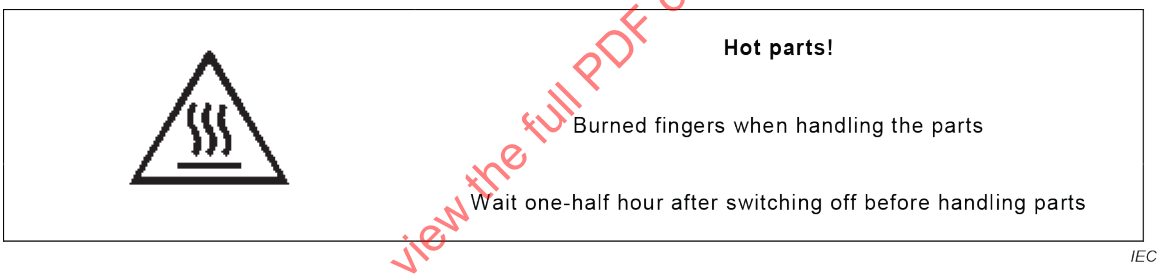
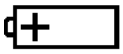


Figure F.1 – Example of an instructional safeguard

See Table F.2 for examples of markings, instructions, and **instructional safeguards**.

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Table F.2 – Examples of markings, instructions, and instructional safeguards

Rating	Example
Rated **DC voltage**	48 V DC 48 V ⎓
Rated AC voltage	230 V ~ 230 V ~ ±10 % 100/120/220/240 V AC 100–250 V AC
Rated 3-phase voltage	400 Y/230 V 3Ø 208 Y/120 V 3-phase 208 Y/120 V 3 ~
Rated frequency	50-60 Hz 50/60 Hz
Rated current	1 A
AC rated power	
DC rated power	
Instruction	**Example**
Positioning of **cell**, IEC 60417-5002 (2002-10)	
AC, IEC 60417-5032 (2002-10)	
DC, IEC 60417-5031 (2002-10)	
Class II equipment, IEC 60417-5172 (2003-02)	
Caution, ISO 7000, 0434a or 0434b (2004-01)	
Dangerous voltage, IEC 60417-5036 (2002-10)	
Earth; ground, IEC 60417-5017 (2006-08)	
Protective earth; protective ground, IEC 60417-5019 (2006-08)	

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Annex G
(normative)

Components

G.1 Switches

G.1.1 General

Requirements for switches that are located in PS3 are specified below.

A switch may be tested separately or in the equipment.

G.1.2 Requirements

Switches used as **disconnect devices** shall comply with the requirements in Annex L.

A switch shall not be fitted in a **mains** supply cord.

A switch shall comply with all of the following:

– comply with the requirements of IEC 61058-1:~~2008~~ 2016, whereby the following applies:
  - 10 000 operating cycles (see 7.1.4.4 of IEC 61058-1:~~2008~~ 2016);
  - the switch shall be suitable for use in the **pollution degree** environment in which it is used, typically a **pollution degree** 2 environment (see 7.1.6.2 of IEC 61058-1:~~2008~~ 2016);
  - the switch have a glow wire temperature of 850 °C (see 7.1.9.3 of IEC 61058-1:~~2008~~ 2016);
  - for **mains** switches used in CRT televisions, the speed of contact making and breaking shall be independent of the speed of actuation;

    NOTE This is because there is a high inrush current due to the degausing coil.
  - the characteristics of the switch with regard to the ratings and classification (see IEC 61058-1) shall be appropriate for the function of the switch under **normal operating conditions** as given below:
    – the ratings of the switch (see Clause 6 of IEC 61058-1:~~2008~~ 2016);
    – the classification of the switch according to:
      - nature of supply (see 7.1.1 of IEC 61058-1:~~2008~~ 2016);
      - type of load to be controlled by the switch (see 7.1.2 of IEC 61058-1:~~2008~~ 2016);
      - ambient air temperature (see 7.1.3 of IEC 61058-1:~~2008~~ 2016).

    Compliance is checked according to IEC 61058-1:~~2008~~ 2016.

– the switch shall be so constructed that it does not attain excessive temperatures under **normal operating conditions**;

  Compliance is checked in the on-position according to 16.2.2 d), l) and m) of IEC 61058-1:2008, except the current is the sum of the equipment current and the maximum current supplied to other equipment, if any.

– a **mains** switch controlling connectors supplying power to other equipment shall withstand the electrical endurance test according to 17.2 of IEC 61058-1:~~2008~~ 2016, with an additional load according to Figure 9 of IEC 61058-1:~~2008~~ 2016. The total current rating of the additional load shall correspond to the marking of the connectors supplying power to other equipment. The peak surge current of the additional load shall have a value as shown in Table G.1.

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Table G.1 – Peak surge current

Current rating A	Peak surge current A
up to and including 0,5	20
up to and including 1,0	50
up to and including 2,5	100
over 2,5	150

G.1.3 Test method and compliance criteria

The tests of IEC 61058-1:~~2008~~ 2016 shall be applied with the modifications shown in G.1.2.

*After the tests, the switch shall show no deterioration of its **enclosure** and no loosening of electrical connections or mechanical fixings.*

G.2 Relays

G.2.1 Requirements

The requirements for relays that are located in a PS3 circuit are specified below.

A relay may be tested separately or in the equipment.

For resistance to heat and fire, see Clause 16 in IEC 61810-1:~~2008~~ 2015.

A relay shall comply with the requirements of IEC 61810-1:~~2008~~ 2015, taking into account the following:

– materials shall comply with 6.4.5.2 or pass a glow wire test at 750 °C or a needle flame test;

– 10 000 operating cycles for endurance (see 5.5 of IEC 61810-1:~~2008~~ 2015) and during the electric endurance test (see Clause 11 of IEC 61810-1:~~2008~~ 2015), no temporary malfunction shall occur;

NOTE A temporary malfunction is an event that has to be eliminated during the test at latest after one additional energization cycle without any external influence (see Clause 11 of IEC 61810-1:~~2008~~ 2015).

– the relay shall be suitable for use in the applicable pollution situation (see Clause 13 of IEC 61810-1:~~2008~~ 2015);

~~– for **mains** relays the speed of contact making and breaking shall be independent of the rate of rise of the coil voltage;~~

– characteristics of the relay with regard to the ratings and classification (see IEC 61810-1), shall be appropriate for the function of the relay under **normal operating condition** as given below:

- rated coil voltage and rated coil voltage range (see 5.1 of IEC 61810-1:~~2008~~ 2015);
- rated contact load and the type of load (see 5.7 of IEC 61810-1:~~2008~~ 2015);
- release voltage (see 5.3 of IEC 61810-1:~~2008~~ 2015);
- the ambient air temperature and upper and lower limit of the temperature (see 5.8 of IEC 61810-1:~~2008~~ 2015);
- only relay technology category RT IV and RT V shall be considered to meet **pollution degree** 1 environment, for example, the relay meets 5.4.1.5.2 of this document (see 5.9 of IEC 61810-1:~~2008~~ 2015);

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– electric strength (see 10.3 of IEC 61810-1:~~2008~~ 2015), except the test voltage shall be the required test voltage specified in 5.4.9.1 of this document;

– if the **required withstand voltage** (referred to as impulse withstand voltage in IEC 61810-1) exceeds 12 kV, **clearances** shall comply with Table 14 of this document;

– if the **RMS working voltage** (referred to as voltage RMS in IEC 61810-1) exceeds 500 V, **creepage distances** shall comply with Table 17 of this document;

– **solid insulation** in accordance with 13.3 of IEC 61810-1:~~2008~~ 2015 or with 5.4.4 of this document.

Compliance is checked according to IEC 61810-1 and the requirements of this document.

G.2.2 Overload test

A relay shall withstand the following test.

The contact of the relay is subjected to an overload test consisting of 50 cycles of operation at the rate of 6 to 10 cycles per minute, making and breaking 150 % of the current imposed in the application, except that where a contact switches a motor load, the test is conducted with the rotor of the motor in a locked condition. After the test, the relay shall still be functional.

G.2.3 Relay controlling connectors supplying power to other equipment

*A **mains** relay controlling connectors supplying power to other equipment shall withstand the endurance test of Clause 11 of IEC 61810-1:~~2008~~ 2015, with an additional load that is equal to the total marked load of the connectors supplying power to other equipment.*

G.2.4 Test method and compliance criteria

*For **mains** relays, the tests of IEC 61810-1 and this document shall be applied with the modifications shown in Clause G.2 of this document.*

*After the tests, the relay shall show no deterioration of its **enclosure**, no reduction of **clearances** and **creepage distances** and no loosening of electrical connections or mechanical fixings.*

G.3 Protective devices

G.3.1 Thermal cut-offs

G.3.1.1 Requirements

A **thermal cut-off** used as a **safeguard** shall comply with requirements a) and b), or c).

NOTE In IEC 60730-1, a "**thermal cut-off**" is a "thermal cut-out"

a) The **thermal cut-off**, when tested as a separate component, shall comply with the requirements and tests of the IEC 60730 series as far as applicable:

– the **thermal cut-off** shall be of Type 2 action (see 6.4.2 of IEC 60730-1:~~2010~~ 2013);

– the **thermal cut-off** shall have at least micro-disconnection, Type 2B (see 6.4.3.2 and 6.9.2 of IEC 60730-1:~~2010~~ 2013);

– the **thermal cut-off** shall have a trip-free mechanism in which contacts cannot be prevented from opening against a continuation of a fault, Type 2E (see 6.4.3.5 of IEC 60730-1:~~2010~~ 2013);

– the number of cycles of automatic action shall be at least:

- 3 000 cycles for a **thermal cut-off** with automatic reset used in circuits that are not switched off when the equipment is switched off (see 6.11.8 of IEC 60730-1:~~2010~~ 2013),

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- 300 cycles for a **thermal cut-off** with automatic reset used in circuits that are switched off together with apparatus and for **thermal cut-off** with no automatic reset that can be reset by hand from the outside of the equipment (see 6.11.10 of IEC 60730-1:~~2010~~ 2013),
- 30 cycles for a **thermal cut-off** with no automatic reset and that cannot be reset by hand from the outside of the equipment (see 6.11.11 of IEC 60730-1:~~2010~~ 2013);

– the **thermal cut-off** shall be tested as designed for a long period of electrical stress across insulating parts (see 6.14.2 of IEC 60730-1:~~2010~~ 2013);

– the **thermal cut-off** shall meet the conditioning requirements for an intended use of at least 10 000 h (see 6.16.3 of IEC 60730-1:~~2010~~ 2013);

– the contact gap, and the distance between the terminations and connecting leads of the contacts, shall comply with 13.1.4 and 13.2 of IEC 60730-1:~~2010~~ 2013.

b) The characteristics of the **thermal cut-off** with regard to

– the ratings of the **thermal cut-off** (see Clause 5 of IEC 60730-1:~~2010~~ 2013);

– the classification of the **thermal cut-off** according to the:

- nature of supply (see 6.1 of IEC 60730-1:~~2010~~ 2013),
- type of load to be controlled (see 6.2 of IEC 60730-1:~~2010~~ 2013),
- degree of protection provided by **enclosures** against ingress of solid objects and dust (see 6.5.1 of IEC 60730-1:~~2010~~ 2013),
- degree of protection provided by **enclosures** against harmful ingress of water (see 6.5.2 of IEC 60730-1:~~2010~~ 2013),
- pollution situation for which the **thermal cut-off** is suitable (see 6.5.3 of IEC 60730-1:~~2010~~ 2013),
- maximum ambient temperature limit (see 6.7 of IEC 60730-1:~~2010~~ 2013),

shall be appropriate for the application in the equipment.

c) The **thermal cut-off** when tested as a part of the equipment shall:

– have at least micro-disconnection according to IEC 60730-1 withstanding a test voltage according to 13.2 of IEC 60730-1:~~2010~~ 2013; and

– have a trip-free mechanism in which contacts cannot be prevented from opening against a continuation of a fault; and

– be conditioned for 300 h when the equipment is operated under **normal operating conditions** at an ambient temperature of 30 °C or at the maximum ambient temperature specified by the manufacturer, whichever is higher; and

– be subjected to a number of cycles of automatic action as specified under a) for a **thermal cut-off** tested as a separate component, by estimating the relevant fault conditions.

G.3.1.2 Test method and compliance criteria

*The **thermal cut-off** is checked according to the test specifications of IEC 60730 series by inspection and by measurement. The test is made on three specimens.*

*During the test, no sustained arcing shall occur. After the test, the **thermal cut-off** shall show no loosening of electrical connections or mechanical fixings.*

G.3.2 Thermal links

G.3.2.1 Requirements

A thermal link used as a **safeguard** shall meet either requirement a) or b) below:

a) The thermal link when tested as a separate component, shall comply with the requirements of IEC 60691.

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The characteristics of the thermal link with regard to:

– the ambient conditions (see Clause 5 of IEC 60691:~~2002~~ 2015);

– the electrical conditions (see 6.1 of IEC 60691:~~2002~~ 2015);

– the thermal conditions (see 6.2 of IEC 60691:~~2002~~ 2015);

– the rating of the thermal link (see Clause 8 b) of IEC 60691:~~2002~~ 2015); and

– the suitability for sealing in, or use with impregnating fluids or cleaning solvents (see Clause 8 c) of IEC 60691:~~2002~~ 2015),

shall be appropriate for the application in the equipment under **normal operating conditions** and under **single fault conditions**.

The electric strength of the thermal link shall meet the requirements of 5.4.9.1 of this document except across the disconnection (contact parts) and except between terminations and connecting leads of the contacts, for which 10.3 of IEC 60691:~~2002~~ 2015 applies.

b) The thermal link when tested as a part of the equipment shall be:

– aged for 300 h at a temperature corresponding to the ambient temperature of the thermal link when the equipment is operated under **normal operating conditions** at an ambient temperature of 30 °C or at the maximum ambient temperature specified by the manufacturer, whichever is higher; and

– subjected to such **single fault conditions** of the equipment that cause the thermal link to operate. During the test, no sustained arcing shall occur; and

– capable of withstanding two times the voltage across the disconnection and have an insulation resistance of at least 0,2 MΩ, when measured with a voltage equal to two times the voltage across the disconnection.

G.3.2.2 Test method and compliance criteria

If a thermal link is tested as a separate component according to G.3.2.1 a) above, compliance is checked according to the test specifications of IEC 60691, by inspection and measurement.

If a thermal link is tested as a part of the equipment according to G.3.2.1 b) above, compliance is checked by inspection and by the specified tests in the given order. The test is carried out three times. The thermal link is replaced partially or completely after each test.

When the thermal link cannot be replaced partially or completely, the complete component part including the thermal link (for example, a transformer) should be replaced.

No failure is allowed.

G.3.3 PTC thermistors

PTC thermistors used as **safeguards** shall comply with Clauses 15, 17, J.15 and J.17 of IEC 60730-1:~~2010~~ 2013.

For PTC thermistors,

– whose continuous power dissipation that appears at its maximum voltage at an ambient temperature of 25 °C or otherwise specified by the manufacturer for tripped state, determined as given in 3.38 of IEC 60738-1:~~2009~~ 2006, exceeds 15 W; and

– with a size of 1 750 mm^3 or more; and

– located in a PS2 or PS3 circuit,

the encapsulation or tubing shall be made of **V-1 class material** or equivalent material.

NOTE Tripped state means the state in which PTC thermistors are shifted to a high resistance condition at a given temperature.

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Compliance is checked by inspection.

G.3.4 Overcurrent protective devices

Except for devices covered by G.3.5, overcurrent protective devices used as a **safeguard** shall comply with their applicable IEC standards in accordance with 4.1.2. Such a protective device shall have adequate breaking (rupturing) capacity to interrupt the maximum fault current (including short-circuit current) that can flow.

Compliance is checked by inspection.

G.3.5 Safeguard components not mentioned in G.3.1 to G.3.4

G.3.5.1 Requirements

Such protective devices (for example, fusing resistors, fuse-links not standardized in IEC 60127 series, IEC 60269 series or miniature circuit breakers) shall have adequate rating including breaking capacity.

For non-resettable protective devices, such as fuse-links, a marking shall be ~~located close to the protective device, so that correct replacement is possible~~ provided in accordance with F.3.5.3.

G.3.5.2 Test method and compliance criteria

*Compliance is checked by inspection and by performing **single fault condition** testing as specified in Clause B.4.*

The test is carried out three times. No failure is allowed.

G.4 Connectors

G.4.1 Clearance and creepage distance requirements

The **clearance** and **creepage distance** between the outer insulating surface of a connector (including an opening in the **enclosure**) and conductive parts that are connected to ES2 within the connector (or in the **enclosure**) shall comply with the requirements for **basic insulation**.

The **clearance** and **creepage distance** between the outer insulating surface of a connector (including an opening in the **enclosure**) and conductive parts that are connected to ES3 within the connector (or in the **enclosure**) shall comply with the requirements for **reinforced insulation**. As an exception, the **clearance** and **creepage distance** may comply with the requirements for **basic insulation** if the connector is:

– fixed to the equipment; and
– located internally to the outer **electrical enclosure** of the equipment; and
– only **accessible** after removal of a subassembly that
  - is required to be in place during **normal operating conditions**, and
  - is provided with an **instructional safeguard** to replace the removed subassembly.

The tests of 5.3.2 apply to such connectors after removal of the subassembly.

G.4.2 Mains connectors

Mains connectors that are listed in IEC TR 60083 and comply with IEC 60884-1, or that comply with one of the following standards – IEC 60309 series, IEC 60320 series,

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IEC 60906-1 or IEC 60906-2 – are considered acceptable without further evaluation when used within their ratings for the purpose of connecting or interconnecting **mains** power.

G.4.3 Connectors other than mains connectors

Connectors other than for connecting **mains** power shall be so designed that the plug has such a shape that insertion into a **mains** socket-outlet or appliance coupler is unlikely to occur.

EXAMPLE Connectors meeting this requirement are those constructed as described in ~~IEC 60130-2,~~ IEC 60130-9, IEC 60169-3 or IEC 60906-3. An example of a connector not meeting the requirements of this subclause is the so-called "banana" plug. Standard 3,5 mm audio plugs are not considered likely to be put in the **mains** socket outlet.

Compliance is checked by inspection.

G.5 Wound components

G.5.1 Wire insulation in wound components

G.5.1.1 General

This clause applies to wound components comprising **basic insulation**, **supplementary insulation** or **reinforced insulation**.

G.5.1.2 Protection against mechanical stress

Where two winding wires, or one winding wire and another wire, are in contact inside the wound component, crossing each other at an angle between 45° and 90°, ~~and subject to winding tension,~~ one of the following applies:

– protection against mechanical stress shall be provided. For example, this protection can be achieved by providing physical separation in the form of insulating sleeving or sheet material, or by using double the required number of insulation layers on the winding wire; or

– the wound component passes the endurance tests of G.5.2.

Additionally, if the above construction provides **basic insulation**, **supplementary insulation** or **reinforced insulation**, the finished wound component shall pass a **routine test** for electric strength in accordance with 5.4.9.2.

G.5.1.3 Test method and compliance criteria

Compliance is checked by 5.4.4.1 and, where required, by G.5.2. If the tests of Annex J are required, they are not repeated if the material data sheets confirm compliance.

G.5.2 Endurance test

G.5.2.1 General test requirements

Where required by G.5.1.2, three samples of the wound component are subjected to 10 test cycles as follows:

– *The samples are subjected to the heat run test of G.5.2.2. After the test, the samples are allowed to cool down to ambient temperature.*

– *The samples are then subjected to the vibration test of G.15.2.4.*

– *The samples are then subjected for two days to the humidity conditioning of 5.4.8.*

The tests described below are made before the start of the 10 cycles and after each cycle.

The electric strength test of 5.4.9.1 is carried out.

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*After the electric strength test, the test of G.4.3 is made on wound components that are supplied from the **mains**, except for switching mode power supply.*

G.5.2.2 Heat run test

Depending on the type thermal classification of the insulation, the specimens are kept in a heating cabinet for a combination of time and temperature as specified in Table G.2. The 10 cycles are carried out with the same combination.

The temperature in the heating cabinet shall be maintained within a tolerance of ± 5 °C.

Table G.2 – Test temperature and testing time (days) per cycle

Thermal classification	Class 105 (A)	Class 120 (E)	Class 130 (B)	Class 155 (F)	Class 180 (H)	Class 200 (N)	Class 220 (R)	Class 250 -
Test temperature °C	Testing time duration for the test of G.5.2							
290								4 days
280								7 days
270								14 days
260							4 days	
250							7 days	
240						4 days	14 days	
230						7 days		
220					4 days	14 days		
210					7 days			
200					14 days			
190				4 days				
180				7 days				
170				14 days				
160			4 days					
150		4 days	7 days					
140		7 days						
130	4 days							
120	7 days							

The classes are related to the classification of electrical insulating materials and EIS in accordance with IEC 60085. The assigned letter designations are given in parentheses.

The manufacturer shall specify the test duration or the test temperature.

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G.5.2.3 Wound components supplied from the mains

*One input circuit is connected to a voltage equal to a test voltage of at least 1,2 times the **rated voltage**, at double the **rated frequency** for 5 min. No load is connected to the transformer. During the test, multiple wire windings, if any, are connected in series.*

*A higher test frequency may be used; the duration of the period of connection, in minutes, then being equal to 10 times the **rated frequency** divided by the test frequency, but not less than 2 min.*

*The test voltage is initially set at **rated voltage** and gradually increased up to 1,2 times the initial value, and then maintained for the time specified. If during the test there is a non-linear change of current in an uncontrollable manner, it is regarded as breakdown between winding turns.*

G.5.2.4 Compliance criteria

*For wound components supplied from the **mains**, there shall be no breakdown of the insulation between the turns of a winding, between input and output windings, between adjacent input windings and between adjacent output windings, or between the windings and any conductive core.*

G.5.3 Transformers

G.5.3.1 General

Transformers shall comply with one of the following:

– meet the requirements given in G.5.3.2 and G.5.3.3;

– IEC 61204-7 for a transformer used in a low-voltage power supply;

– meet the requirements of IEC 61558-1 and the relevant parts of IEC 61558-2 with the following additions and limitations:

- the limit values for ES1 of this document apply (see 5.2.2.2);
- for **working voltages** above 1 000 V RMS, see 18.3 of IEC 61558-1:~~2005~~ 2017 using the test voltage specified in 5.4.9.1;
- the overload test according to G.5.3.3; and
- IEC 61558-2-16 for transformers used in a switch mode power supply; or

– meet the requirements given in G.5.3.4 for a transformer that uses **FIW**.

~~NOTE~~ EXAMPLES The relevant parts of IEC 61558-2 are:

– IEC 61558-2-1: Separating transformers;

– IEC 61558-2-4: Isolating transformers; and

– IEC 61558-2-6: Safety isolating transformers.

G.5.3.2 Insulation

G.5.3.2.1 Requirements

Insulation in transformers shall comply with the following requirements.

Windings and conductive parts of transformers shall be treated as parts of the circuits to which they are connected, if any. The insulation between them shall comply with the relevant requirements of Clause 5 and pass the relevant electric strength tests, according to the application of the insulation in the equipment.

Precautions shall be taken to prevent the reduction below the required minimum values of **clearances** and **creepage distance** that provide **basic insulation**, **supplementary insulation** or **reinforced insulation** by:

– displacement of windings, or their turns;

– displacement of internal wiring or wires for external connections;

– undue displacement of parts of windings or internal wiring, in the event of rupture of wires adjacent to connections or loosening of the connections; and

– bridging of insulation by wires, screws, washers and the like should they loosen or become free.

It is not expected that two independent fixings will loosen at the same time.

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All windings shall have the end turns retained by positive means.

Examples of acceptable forms of construction are the following (there are other acceptable forms of construction):

– windings isolated from each other by placing them on separate limbs of the core, with or without spools;
– windings on a single spool with a partition wall, where either the spool and partition wall are pressed or moulded in one piece, or a pushed-on partition wall has an intermediate sheath or covering over the joint between the spool and the partition wall;
– concentric windings on a spool of insulating material without flanges, or on insulation applied in thin sheet form to the transformer core;
– insulation is provided between windings consisting of sheet insulation extending beyond the end turns of each layer;
– concentric windings, separated by an earthed conductive screen that consists of metal foil extending the full width of the windings, with suitable insulation between each winding and the screen. The conductive screen and its lead-out wire have a cross-section sufficient to ensure that on breakdown of the insulation an overload device will open the circuit before the screen is destroyed. The overload device may be a part of the transformer.

If a transformer is fitted with an earthed screen for protective purposes, the transformer shall pass the test of 5.6.6 between the earthed screen and the earthing terminal of the transformer.

No electric strength test applies to insulation between any winding and the core or screen, provided that the core or screen is totally enclosed or encapsulated and there is no electrical connection to the core or screen. However, the tests between windings that have terminations continue to apply.

G.5.3.2.2 Compliance criteria

Compliance is checked by inspection, measurement and where applicable by test.

G.5.3.3 Transformer overload tests

G.5.3.3.1 Test conditions

If the tests are carried out under simulated conditions on the bench, these conditions shall include any protective device that would protect the transformer in the complete equipment.

Transformers for switch mode power supply units are tested in the complete power supply unit or in the complete equipment. Test loads are applied to the output of the power supply unit.

*A linear transformer or a ferro-resonant transformer has each winding isolated from the **mains** loaded in turn, with any other winding isolated from the **mains** loaded between zero and its specified maximum load to result in the maximum heating effect.*

The output of a switch mode power supply is loaded to result in the maximum heating effect in the transformer.

*Where an overload condition cannot occur or is unlikely to cause a **safeguard** to fail, the tests are not made.*

G.5.3.3.2 Compliance criteria

Maximum temperatures of windings shall not exceed the values in Table G.3 when measured as specified in B.1.5, and determined as specified below:

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– *with an external overcurrent ~~protection~~ protective device: at the moment of operation, for determination of the time until the overcurrent ~~protection~~ protective device operates, reference may be made to a data sheet of the overcurrent protective device showing the trip time versus the current characteristics;*

– *with an automatic reset **thermal cut-off**: as shown in Table G.3 and after 400 h;*

– *with a manual reset **thermal cut-off**: at the moment of operation; or*

– *for current limiting transformers: after the temperature has stabilized.*

If the temperature of the windings of a transformer with a ferrite core, measured as specified in B.1.5, exceeds 180 °C, it shall be retested at maximum rated ambient temperature (T_{amb} = T_{ma}), and not as calculated according to B.2.6.3.

*Windings isolated from the **mains**, that exceed the temperature limits but that become open circuit or otherwise require replacement of the transformer, do not constitute a failure of this test provided that the transformer continues to comply with B.4.8.*

During the test the transformer shall not emit flames or molten-metal. After the test, the transformer shall withstand the electric strength test in 5.4.9.1 as applicable.

Table G.3 – Temperature limits for transformer windings and for motor windings (except for the motor running overload test)

Method of protection	Maximum temperature °C							
	Class 105 (A)	**Class 120** (E)	**Class 130** (B)	**Class 155** (F)	**Class 180** (H)	**Class 200** (N)	**Class 220** (R)	**Class 250** -
~~Protection~~ No protective device used or protected by ~~inherent~~ internal or external impedance	150	165	175	200	225	245	265	295
~~Protection~~ Protected by a protective device that operates during the first hour	200	215	225	250	275	295	315	345
~~Protection~~ Protected by any protective device:								
– maximum after first hour	175	190	200	225	250	270	290	320
– arithmetic average temperature (t_A) during the 2nd hour and during the 72nd hour and during the 400th hour [a]	150	165	175	200	225	245	265	295

The classes are related to the classification of electrical insulating materials and EIS in accordance with IEC 60085. The assigned letter designations are given in parentheses.

[a] The arithmetic average temperature is determined as follows:

The graph of temperature against time (see Figure G.1), while the power to the transformer is cycling on and off, is plotted for the period of test under consideration. The arithmetic average temperature (t_A) is determined by the formula:

$$t_A = \frac{t_{max} + t_{min}}{2}$$

where:

t_{max} is the average of the maxima,

t_{min} is the average of the minima.

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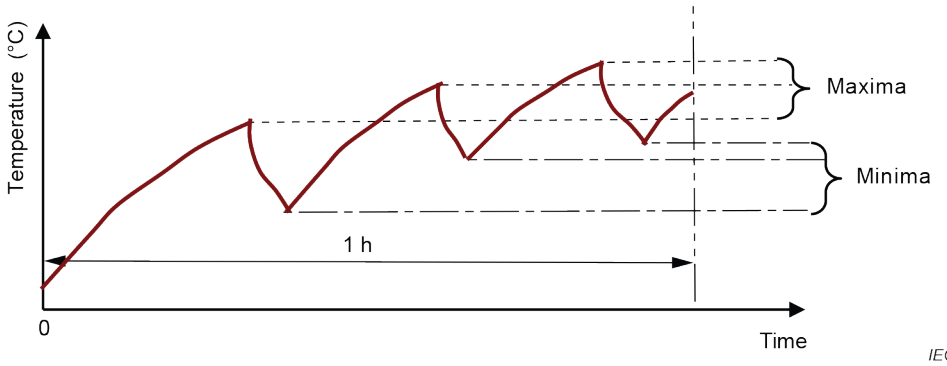


Figure G.1 – Determination of arithmetic average temperature

G.5.3.3.3 Alternative test method

*The transformer is covered with a single layer of **cheesecloth** and is placed on a wooden board that is covered with a single layer of **wrapping tissue**. The transformer is then gradually loaded until one of the following situations occurs:*

– *the overload protective device operates;*
– *the winding becomes an open circuit; or*
– *the load cannot be increased any further without reaching a short-circuit or foldback condition.*

The transformer is then loaded to a point just before the above applicable situation occurs and is operated for 7 h.

*During the test the transformer shall not emit flames or molten metal. The **cheesecloth** or **wrapping tissue** shall not char or catch fire.*

*If the transformer voltage exceeds ES1, the **basic safeguard** or **reinforced safeguard** provided in the transformer shall withstand the electric strength test in 5.4.9.1 as applicable after it has cooled to room temperature.*

G.5.3.4 Transformers using fully insulated winding wire (FIW)

G.5.3.4.1 General

The requirements of G.5.3.4 may only be applied to equipment intended for use in Overvoltage Categories I and II.

Where **FIW** is used within a transformer, the **FIW** shall comply with IEC 60851-5:2008, IEC 60317-0-7 and IEC 60317-56.

FIW windings at ES2 or ES3 levels shall not be **accessible** to an **ordinary person** or an **instructed person**.

If the wire has a nominal diameter other than defined in Table G.5 (FIW3-9), the minimum electric strength value can be calculated according to the formula below Table G.5.

A transformer that uses **FIW** shall comply with IEC 60085 and may only be used up to and including insulation Class 155 (F).

Where mechanical separation is required below, the mechanical separation shall comply with the electric strength test for **basic insulation** in accordance with 5.4.9.1 except that Table G.4 shall be applied instead of Table 26.

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Table G.4 – Test voltages for electric strength tests based on the peak of the working voltages

Voltage up to and including	Test voltage for basic insulation or supplementary insulation	Test voltage for reinforced insulation
V peak	kV peak or DC (Vrms)	
< 70,5	0,35 (0,25)	0,7 (0,5)
212	2 (1,41)	4 (2,82)
423	3 (2,12)	6 (4,24)
846	3,5 (2,47)	7 (4,95)
1 410	3,9 (2,76)	7,8 (5,52)
Linear interpolation may be used between the nearest two points.		
This table is based on Table 14 of IEC 61558-1:2017.		

G.5.3.4.2 Transformers with basic insulation only

FIW serving as **basic insulation** shall be a construction having a minimum test voltage per Table G.5 that exceeds the test voltages for electric strength tests based on 5.4.9.1 except that Table G.4 shall be applied instead of Table 26.

Mechanical separation is required between the **FIW** and enamelled wire.

Clearances and **creepage distances** between the **FIW** and enamelled wire are not required.

NOTE 1 An example of this construction is a transformer with **FIW** as one winding and enamelled wire as the other.

NOTE 2 The specified values in Table G. are RMS

G.5.3.4.3 Transformers with double insulation or reinforced insulation

Transformers with **double insulation** or **reinforced insulation** comprised of:

– two or more **FIW** windings insulated with **basic insulation** and **supplementary insulation**, shall comply with all of the following:
  - **FIW** serving as **basic insulation** and the **FIW** serving as **supplementary insulation** shall each have a minimum test voltage per Table G.5 that exceeds the test voltages for electric strength tests based on 5.4.9.1 except that Table G.4 shall be applied instead of Table 26;
  - mechanical separation that fulfils the electric strength test for **basic insulation** is required between both **FIW** windings; and
  - **clearances** and **creepage distances** between the **FIW** are not required.
– one **FIW** winding provided with **reinforced insulation** shall comply with all of the following:
  - **FIW** serving as **reinforced insulation** shall have a minimum test voltage per Table G.5 that exceeds the test voltages for electric strength tests based on 5.4.9.1 except that Table G.4 shall be applied instead of Table 26;
  - mechanical separation that fulfils the electric strength test for **basic insulation** is required between the **FIW** and enamelled wire windings; and
  - **clearances** and **creepage distances** between the **FIW** and enamelled wire are not required.
– one **FIW** winding provided with **basic insulation** in combination with solid or thin layer insulation serving as **supplementary insulation**, shall comply with all of the following:

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- **FIW** serving as **basic insulation** shall have a minimum test voltage in accordance with Table G.5 that exceeds the test voltages for electric strength tests based on 5.4.9.1 except that Table G.4 shall be applied instead of Table 26;
- solid or thin layer insulation serving as **supplementary insulation** shall comply with Clause 5, including **solid insulation**; and
- **clearances** and **creepage distances** between the **FIW** and enamelled wire are required.

G.5.3.4.4 Transformers with FIW wound on metal or ferrite core

FIW shall be designated **basic insulation** based on the peak of the **working voltage**.

FIW serving as **basic insulation** shall be a construction having a minimum test voltage in accordance with Table G.5 that exceeds the test voltages for electric strength tests based on 5.4.9.1 except that Table G.4 shall be applied instead of Table 26.

Mechanical separation is required between the **FIW** and the metal or ferrite core.

G.5.3.4.5 Thermal cycling test and compliance

*For **transformers** with **FIW** the following test is required:*

Three samples of the transformer shall be used. The samples shall be subjected 10 times to the following sequence of temperature cycles:

– *68 h at the highest winding temperature ± 2 °C measured in normal use plus 10 K with a minimum of 85 °C;*
– *1 h at 25 °C ± 2 °C;*
– *2 h at 0 °C ± 2 °C;*
– *1 h at 25 °C ± 2 °C.*

*During each thermal cycling test, a voltage of twice the value of the **working voltage** at 50 Hz or 60 Hz shall be applied to the samples between the windings.*

After conditioning of the three samples above,

– *two of the three samples are then subjected to the humidity treatment of 5.4.8 (48 h treatment) and the relevant electric strength test of 5.4.9.1, except that* Table G.4 *is applied instead of Table 26; and*
– *the remaining sample shall be subjected to the relevant electric strength test of 5.4.9.1 except that* Table G.4 *is applied instead of Table 26 immediately at the end of the last period at highest temperature during the thermal cycling test.*

There shall be no insulation breakdown during the test.

G.5.3.4.6 Partial discharge test

*If **FIW** is used and if the recurring peak voltage U_t across the insulation is greater than 750 V, a partial discharge test according to IEC 60664-1 (additional test description details below) shall be performed. The partial discharge test shall be done after the thermal cycling test of G.5.3.4.5 at normal room temperature for the two samples that were subjected to the humidity treatment.*

The relevant recurring peak voltage is the maximum measured voltage between the input and the transformer and associated circuitry if the secondary side is earthed.

*The measuring shall be done at the maximum of the **rated voltage** of the equipment.*

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A partial discharge test shall be done at the transformer with the measured recurring peak voltage U_t where:

- *U_t is the maximum peak of the **working voltage**;*
- *t_1 is 5 s;*
- *t_2 is 15 s.*

Partial discharge shall be less than or equal to 10 pC at time t_2. The test shall be done according to Figure G.2. For other applications higher values may be required (for example, IEC 61800-5-1).

G.5.3.4.7 Routine test

*The finished component is subjected to **routine tests** for electric strength (between windings and between windings and the core, see G.5.3.2.1), in accordance with 5.4.9.2.*

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Table G.5 – Values of FIW wires with maximum overall diameter and minimum test voltages according to the enamel increase

Nominal conductor diameter d_{Cu} [mm]	Minimum specific breakdown voltage [a] U_b [V/µm]	Minimum overall FIW diameter d_o [mm]							Minimum dielectric strength test voltage values per wire for basic or reinforced insulation at overall diameter, U_s [V] (duration of 60 s)						
		Grade of FIW 3	Grade of FIW 4	Grade of FIW 5	Grade of FIW 6	Grade of FIW 7	Grade of FIW 8	Grade of FIW 9	Grade of FIW 3	Grade of FIW 4	Grade of FIW 5	Grade of FIW 6	Grade of FIW 7	Grade of FIW 8	Grade of FIW 9
0,04	56	0,055	0,059	0,070	0,080	0,090	0,100		714	904	1 428	1 904	2 380	2 856	
0,045	56	0,062	0,067	0,079	0,090	0,101	0,112		809	1 047	1 618	2 142	2 666	3 189	
0,05	56	0,067	0,073	0,084	0,095	0,106	0,117		809	1 095	1 618	2 142	2 666	3 189	
0,056	56	0,075	0,082	0,093	0,105	0,117	0,129		904	1 238	1 761	2 332	2 904	3 475	
0,063	56	0,084	0,090	0,103	0,116	0,129	0,142		1 000	1 285	1 904	2 523	3 142	3 760	
0,071	56	0,092	0,098	0,111	0,124	0,137	0,150	0,163	1 000	1 285	1 904	2 523	3 142	3 760	4 379
0,08	56	0,102	0,109	0,123	0,137	0,151	0,165	0,179	1 047	1 380	2 047	2 713	3 380	4 046	4 712
0,09	56	0,114	0,121	0,135	0,149	0,163	0,177	0,191	1 142	1 476	2 142	2 808	3 475	4 141	4 808
0,1	56	0,126	0,133	0,149	0,165	0,181	0,197	0,213	1 238	1 571	2 332	3 094	3 856	4 617	5 379
0,112	53	0,140	0,148	0,165	0,182	0,199	0,216	0,233	1 261	1 622	2 388	3 154	3 919	4 685	5 451
0,125	53	0,155	0,164	0,182	0,200	0,218	0,236	0,254	1 352	1 757	2 568	3 379	4 190	5 001	5 811
0,14	53	0,172	0,182	0,202	0,222	0,242	0,262	0,282	1 442	1 892	2 793	3 694	4 595	5 496	6 397
0,16	53	0,195	0,206	0,228	0,250	0,272	0,294	0,316	1 577	2 072	3 063	4 055	5 046	6 037	7 028
0,18	53	0,218	0,230	0,254	0,278	0,302	0,326	0,350	1 712	2 253	3 334	4 415	5 496	6 577	7 659
0,2	53	0,240	0,253	0,278	0,303	0,328	0,353	0,378	1 802	2 388	3 514	4 640	5 766	6 893	8 019
0,224	53	0,267	0,281	0,308	0,335	0,362	0,389	0,416	1 937	2 568	3 784	5 001	6 217	7 433	8 650
0,25	53	0,298	0,313	0,343	0,373	0,403	0,433	0,463	2 162	2 838	4 190	5 541	6 893	8 244	9 596
0,28	53	0,330	0,346	0,377	0,408	0,439	0,470	0,501	2 253	2 973	4 370	5 766	7 163	8 560	9 956
0,315	53	0,368	0,385	0,416	0,447	0,478	0,509	0,540	2 388	3 154	4 550	5 947	7 343	8 740	10 136
0,355	53	0,412	0,429	0,460	0,491	0,522	0,553	0,584	2 568	3 334	4 730	6 127	7 523	8 920	10 316
0,4	49	0,460	0,479	0,510	0,541	0,572	0,603		2 499	3 290	4 582	5 873	7 164	8 455	
0,45	49	0,514	0,534	0,565	0,596	0,627	0,658		2 666	3 499	4 790	6 081	7 372		
0,5	49	0,567	0,588	0,629	0,670	0,711			2 791	3 665	5 373	7 081	8 788		
0,56	37	0,631	0,654	0,695	0,736	0,777			2 233	2 956	4 246	5 535	6 825		
0,63	37	0,705	0,729	0,770	0,811	0,852			2 359	3 114	4 403	5 692	6 982		
0,71	37	0,790	0,815	0,856	0,897	0,938			2 516	3 302	4 592	5 881	7 171		
0,8	37	0,885	0,912	0,963	1,014				2 673	3 522	5 126	6 730			
0,9	37	0,990	1,019	1,070	1,121				2 831	3 743	5 347	6 950			
1	37	1,095	1,125	1,176	1,227				2 988	3 931	5 535	7 139			
1,12	33	1,218	1,249	1,310					2 749	3 618	5 380				
1,25	33	1,350	1,382	1,443					2 805	3 703	5 414				
1,4	33	1,503	1,536	1,597					2 889	3 815	5 526				
1,6	33	1,707	1,741	1,802					3 001	3 955	5 666				

[a] Value according to Table 7 of IEC 60317-0-7:2017.

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*The values of allowed voltage strength for **FIW** dimensions other than specified in Table G.5 are calculated according to the following formula:*

$$V = \frac{d_a - d_{Cu}}{2} \times U \times 10^3$$

where:

d_a *is the maximum overall diameter in mm;*

d_{Cu} *is the nominal copper diameter in mm;*

U *is the voltage value according to Table 7 of IEC 60317-0-7:2017 (see column 2) in V/µm;*

V *is the allowed voltage strength for **FIW** wire in volts.*

Higher voltage values, based on the "enamel increase" of Table 6 of IEC 60317-0-7:2017, are under consideration.

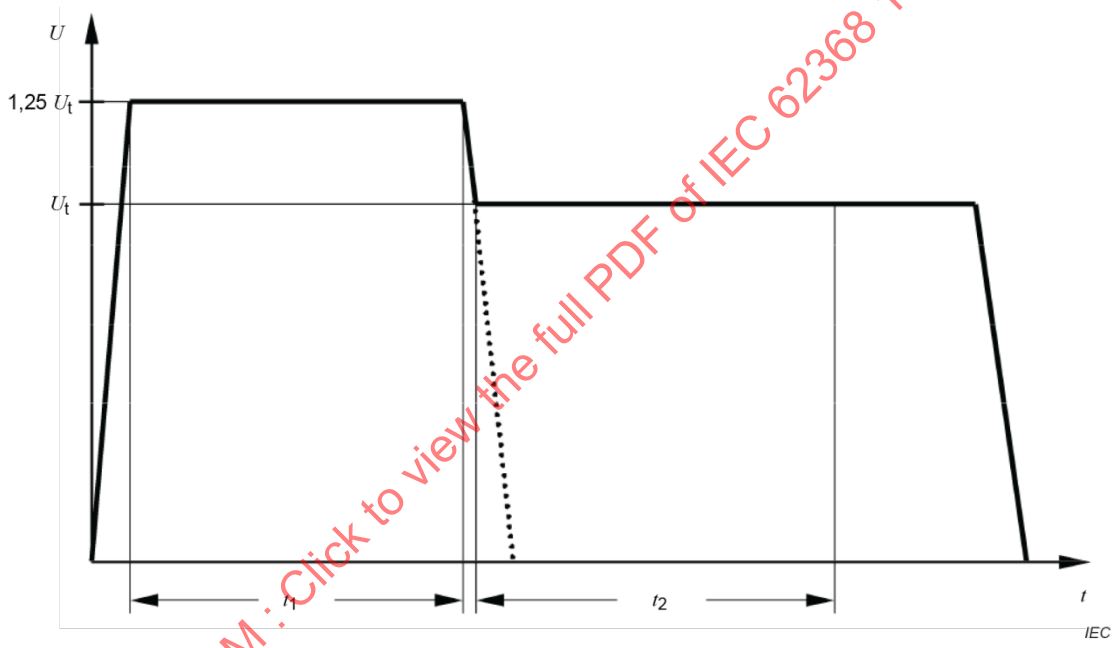


Figure G.2 – Test voltages

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G.5.4 Motors

G.5.4.1 General requirements

DC motors supplied from PS2 or PS3 circuits isolated from the AC **mains** shall comply with the tests of G.5.4.5, G.5.4.6 and G.5.4.9. DC motors that by their intrinsic operation normally operate under locked-rotor conditions, such as stepper motors, are not tested and DC motors that are used for air-handling only and where the air propelling component is directly coupled to the motor shaft are not required to pass the test of G.5.4.5.

All other motors supplied from PS2 or PS3 circuits shall comply with the overload tests of G.5.4.3 and G.5.4.4 and, where applicable, G.5.4.7, G.5.4.8 and G.5.4.9.

However, the following motors are exempt from the test of G.5.4.3:

– motors that are used for air-handling only and where the air-propelling component is directly coupled to the motor shaft; and
– shaded pole motors whose values of locked-rotor current and no-load current do not differ by more than 1 A and have a ratio of not more than 2/1.

G.5.4.2 Motor overload test conditions

*Unless otherwise specified, during the test, the equipment is operated at **rated voltage** or at the highest voltage of the **rated voltage range**.*

The tests are carried out either in the equipment or under simulated conditions on the bench. Separate samples may be used for bench tests. Simulated conditions include:

– *any protective device that would protect the motor in the complete equipment; and*
– *use of any mounting means that may serve as a heat sink to the motor frame.*

*Temperatures of windings are measured as specified in B.1.5. Where thermocouples are used they are applied to the surface of the motor windings. Temperatures are measured at the end of the test period where specified, otherwise when the temperature has stabilized, or at the instant of operation of fuses, **thermal cut-offs**, motor protective devices and the like.*

For totally enclosed, impedance-protected motors, the temperatures are measured by thermocouples applied to the motor case.

When motors without inherent thermal protection are tested under simulated conditions on the bench, the measured winding temperature is adjusted to take into account the ambient temperature in which the motor is normally located within the equipment.

G.5.4.3 Running overload test and compliance criteria

*A running overload test is carried out by operating the motor under **normal operating conditions**. The load is then increased so that the current is increased in appropriate gradual steps, the motor supply voltage being maintained at its original value. When steady conditions are established, the load is again increased. The load is thus progressively increased in appropriate steps but without reaching locked-rotor condition (see G.5.4.4), until the overload protective device operates.*

Compliance is checked by measuring the motor winding temperatures during each steady period. The measured temperatures shall not exceed the values in Table G.6*.*

Table G.6 – Temperature limits for running overload tests

Maximum temperature °C							
Class 105 (A)	**Class 120 (E)**	**Class 130 (B)**	**Class 155 (F)**	**Class 180 (H)**	**Class 200 (N)**	**Class 220 (R)**	**Class 250 -**
140	155	165	190	215	235	255	275
The classes are related to the classification of electrical insulating materials and EIS in accordance with IEC 60085. The assigned letter designations are given in parentheses.							

G.5.4.4 Locked-rotor overload

G.5.4.4.1 Test method

A locked-rotor test is carried out starting at room temperature.

The duration of the test is as follows:

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– *a motor protected by inherent or external impedance is operated on locked-rotor for 15 days except that testing is discontinued when the windings of the motor reach a constant temperature, provided that the constant temperature is not more than that specified in Table 9 for the insulation system used;*

– *a motor with an automatic reset protective device is cycled on locked-rotor for 18 days;*

– *a motor with a manual reset protective device is cycled on locked-rotor for 60 cycles, the protective device being reset after each operation as soon as possible for it to remain closed, but after not less than 30 s;*

– *a motor with a non-resettable protective device is operated until the device operates.*

G.5.4.4.2 Compliance criteria

Compliance is checked by measuring temperatures at regular intervals during the first three days for a motor with inherent or external impedance protection or with an automatic reset protective device, or during the first 10 cycles for a motor with a manual reset protective device, or at the time of operation of a non-resettable protective device. The measured temperatures shall not exceed the values in Table G.3.

During the test, protective devices shall operate reliably without permanent damage to the motor including:

– *severe or prolonged smoking or flaming;*

– *electrical or mechanical breakdown of any associated component part such as a capacitor or starting relay;*

– *flaking, embrittlement or charring of insulation; or*

– *deterioration of the insulation.*

Discoloration of the insulation may occur, but charring or embrittlement to the extent that insulation flakes off or material is removed when the winding is rubbed with the thumb is not acceptable.

After the period specified for temperature measurement, the motor shall withstand the electric strength test of 5.4.9.1 after the insulation has cooled to room temperature and with test voltages reduced to 0,6 times of the specified values.

NOTE Continuation of the test of an automatic reset protective device beyond 72 h, and of a manual reset protective device beyond 10 cycles, is only for the purpose of demonstrating the capability of the device to make and break locked-rotor current for an extended period of time.

G.5.4.5 Running overload for DC motors

G.5.4.5.1 Requirements

The test of G.5.4.5.2 is carried out only if a possibility of an overload occurring is determined by inspection or by review of the design. For example, the test need not be carried out where electronic drive circuits maintain a substantially constant drive current.

If difficulty is experienced in obtaining accurate temperature measurements, due to the small size or unconventional design of the motor, the method of G.5.4.5.3 can be used instead.

G.5.4.5.2 Test method and compliance criteria

*The motor is operated under **normal operating conditions**. The load is then increased so that the current is increased in appropriate gradual steps, the motor supply voltage being maintained at its original value. When steady conditions are established, the load is again increased. The load is thus progressively increased in appropriate steps until either the overload protection device operates, the winding becomes an open circuit or the load cannot be increased any further without reaching a locked rotor condition.*

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The motor winding temperatures are measured during each steady period. The measured temperatures shall not exceed the values in Table G.6.

*Following the test, if the motor voltage exceeds ES1, the **basic safeguard** or **reinforced safeguard** provided in the motor shall withstand the electric strength test in 5.4.9.1 after it has cooled to room temperature, but with test voltages reduced to 0,6 times the specified values.*

G.5.4.5.3 Alternative method

*The motor is covered with a single layer of **cheesecloth** and placed on a wooden board that is covered with a single layer of **wrapping tissue**. The motor is then gradually loaded until one of the following situations occur:*

- *the overload protective device operates;*
- *the winding becomes an open circuit; or*
- *the load cannot be increased any further without reaching a locked rotor condition.*

~~*The motor is then loaded to a point just before the above applicable situation occurs and is operated for 7 h.*~~

*During the test, the motor shall not emit flames or molten metal. The **cheesecloth** or **wrapping tissue** shall not char or catch fire.*

*Following the test, if the motor voltage exceeds ES1, the **basic safeguard** or **reinforced safeguard** provided in the motor shall withstand the electric strength test in 5.4.9.1 after it has cooled to room temperature, but with test voltages reduced to 0,6 times the specified values.*

G.5.4.6 Locked-rotor overload for DC motors

G.5.4.6.1 Requirements

Motors shall pass the test in G.5.4.6.2.

Where difficulty is experienced in obtaining accurate temperature measurements because of the small size or unconventional design of the motor, the method of G.5.4.6.3 can be used instead.

G.5.4.6.2 Test method and compliance criteria

The motor is operated at the voltage used in its application and with its rotor locked for 7 h or until steady state conditions are established, whichever is longer. However, if the motor winding opens, or the motor otherwise becomes permanently de-energized, the test is discontinued.

Compliance is checked by measuring the motor winding temperatures during the test. The measured temperatures shall not exceed the values in Table G.3.

Following the test, if the motor voltage exceeds ES1, and after it has cooled to room temperature, the motor shall withstand the electric strength test in 5.4.9.1 but with test voltages reduced to 0,6 times the specified values.

G.5.4.6.3 Alternative method

*The motor is covered with a single layer of **cheesecloth** and placed on a wooden board that is covered with a single layer of **wrapping tissue**.*

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The motor is then operated at the voltage used in its application and with its rotor locked for 7 h or until steady state conditions are established, whichever is the longer. However, if the motor winding opens, or the motor otherwise becomes permanently de-energized, the test is discontinued.

During the test, the motor shall not emit flames or molten metal. The ***cheesecloth*** *or* ***wrapping tissue*** *shall not char or catch fire.*

Following the test, if the motor voltage exceeds ES1, and after it has cooled to room temperature, the motor shall withstand the electric strength test in 5.4.9.1 but with test voltages reduced to 0,6 times the specified values.

G.5.4.7 Test method and compliance criteria for motors with capacitors

Motors having phase-shifting capacitors are tested under locked-rotor conditions with the capacitor short-circuited or open-circuited (whichever is the more unfavourable).

The short-circuit test is not made if the capacitor is so designed that, upon failure, it will not remain short-circuited.

Compliance is checked by measuring the motor winding temperatures during the test. The measured temperatures shall not exceed the values in Table G.3.

G.5.4.8 Test method and compliance criteria for three-phase motors

Three-phase motors are tested under ***normal operating conditions****, with one phase disconnected, unless circuit controls prevent the application of voltage to the motor when one or more supply phases are missing.*

The effect of other loads and circuits within the equipment may necessitate that the motor be tested within the equipment and with the three supply phases disconnected one at a time.

Compliance is checked by measuring the motor winding temperatures during the test. The measured temperatures shall not exceed the values in Table G.3.

G.5.4.9 Test method and compliance criteria for series motors

Series motors are operated at a voltage equal to 1,3 times the voltage rating of the motor for 1 min with the lowest possible load.

After the test, windings and connections shall not have worked loose and all applicable ***safeguards*** *shall remain effective.*

G.6 Wire insulation

G.6.1 General

Except for enamelled winding insulation, the following requirements apply to all wires, including wires in wound components (see also Clause G.5), lead-out wires and the like, whose insulation provides **basic insulation**, **supplementary insulation** or **reinforced insulation**.

NOTE 1 For insulation provided in addition to insulation on winding wire, see 5.4.4.

If the peak of the **working voltage** does not exceed ES2, there is no dimensional or constructional requirement.

If the peak of the **working voltage** exceeds ES2, one of the following applies:

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a) There is no dimensional or constructional requirement for **basic insulation** that is not under mechanical stress (for example, from winding tension). For **basic insulation** that is under such mechanical stress, b) or c) applies.

NOTE 2 This exception does not apply to **supplementary insulation** or **reinforced insulation**.

b) For **basic insulation**, **supplementary insulation** or **reinforced insulation**, the insulation on the wire shall ~~either~~:

- have a thickness of at least 0,4 mm provided by a single layer; or
- comply with 5.4.4.6 if the wire is not a winding wire; or
- ~~and~~ comply with Annex J if the wire is a winding wire.

c) The winding wire shall comply with Annex J. The minimum number of overlapping layers of spirally wrapped tape or extruded layers of insulation shall be as follows:

- for **basic insulation**: one layer;
- for **supplementary insulation**: two layers;
- for **reinforced insulation**: three layers.

d) **FIW** used as a **safeguard** in transformers shall comply with G.5.3.4.

For insulation between two adjacent winding wires, one layer on each conductor is considered to provide **supplementary insulation**.

~~Spirally wrapped tape wound with not more than 50 % overlap is considered to constitute one layer. Spirally wrapped tape wound with more than 50 % overlap is considered to constitute two layers.~~

Spirally wrapped tape shall be sealed and pass the tests of 5.4.4.5 a), b) or c).

NOTE 3 For wires insulated by an extrusion process, sealing is inherent to the process.

The winding wire shall pass a **routine test** for electric strength test, using the test as specified in J.3.2.

G.6.2 ~~Solvent-based enamel winding insulation~~ Enamelled winding wire insulation

~~Solvent-based enamel is not considered to provide **supplementary insulation** or **reinforced insulation**, under any circumstances.~~

Enamelled winding wire is not considered to provide **supplementary insulation** or **reinforced insulation**, unless it complies with the requirements for **FIW** as specified in G.5.3.4.

~~Solvent-based enamel is considered **basic insulation** where~~ Other enamelled winding wires used as **basic insulation** shall comply with all the following conditions ~~are met~~:

- the insulation provides **basic insulation** in a wound component between an **external circuit** and an internal circuit operating at ES2 and ES1;
- the insulation over all conductors comprises enamel complying with the requirements of a grade 2 winding wire of IEC 60317 series of standards with the **routine test** conducted at the highest voltage of Table 25 and Table 26;
- the finished component is subjected to a **type test** for electric strength (between windings and between windings and the core, see G.5.3.2.1), in accordance with 5.4.9.1; and
- the finished component is subjected to **routine tests** for electric strength (between windings and between windings and the core, see G.5.3.2.1), in accordance with 5.4.9.2.

~~Except as given in 4.3.2.3, the core of the above wound component shall not be **accessible** to an **ordinary person**.~~

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G.7 Mains supply cords

G.7.1 General

A **mains** supply cord shall be of the sheathed type and comply with the following as appropriate:

– if rubber sheathed, be of synthetic rubber and not lighter than ordinary tough rubber-sheathed flexible cord according to IEC 60245-1 (designation 60245 IEC 53);

– if PVC sheathed:

- for equipment provided with a **non-detachable power supply cord** and having a mass not exceeding 3 kg, be not lighter than light PVC sheathed flexible cord according to IEC 60227-1 (designation 60227 IEC 52),
- for equipment provided with a **non-detachable power supply cord** and having a mass exceeding 3 kg, be not lighter than ordinary PVC sheathed flexible cord according to IEC 60227-1 (designation 60227 IEC 53),

  NOTE 1 There is no limit on the mass of the equipment if the equipment is intended for use with a detachable power supply cord.

- for equipment provided with a detachable power supply cord, be not lighter than light PVC sheathed flexible cord according to IEC 60227-1 (designation 60227 IEC 52),
- for screened cords of **movable equipment**, the flexing test of 3.1 of IEC 60227-2:~~2003~~ 1997;

  NOTE 2 Although screened cords are not covered in the scope of IEC 60227-2, the relevant flexing tests of IEC 60227-2 are used.

– other types of cords may be used if they have similar electro-mechanical and fire safety properties as above.

  NOTE 3 Where national or regional standards exist, they can be used to show compliance with the above paragraph.

For **pluggable equipment type A** or **pluggable equipment type B** that has **protective earthing**, a **protective earthing conductor** shall be included in the **mains** supply cord. For all other equipment, if a **mains** supply cord is supplied without a **protective earthing conductor**, a **protective earthing conductor** cable shall be supplied as well.

Equipment intended to be used by musicians while performing (for example, musical instruments and amplifiers) shall have:

– an appliance inlet according to IEC 60320-1 for connection to the **mains** by detachable cord sets; or

– a means of stowage to protect the **mains** supply cord when not in use (for example, a compartment, hooks or pegs).

Compliance is checked by inspection. For screened cords, damage to the screen is acceptable provided that:

– *during the flexing test the screen does not make contact with any conductor; and*

– *after the flexing test, the sample withstands the appropriate electric strength test between the screen and all other conductors.*

G.7.2 Cross sectional area

Mains supply cords shall have conductors with cross-sectional areas not less than those specified in Table G.7 (see also 5.6.3).

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Table G.7 – Sizes of conductors

Rated current of the equipment up to and including [a]	Minimum conductor sizes	
	Cross-sectional area	AWG or kcmil
A	mm^2	[cross-sectional area in mm^2] [e]
3	0,5 [b]	20 [0,5]
6	0,75	18 [0,8]
10	1,00 (0,75) [c]	16 [1,3]
16	1,50 (1,0) [d]	14 [2]
25	2,5	12 [3]
32	4	10 [5]
40	6	8 [8]
63	10	6 [13]
80	16	4 [21]
100	25	2 [33]
125	35	1 [42]
160	50	0 [53]
190	70	000 [85]
230	95	0000 [107]
		kcmil
		[cross-sectional area in mm^2] [e]
260	120	250 [126]
300	150	300 [152]
340	185	400 [202]
400	240	500 [253]
460	300	600 [304]

NOTE 1 IEC 60320-1 specifies acceptable combinations of appliance couplers and flexible cords, including those covered by footnotes [b], [c] and [d]. However, a number of countries have indicated that they do not accept all of the values listed in this table, particularly those covered by footnotes [b], [c] and [d].

NOTE 2 For higher currents see the IEC 60364 series.

[a] The **rated current** includes currents that can be drawn from a socket outlet providing **mains** power for other equipment. If the **rated current** of the equipment is not declared by the manufacturer, it is the calculated value of the **rated power** divided by **rated voltage**.

[b] For **rated current** up to 3 A, a nominal cross-sectional area of 0,5 mm^2 may be used in some countries provided that the length of the cord does not exceed 2 m.

[c] The value in parentheses applies to detachable power supply cords fitted with the connectors rated 10 A in accordance with IEC 60320-1 (types C13, C15, C15A and C17) provided that the length of the cord does not exceed 2 m.

[d] The value in parentheses applies to detachable power supply cords fitted with the connectors rated 16 A in accordance with IEC 60320-1 (types C19, C21 and C23) provided that the length of the cord does not exceed 2 m.

[e] AWG and kcmil sizes are provided for information only. The associated cross-sectional areas, in square brackets, have been rounded to show significant figures only. AWG refers to the American Wire Gage and the term "cmil" refers to circular mils where one circular mil is equal to the area of a circle having a diameter of one mil (one thousandth of an inch). These terms are commonly used to designate wire sizes in North America.

Compliance is checked by inspection.

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G.7.3 Cord anchorages and strain relief for non-detachable power supply cords

G.7.3.1 General

Safeguards against strain being transmitted to the equipment terminations of the conductors of cords or interconnecting cables connected to ES2 circuits, ES3 circuits or PS3 circuits are specified below.

G.7.3.2 Cord strain relief

G.7.3.2.1 Requirements

A knot shall not be used as a strain relief mechanism.

A screw that bears directly on the cord or cable shall not be used as a strain relief mechanism unless the cord anchorage, including the screw, is made of insulating material and the screw is of comparable size to the diameter of the cord being clamped.

When a linear force and a torque are applied to a **non-detachable power supply cord** or cable, a **basic safeguard** shall minimize strain from being transmitted to the cord or cable terminations.

The linear force applied to the cord or cable is specified in Table G.8. The force is applied in the most unfavourable direction for 1 s and repeated 25 times.

Table G.8 – Strain relief test force

Mass of the equipment kg	Force N
Up to and including 1	30
Over 1 up to and including 4	60
Over 4	100

A torque of 0,25 Nm is applied for 1 min to the cord or cable immediately after the linear force application. The torque is applied as close as practicable to the strain relief mechanism and is repeated in the opposite direction.

Compliance is determined by applying the specified force and torque, by measurement, and visual inspection. There shall be no damage to the cord or conductors and the displacement of the conductors shall not exceed 2 mm. Stretching of the cord outer jacket without displacement of the conductors is not considered displacement.

G.7.3.2.2 Strain relief mechanism failure

If the **basic safeguard** (strain relief mechanism) should fail and strain is transmitted to the **non-detachable power supply cord** or cable terminations, a **supplementary safeguard** shall ensure that the earth termination is the last to take the strain.

*Compliance is determined by inspection and, if necessary, by defeating the **basic safeguard** and inspecting the conductor slack while applying the force in Table G.8.*

G.7.3.2.3 Cord sheath or jacket position

The cord or cable sheath or jacket shall extend from the **basic safeguard** (strain relief mechanism) into the equipment at least one-half the diameter of the cord or cable.

Compliance is checked by inspection.

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G.7.3.2.4 Strain relief and cord anchorage material

The cord anchorage shall either be made of insulating material or have a lining of insulating material complying with the requirements for **basic insulation**. Where the cord anchorage is a bushing that includes the electrical connection to the screen of a screened power cord, this requirement shall not apply.

If the **basic safeguard** (strain relief mechanism) is made of polymeric material, the **basic safeguard** shall retain its structural properties following the mould stress relief according to Clause T.8.

*Compliance is determined by inspection and by applying the force and torque tests of G.7.3.2.1 after the **basic safeguard** has come to room temperature.*

G.7.4 Cord entry

Safeguards against electric shock and electrically-caused fire from cords or cables connected to ES2 circuits, ES3 circuits or PS3 circuits are specified below.

The entry of a cord or cable into the equipment shall be provided with **safeguards** against electric shock as specified in Clause 5. If the cord jacket passes the electric strength test of 5.4.9.1 for **supplementary insulation**, the cord jacket may be considered a **supplementary safeguard**.

The cord or cable entry shall be provided with a **supplementary safeguard** to:

– prevent abrasion of the cord or cable outer surface; and

– prevent the cord or cable from being pushed into the equipment to such an extent that the cord or its conductors, or both, could be damaged or internal parts of the equipment could be displaced.

*Compliance is determined by an electric strength test between the cord or cable conductors and **accessible** conductive parts following the tests of G.7.3.2.1. The test voltage shall be for **reinforced insulation** in accordance with 5.4.9.1.*

G.7.5 Non-detachable cord bend protection

G.7.5.1 Requirements

The **non-detachable power supply cord** of **hand-held equipment** or equipment intended to be moved while in operation shall be provided with a **safeguard** against jacket, insulation, or conductor damage due to bending at the equipment entrance.

Alternatively, the inlet or bushing shall be provided with a smoothly rounded bell-mouthed opening having a radius of curvature equal to at least 1,5 times the overall diameter of the cord with the largest cross-sectional area to be connected.

The cord bending **safeguard** shall:

– be so designed as to protect the cord against excessive bending where it enters the equipment; and

– be of insulating material; and

– be fixed in a reliable manner; and

– project outside the equipment beyond the inlet opening for a distance of at least five times the overall diameter or, for flat cords, at least five times the major overall cross-sectional dimension of the cord.

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G.7.5.2 Test method and compliance criteria

The equipment is so placed that the axis of the cord bending ***safeguard****, where the cord emerges, projects at an angle of 45° when the cord is free from stress. A mass equal to* $10 \times D^2$ *g is then attached to the free end of the cord, where* D *is the overall diameter or, for flat cords, the minor overall dimension of the cord, in millimetres.*

If the cord guard is of temperature-sensitive material, the test is made at 23 °C $\pm$ *2 °C.*

Flat cords are bent in the plane of least resistance.

Immediately after the mass has been attached, the radius of curvature of the cord shall nowhere be less than 1,5 D*.*

Compliance is checked by inspection, by measurement and, where necessary, by test with the cord as delivered with the equipment.

G.7.6 Supply wiring space

G.7.6.1 General requirements

The supply wiring space provided inside, or as part of, the equipment for permanent connection or for connection of an ordinary **non-detachable power supply cord** shall be designed:

– to allow the conductors to be introduced and connected easily; and

– so that the uninsulated end of a conductor is unlikely to become free from its terminal, or, should it do so, cannot come into contact with:

  - an **accessible** conductive part that is not connected to a **protective conductor**; or
  - an **accessible** conductive part of **hand-held equipment**; and

– to permit checking before fitting the cover, if any, that the conductors are correctly connected and positioned; and

– so that covers, if any, can be fitted without risk of damage to the supply conductors or their insulation; and

– so that covers, if any, giving access to the terminals can be removed with a **tool**.

Compliance is checked by inspection and by an installation test with cords of the largest cross-sectional area of the appropriate range specified in Table G.9*.*

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Table G.9 – Range of conductor sizes to be accepted by terminals

Rated current of equipment A	Nominal cross-sectional area mm²	
	Flexible cords	Other cables
Up to and including 3	0,5 to 0,75	1 to 2,5
Over 3 up to and including 6	0,75 to 1	1 to 2,5
Over 6 up to and including 10	1 to 1,5	1 to 2,5
Over 10 up to and including 13	1,25 to 1,5	1,5 to 4
Over 13 up to and including 16	1,5 to 2,5	1,5 to 4
Over 16 up to and including 25	2,5 to 4	2,5 to 6
Over 25 up to and including 32	4 to 6	4 to 10
Over 32 up to and including 40	6 to 10	6 to 16
Over 40 up to and including 63	10 to 16	10 to 25

G.7.6.2 Stranded wire

G.7.6.2.1 Requirements

The end of a stranded conductor shall not be consolidated by soft soldering at places where the conductor is subject to contact pressure unless the method of clamping is designed so as to reduce the likelihood of a bad contact due to cold flow of the solder.

Spring terminals that compensate for the cold flow are considered to satisfy this requirement.

Preventing the clamping screws from rotating is not considered to be adequate.

Terminals shall be located, guarded or insulated so that, should a strand of a flexible conductor escape when the conductor is fitted, there is no likelihood of accidental contact between such a strand and:

– **accessible** conductive parts; or

– unearthed conductive parts separated from **accessible** conductive parts by **supplementary insulation** only.

G.7.6.2.2 Test method and compliance criteria

Compliance is checked by inspection and, unless a special cord is prepared in such a way as to prevent the escape of strands, by the following test.

A piece of insulation approximately 8 mm long is removed from the end of a flexible conductor having the appropriate nominal cross-sectional area. One wire of the stranded conductor is left free and the other wires are fully inserted into, and clamped in the terminal. Without tearing the insulation back, the free wire is bent in every possible direction, but without making sharp bends around the guard.

*If the conductor is an ES3 source, the free wire shall not touch any conductive part which is **accessible** or is connected to an **accessible** conductive part or, in the case of double insulated equipment, any conductive part which is separated from **accessible** conductive parts by **supplementary insulation** only.*

If the conductor is connected to an earthing terminal, the free wire shall not touch any ES3 source.

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G.8 Varistors

G.8.1 General

~~A varistor shall comply with:~~

~~– the **safeguards** against electric shock of G.8.2; and~~

~~– the **safeguards** against fire of G.8.3 if the method "reduce the likelihood of ignition" of 6.4.1 is chosen.~~

~~The **safeguards** against fire of G.8.3 are not applicable to a varistor used in a suppression circuit whose clamping voltage (see IEC 61051-1) is above a.c. **mains transient voltage**.~~

~~NOTE 1 A varistor is sometimes referred to as an MOV or a VDR.~~

~~NOTE 2 Such connections described above make the varistor a **PIS**.~~

~~G.8.2 Safeguards against electric shock~~

A varistor shall comply with IEC 61051-2 or IEC 61643-331:2017, whether a **fire enclosure** is provided or not, taking into account all of the following:

– Preferred climatic categories (see 2.1.1 of IEC 61051-2:1991):
  - lower category temperature: −10 °C
  - upper category temperature: +85 °C
  - duration of damp heat, steady state test: 21 days,

  or

  Preferred climatic categories (see 4.1 of IEC 61643-331:2017)
  - lower category temperature: −40 °C
  - upper category temperature: +85 °C
  - relative humidity: 25 % to 75 %.

– Maximum continuous voltage:
  - at least 1,25 times the **rated voltage** of the equipment; or
  - at least 1,25 times the upper voltage of the **rated voltage range**.

  NOTE The maximum continuous voltages are not limited to values specified in 2.1.2 of IEC 61051-2:1991 or the values in Table 1 and Table 2 of IEC 61643-331:2017, other voltages can be used.

– Combination pulse (Table I group 1 of IEC 61051-2:1991/AMD1:2009 or 8.1.1 of IEC 61643-331:2017, Figure 4).

  For the test, a combination pulse is selected from 2.3.6 in IEC 61051-2:1991/AMD1:2009 or from 8.1.1 of IEC 61643-331:2017, Figure 4. The test consists of 10 positive pulses or 10 negative pulses, each having a shape of 1,2/50 μs for voltage and 8/20 μs for current.

  For the selection, AC **mains** voltage and overvoltage category, see Table 12.

  Mains under 300 V is considered to be 300 V.

  For Overvoltage Category IV of Table 12, a combination pulse 6kV/3kA is used except for 600 V, for which a combination pulse of 8 kV/4 kA is used. As an alternative, the combination pulse test of IEC 61051-2:1991/AMD1:2009 (2.3.6, Table I group 1 and Annex A) or the combination pulse test of 8.1.1 Figure 4 of IEC 61643-331:2017, including consideration of the nominal **mains** voltage and overvoltage category, is acceptable.

  ~~In addition to the performance requirements of Table I group 1 of IEC 61051-2:1991 and Amendment 1:2009~~ After the test, the varistor voltage at the manufacturer's specified current ~~after the test~~ shall not have changed by more than 10 % when compared to the value before the test.

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The body of surge suppression varistor shall comply with the needle flame according to IEC 60695-11-5, with the following test severities:

– Duration of application of the test flame: 10 s.
– After flame time: 5 s.

If the body of surge suppression varistor complies with **V-1 class material**, the needle flame test does not need to be performed.

NOTE 1 A varistor is sometimes referred to as an MOV or a VDR.

NOTE 2 Nominal varistor voltage is a voltage, at a specified DC current, used as a reference point in the component characteristic (see IEC 61051-1).

G.8.2 Safeguards against fire

G.8.2.1 General

~~**Supplementary safeguards** to be provided against fire resulting from the failure of the varistor if the method "reduce the likelihood of ignition" of 6.4.1 is chosen are specified below.~~

~~A varistor shall be regarded as a **PIS**. In case the method "reduce the likelihood of ignition" is chosen, the varistor overload test of G.8.3.2; and **temporary overvoltage** test of G.8.3.3 shall be performed depending on the maximum continuous a.c. voltage of the varistor according to Table G.7.~~

This subclause applies to varistors used as a **safeguard** against fire:

– when the method "reduce the likelihood of ignition" of 6.4.1 is chosen; or
– when the method "control fire spread" of 6.4.1 is chosen and the **enclosure** is made of **combustible material** and located less than 13 mm from the varistor.

The **safeguards** in this subclause are not applicable to a varistor used in a suppression circuit whose nominal varistor voltage, as specified in IEC 61051-1, is above AC **mains transient voltage**.

A varistor shall be regarded as a **PIS**.

The varistor overload test of G.8.2.2 and the **temporary overvoltage** test of G.8.2.3 shall be performed depending on the maximum continuous AC voltage of the varistor according to Table G.10.

Table G.10 – Varistor overload and temporary overvoltage test

Maximum continuous AC voltage of a varistor	Connection between		
	L to N or L to L	L to PE	N to PE
1,25 × V_r to 2 × V_r	G.8.2.2	G.8.2.2 and G.8.2.3	G.8.2.2 and G.8.2.3
Over 2 × V_r to 1 200 + 1,1 × V_r	No test	G.8.2.3	G.8.2.3
Over 1 200 + 1,1 × V_r	No test	No test	No test
V_r is the **rated voltage** or the upper voltage of the **rated voltage range** of the equipment.			

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G.8.2.2 Varistor overload test

*The following test is simulated as required by Table G.10 to either a varistor or a surge suppression circuit containing varistors connected across the **mains** (L to L or L to N), line to protective earth (L to PE), or neutral to protective earth (N to PE).*

The following test simulation circuit shall be used:

- *Voltage is the AC source of 2 × V_r.*
- *Current is the current resulted from a test resistor R_x connected in series with the AC source.*
- *V_r is the **rated voltage** or the upper voltage of the **rated voltage range** of the equipment.*

~~*For line to neutral, if a fuse not exceeding 10 A is located in the equipment before and in series with the varistor, either an initial test resistor (R_1) may be used resulting in the same current as the fuse, or a short-circuit may be applied. If no fuse is connected in series,*~~ *The test shall be performed with an initial test resistor R_1 = 16 × V_r.*

~~*For line to protective earth and neutral to protective earth, the test shall be performed with an initial test resistor R_1 = 16 × V_r.*~~

If the circuit does not open immediately during the initial application of test current, the test shall be continued until temperature stability (see B.1.5).

Subsequently, the test shall be repeated with new values of R_x (R_2, R_3, R_4, etc.) until the circuit opens, where:

- R_2 = 8 × V_r Ω
- R_3 = 4 × V_r Ω
- R_4 = 2 × V_r Ω
- R_x = 0,5 × (R_{x-1}) × V_r Ω.

~~*During the test, the circuit may open due to the operation of a protective device such as a fuse, a thermal fuse or a GDT.*~~

Components in parallel with the varistor that may be affected by this test shall be disconnected.

*During and following the test, there shall be no risk of fire and **equipment safeguards**, other than the varistor under test, shall remain effective.*

During the test, the circuit may:

- *open due to the operation of a protective device such as a fuse, a thermal fuse; or*
- *close due to the operation of a GDT.*

G.8.2.3 Temporary overvoltage test

*The **temporary overvoltage** test is simulated by the following test methods where applicable:*

~~*A varistor or a surge suppression circuit containing varistors connected between the **mains** conductors and the earth, "Line to Protective Earth" and "Neutral to Protective Earth", the **temporary overvoltage** described below is applied. The test method and compliance criteria are described in 8.3.8.1 and 8.3.8.2 of IEC 61643-11.*~~

~~*– Line to Protective Earth:*~~

~~*• withstand 1,71 × U_0 for 5 s.*~~

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- ~~withstand 1 200 + 1,1 × U_0 V ac for 5 s or fail safely.~~

~~– Neutral to Protective Earth:~~

- ~~withstand 1 200 V a.c. for 200 ms.~~

~~NOTE 1 U_0 is the nominal a.c. voltage of the system as defined in IEC 61643-11, which is the nominal line to neutral voltage (r.m.s. value of the a.c. voltage) of the system to which the EUT is intended to be connected.~~

~~If a surge suppression circuit is used, the combination pulse specified in G.8.2 is applied before this test.~~

~~During the test, the circuit may open due to the operation of a protective device such as a thermal fuse or a GDT.~~

~~NOTE 2 For different power distribution systems, the **temporary overvoltages** are defined in Annex B of IEC 61643-1.~~

*A surge suppression circuit containing varistors connected between the **mains** conductors and the earth is tested according to 8.3.8.1 and 8.3.8.2 of IEC 61643-11:2011. The compliance criteria of B.4.8 may be used as an alternative to the compliance criteria of IEC 61643-11.*

If a surge suppression circuit is used, the combination pulse specified in G.8.2 is applied before this test.

During the test, the circuit may:

– *open due to the operation of a protective device such as a thermal fuse; or*

– *close due to the operation of a GDT.*

NOTE For different power distribution systems, the **temporary overvoltages** are defined in Annex B of IEC 61643-11:2011.

Components in parallel with the varistor that may be affected by this test shall be disconnected.

G.9 Integrated circuit (IC) current limiters

G.9.1 Requirements

IC current limiters used for current limiting in power sources ~~to~~ so that the available output power becomes PS1 or PS2 are not shorted from input to output if they comply with all of the following ~~conditions are met~~:

– the IC current limiters limit the current to manufacturer's defined value (not to be more than 5 A) under **normal operating conditions** with any specified drift taken into account;

– the IC current limiters are entirely electronic and have no means of manual operation or reset;

~~– the IC current limiters are supplied by a source whose output does not exceed 250 VA;~~

– the IC current limiters output current is limited to 5 A or less (specified maximum load);

– the IC current limiters limit the current or voltage to the required value with the manufacturer's defined drift, as applicable, taken into account after each of the conditioning tests; and

– the test program as specified in G.9.2.

~~At the choice of the manufacturer, the conditioning tests shall be conducted in accordance with G.9.2, G.9.3 or G.9.4. IC current limiters that meet the test program of either G.9.2, G.9.3 or G.9.4 are considered to comply with the above requirements.~~

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A different sample may be used for each test.

The power source for the tests should be capable of delivering 250 VA minimum unless the IC current limiter is tested in the end product.

G.9.2 Test program 1

Test program 1 consists of the following:

- *10 000 cycles of turning enable on and off with a 100 Ω ± 5 Ω resistor and a 425 µF ± 10 µF capacitor in parallel with the output;*
- *10 000 cycles of turning enable on and off with a ferrite-core inductor having 0,35 mH ± 0,1 mH inductance at 1 kHz and a d.c. resistance not exceeding 1 Ω;*
- *10 000 cycles of turning enable on and off with the input connected to a capacitor rated 425 µF ± 1 µF and shorting the output;*
- *10 000 cycles of turning the input pin on and off with a capacitor rated 425 µF ± 1 µF connected to the input supply while keeping enable active and shorting the output;*
- *10 000 cycles of turning the input pin on and off with a ferrite-core inductor having 0,35 mH ± 0,1 mH inductance at 1 kHz and a d.c. resistance not exceeding 1 Ω connected to the input supply and return while keeping enable active and shorting the output;*
- *50 cycles with the enable pin held active with the output open-circuited, each cycle consisting of shorting the output and then opening the output;*
- *50 cycles with the enable pin held active while applying a short to the output, each cycle consisting of turning the power on and off;*
- *50 cycles with the enable pin held active while power is applied, each cycle consisting of shorting the output, removing power, reapplying power, removing the short, followed by removal of power.*

G.9.3 Test program 2

Test program 2 consists of the following:

- *50 cycles with the enable pin held active with the output open-circuited; each cycle consisting of shorting the output and then opening the output;*
- *50 cycles with the enable pin held active while applying a short to the output; each cycle consisting of turning the power on and off;*
- *50 cycles with the enable pin held active with the output loaded to maximum power, each cycle consisting of turning the power on and off;*
- *50 cycles with the enable pin held active while power is applied, each cycle consisting of shorting the output, removing power, reapplying power, removing the short, followed by removal of power;*
- *3 cycles of exposing the device (not energized) to 70 °C ± 2 °C for 24 h; followed by at least 1 h at room ambient; followed by at least 3 h at −30 °C ± 2 °C; followed by 3 h at room ambient;*
- *10 cycles of exposing the device (while energized) to 50 °C ± 2 °C for 10 min; followed by 10 min at 0 °C ± 2 °C with a 5 min period of transition from one state to the other;*
- *7 days with the output short-circuited and the device wrapped in a double layer of **cheesecloth**. A quick acting 5 A fuse kept in series with the output shall not open and a current meter shall not show a current of more than 5 A.*

G.9.4 Test program 3

Test program 3 consists of the following:

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~~– Subclause H.17.1.4.2 of IEC 60730-1:2010;~~

~~– 10 000 cycles of turning enable on and off with a 100 Ω resistor and 425 µF capacitor in parallel with the output;~~

~~– 10 000 cycles of turning enable on and off with a ferrite-core inductor having 0,35 mH ± 0,1 mH inductance at 1 kHz and a d.c. resistance not exceeding 1 Ω connected in the output circuit;~~

~~– 10 000 cycles of turning enable on and off while input connected to a capacitor rated 425 µF and shorting the output;~~

~~– 10 000 cycles of turning input pin on and off while a capacitor rated 425 µF to the input supply keeping enable active and shorting the output;~~

~~– 10 000 cycles of turning input pin on and off with a ferrite-core inductor having 0,35 mH ± 0,1 mH inductance at 1 kHz and a d.c. resistance not exceeding 1 Ω connected to the input supply keeping enable active and shorting the output;~~

~~– 50 cycles with enable pin held active and applying short to output with power on and off;~~

~~– 50 cycles with enable pin held active and output loaded to maximum power with power on and off;~~

~~– 50 cycles with enable pin held active and applying power, apply short to output; remove power, apply power, remove short, remove power;~~

~~– 3 cycles of exposing the device (not energized) to 70 °C for 24 h; followed by at least 1 h at room ambient; followed by at least 3 h at –30 °C; followed by 3 h at room ambient;~~

~~– 10 cycles of exposing the device (while energized) to 49 °C for 10 min; followed by 10 min at 0 °C with a 5 min period of transition from one state to the other.~~

G.9.2 Test program

The test program consists of the performance tests outlined in Table G.11.

The following specifications are to be supplied by the manufacturer for application of tests:

– *power source limitation/specification (if less than 250 VA);*
– *maximum input voltage (volts); and*
– *maximum output load (amperes).*

Six samples are used for testing as follows:

Sample 1: Line 1
Sample 2: Lines 2 and 3
Sample 3: Lines 4 and 5
Sample 4: Line 6
Sample 5: Line 7
Sample 6: Line 8.

The power source for the tests should be capable of delivering 250 VA minimum, unless the IC current limiter has a lower specification or is tested in the end product.

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Table G.11 – Performance test program for integrated circuit (IC) current limiters

Line	Test category	Test condition	Cycles	Device condition temperature °C [a b c]	Device enable voltage	Device input voltage	Device output load (amperes) to RTN [d,e]
1	Start up	Enable pin – cycle	10 000	25	Off to On	Maximum (rated)	Maximum (rated)
2	"	Enable pin – cycle	50	70	Off to On	Maximum (rated)	0 Ω || 470 µF
3	"	Enable pin – cycle	50	-30	Off to On	Maximum (rated)	0 Ω || 470 µF
4	"	Input power pin – cycle	50	70	On	Maximum (rated)	0 Ω || 470 µF
5	"	Input power pin – cycle	50	-30	On	Maximum (rated)	0 Ω || 470 µF
6	Short Circuit	Output power pin – short circuit	50	70	On	Maximum (rated)	Open to 0 Ω (open to short)
7	Overload	Enable pin – cycle	50	25	Off to On	Maximum (rated)	150 % maximum
8	"	Input power pin – cycle	50	25	On	Maximum (rated)	150 % maximum

RTN = Return

\|\| = in parallel

a T_{ma} not applied

b ± 2 °C

c sample conditioned 3 h before test

d ± 20 %

e Load should be implemented through a suitably rated capacitor and a parallel conductive wire providing similar characteristics to a shorted, zero ohm (0 Ω) resistive load. The capacitor voltage rating should be not less than the maximum voltage rating of the component under test.

G.9.3 Compliance criteria

After ~~each of~~ the test~~s above~~ program, the device shall limit the current in accordance with its specification as applicable or the device shall become open circuit. The open circuited device is replaced with a new sample and tests continued as applicable.

G.10 Resistors

G.10.1 General

~~When required by 5.5.6, ten samples are tested for the resistor test of G.10.2. A sample is a single resistor if used alone, or a group of resistors in series.~~

For each of the tests in this clause, ten samples of resistors are tested. A sample is a single resistor if used alone or a group of resistors as used in the application. Prior to each test, the resistance of the samples is measured, followed by the conditioning of G.10.2.

G.10.2 Conditioning

~~*Before the test, the resistance of ten samples is measured.*~~

The samples shall be subjected to the damp heat test according to IEC 60068-2-78, with the following details:

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– *temperature:* *(40 ± 2) °C;*
– *humidity:* *(93 ± 3) % relative humidity;*
– *test duration:* *21 days.*

G.10.3 Resistor test

Each sample is then subjected to 10 impulses of alternating polarity, using the impulse test generator circuit 2 of Table D.1. The interval between successive impulses is 60 s, and U_c is equal to the applicable ***required withstand voltage****.*

After the test, the resistance of each sample shall not have changed by more than 10 %. No failure is allowed.

The lowest resistance value of the ten samples tested is used to measure the current when determining compliance with Table 4.

~~NOTE If a resistor or a group of resistors is connected between a circuit supplied by the **mains** and coaxial cable, G.10.3 applies.~~

~~**G.10.3 Resistors serving as safeguards between the mains and an external circuit consisting of a coaxial cable**~~

~~**G.10.3.1 General**~~

~~Test requirements for resistors bridging insulation between the **mains** and an **external circuit** consisting of a coaxial cable and that ensure that they do not significantly change in value over a long period of time are given below.~~

~~Ten samples of resistors (a sample is a single resistor if used alone or a group of resistors in series) are subjected to the conditioning of G.10.2 and followed by the test of G.10.3.2 or G.10.3.3 as applicable.~~

G.10.4 Voltage surge test

Each sample is subjected to 50 discharges from the impulse test generator circuit 3 of Table D.1, at not more than 12 discharges per minute, with U_c equal to 10 kV ~~if the sample resistor is connected to coaxial cable connected to antenna (see Table 14)~~.

After the tests, the resistance of each sample shall not have changed by more than 20 %. No failure is allowed.

G.10.5 Impulse test

Each sample is subjected to 10 pulses from the impulse test generator circuit 1 of Table D.1, with U_c equal to 4 kV or 5 kV of alternating polarity with a minimum of 60 s interval between pulses as applicable (see Table 13).

~~**G.10.3.4 Compliance criteria**~~

After the tests ~~of G.10.3.2 or G.10.3.3~~, the resistance of each sample shall not have changed by more than 20 %. No failure is allowed.

G.10.6 Overload test

The samples are each subjected to a voltage of such a value that the current through it is 1,5 times the value measured through a resistor, having a resistance equal to the specified rated value, which is fitted to the equipment, when operated under ***single fault conditions****. During the test the voltage is kept constant. The test is performed until thermal steady state is reached.*

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After the tests, the resistance of each sample shall not have changed by more than 20 %. No failure is allowed.

G.11 Capacitors and RC units

G.11.1 General

The requirements below specify conditioning criteria when testing capacitors and RC units or discrete components forming an RC unit and serving as **safeguards** and provides selection criteria for capacitors and RC units that comply with IEC 60384-14.

G.11.2 Conditioning of capacitors and RC units

When required by 5.5.2.1, the following conditioning is applied when evaluating a capacitor or an RC unit to the requirements of IEC 60384-14.

The duration of the damp heat, steady state test as specified in 4.12 of IEC 60384-14:2005, shall be 21 days at a temperature of (40 ± 2) °C and a relative humidity of (93 ± 3) %.

Capacitors subjected to a duration that is longer than 21 days during the above test are considered acceptable.

G.11.3 Rules for selecting capacitors

The appropriate capacitor subclass shall be selected from those listed in Table G.12, according to the rules of application in the table.

Table G.12 – Capacitor ratings according to IEC 60384-14

Capacitor subclass according to IEC 60384-14	Rated voltage of the capacitor V RMS	Type test impulse test voltage of the capacitor kV peak	Type test RMS test voltage of the capacitor kV RMS
Y1	Up to and including 500	8	4
Y2	Over 150 up to and including 300	5 [a]	1,5
Y4	Up to and including 150	2,5	0,9
X1	Up to and including 760	4 [a]	-
X2	Up to and including 760	2,5 [a]	-

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Rules for the application of this table. 1 The voltage rating of the capacitor shall be at least equal to the **RMS working voltage** across the insulation being bridged, determined according to 5.4.1.8.2. As an exception to the requirements in the table, one Y2 capacitor may be used in cases where 2,5 kV is required. 2 For a single capacitor (X type) serving as **functional insulation**, failure of the capacitor shall not result in the failure of a **safeguard** and the **type test** impulse test voltage shall be at least equal to the **required withstand voltage**. 3 A higher grade capacitor than the one specified may be used, as follows: – subclass Y1 if subclass Y2 is specified; – subclass Y1 or Y2 if subclass Y4 is specified; – subclass Y1 or Y2 if subclass X1 is specified; – subclass X1, Y1 or Y2 if subclass X2 is specified. 4 Two or more capacitors may be used in series in place of the single capacitor specified, as follows: – subclass Y1 or Y2 if subclass Y1 is specified; – subclass Y2 or Y4 if subclass Y2 is specified; – subclass X1 or X2 if subclass X1 is specified. 5 If two or more capacitors are used in series they shall comply with 5.5.2.1 as applicable and comply with the other rules above.
[a] For capacitance values of more than 1 μF, this test voltage is reduced by a factor equal to $\sqrt{C}$, where C is the capacitance value in μF.

~~G.11.4 Examples of the application of capacitors~~

~~Table G.9 gives examples for the number of Y capacitors required bridging **basic insulation**, **supplementary insulation** or **reinforced insulation** based on the **required withstand voltage**. Table G.10 gives the maximum voltage that can appear across a Y capacitor based on the **peak working voltage**.~~

~~Table G.11 gives examples for the number of Y capacitors required bridging **basic insulation** and **reinforced insulation** based on the **temporary overvoltages**. Table G.12 gives examples of the application of X capacitors selected in accordance with Table G.8.~~

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Table G.9 – Examples of the application of Y capacitors based on the test voltages of Table 26

AC mains supply voltage up to and including V r.m.s.	Overvoltage category	Mains transient voltage kV	Bridged insulation	Capacitor type	Required number of capacitors
150	II	1,5	B or S	Y2	1
	II	1,5	D or R	Y2	2
	II	1,5	D or R	Y1	1
	III	2,5	B or S	Y2	2
	III	2,5	D or R	Y1	1
	IV	4,0	B or S	Y1	1
	IV	4,0	D or R	Y1	2
300	II	2,5	B or S	Y2	2
	II	2,5	D or R	Y1	1
	II	2,5	D or R	Y2	2
	III	4,0	B or S	Y1	1
	III	4,0	B or S	Y2	2
	III	4,0	D or R	Y1	2
	III	4,0	D or R	Y2	3
	IV	6,0	B or S	Y1	2
	IV	6,0	D or R	Y1	2
500	II	4,0	B or S	Y1	1
	II	4,0	D or R	Y1	2
	III	6,0	B or S	Y1	2
	III	6,0	D or R	Y1	2
	IV	8,0	B or S	Y1	2
	IV	8,0	D or R	Y1	3
B basic insulation S supplementary insulation			D double insulation R reinforced insulation		

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Table G.10 – Examples of the application of Y capacitors based on the test voltages of Table 27

Capacitor type	Bridged insulation	Peak working voltage across the capacitor not to exceed kV
Any type [a]	B	Capacitors located in circuits isolated from the **mains** [b], shall comply with the electric strength test of 5.4.9.1
Y4	B or S	0,978
Y4	D or R	0,795
Y2	B or S	1,631
Y2	D or R	1,325
Y1	B or S	4,350
Y1	D or R	3,535
[a] For capacitors that bridge **basic insulation** and are located in circuits isolated from the **mains**, see 5.5.2.1. [b] For application of Y capacitor located in circuits connected to the **mains**, see Table G.9 and Table G.11.		
B **basic insulation** S **supplementary insulation**	D **double insulation** R **reinforced insulation**	

Table G.11 – Examples of the application of Y capacitors based on the test voltages of Table 28

Nominal mains voltage V r.m.s. up to and including	Bridged insulation	Capacitor type	Number of capacitors
250	B	Y2	1
	R	Y2	2
	B	Y1	1
	R	Y1	1
600	B	Y2	2
	R	Y2	3
	B	Y1	1
	R	Y1	1
B **basic insulation** R **reinforced insulation**			

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~~**Table G.12 – Examples of the application of X capacitors, line to line or line to neutral**~~

~~AC mains supply voltage up to and including V r.m.s.~~	~~Overvoltage category~~	~~Mains transient voltage kV~~	~~Capacitor type~~	~~Required number of capacitors based on required withstand voltage~~
~~150~~	~~II~~	~~1,5~~	~~X2~~	~~1~~
	~~III~~	~~2,5~~	~~X2~~	~~1~~
	~~IV~~	~~4,0~~	~~X1~~	~~1~~
~~250~~	~~II~~	~~2,5~~	~~X2~~	~~1~~
	~~III~~	~~4,0~~	~~X1~~	~~1~~
	~~IV~~	~~6,0~~	~~X1~~	~~2~~
~~500~~	~~II~~	~~4,0~~	~~X1~~	~~1~~
	~~III~~	~~6,0~~	~~X1~~	~~2~~
	~~IV~~	~~8,0~~	~~X1~~	~~2~~

G.12 Optocouplers

Optocouplers shall comply with the requirements of IEC 60747-5-5:2007. In the application of IEC 60747-5-5:2007,

– the **type testing** as specified in 7.4.3 of IEC 60747-5-5:2007 shall be performed with a voltage $V_{ini,a}$ that is at least equal to the appropriate test voltage in 5.4.9.1 of this document; and

– the **routine testing** as specified in 7.4.1 of IEC 60747-5-5:2007 shall be performed with a voltage $V_{ini,b}$ that is at least equal to the appropriate test voltage in 5.4.9.2 of this document.

G.13 Printed boards

G.13.1 General

The requirements for **basic insulation**, **supplementary insulation**, **reinforced insulation** and **double insulation** on printed boards are specified below.

These requirements also apply to the windings of a planar transformer.

G.13.2 Uncoated printed boards

The insulation between conductors on the outer surfaces of an uncoated printed board shall comply with the minimum **clearance** requirements of 5.4.2 and the minimum **creepage distance** requirements of 5.4.3.

Compliance is checked by inspection and by measurement.

G.13.3 Coated printed boards

The requirements for separation distances before the boards are coated are specified below.

An alternative method to qualify coated printed boards is given in IEC 60664-3.

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For printed boards whose outer surfaces are to be coated with a suitable coating material, the minimum separation distances of Table G.13 apply to conductive parts before they are coated.

Double insulation and **reinforced insulation** shall pass **routine tests** for electric strength of 5.4.9.2.

Either one or both conductive parts and the entire distances over the surface between the conductive parts shall be coated.

The minimum **clearances** of 5.4.2 and the minimum **creepage distances** of 5.4.3 shall apply:

– if the above conditions are not met;
– between any two uncoated conductive parts; and
– over the outside of the coating.

Compliance is checked by inspection and measurement, taking Figure O.11 and Figure O.12 into account, and by the tests of G.13.6.

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Table G.13 – Minimum separation distances for coated printed boards

Peak of the working voltage up to and including	Basic insulation or supplementary insulation	Reinforced insulation
V peak	mm	mm
71 [a]	0,025	0,05
89 [a]	0,04	0,08
113 [a]	0,063	0,125
141 [a]	0,1	0,2
177 [a]	0,16	0,32
227 [a]	0,25	0,5
283 [a]	0,4	0,8
354 [a]	0,56	1,12
455 [a]	0,75	1,5
570	1,0	2,0
710	1,3	2,6
895	1,8	3,6
1 135	2,4	3,8
1 450	2,8	4,0
1 770	3,4	4,2
2 260	4,1	4,6
2 830	5,0	5,0
3 540	6,3	6,3
4 520	8,2	8,2
5 660	10	10
7 070	13	13
8 910	16	16
11 310	20	20
14 140	26	26
17 700	33	33
22 600	43	43
28 300	55	55
35 400	70	70
45 200	86	86
Linear interpolation may be used between the nearest two points, the calculated spacing being rounded up to the next higher 0,1 mm increment.		
[a] The test of G.13.6 is not required.		

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G.13.4 Insulation between conductors on the same inner surface

The requirements for insulation on the same inner layer of a multilayer board are specified below.

On an inner surface of a multi-layer printed board (see Figure O.14), the path between any two conductors shall comply with the requirements for a cemented joint in 5.4.4.5.

G.13.5 Insulation between conductors on different surfaces

The requirements for insulation on the different layers of a multilayer board are specified below.

For **basic insulation** there is no thickness requirement.

Supplementary insulation or **reinforced insulation** between conductive parts on different surfaces in double-sided single-layer printed boards, multi-layer printed boards and metal core printed boards, shall either have a minimum thickness of 0,4 mm provided by a single layer or conform with one of the specifications and pass the relevant tests in Table G.14.

Table G.14 – Insulation in printed boards

Specification of insulation	Type tests [a]	Routine tests for electric strength [c]
Two layers of sheet insulating material including pre-preg [b]	No	Yes
Three or more layers of sheet insulating material including pre-preg [b]	No	No
An insulation system with ceramic coating over a metallic substrate, cured at ≥ 500 °C	No	Yes
An insulation system, with two or more coatings other than ceramic over a metallic substrate, cured at < 500 °C	Yes	Yes
NOTE 1 Pre-preg is the term used for a layer of glass cloth impregnated with a partially cured resin. NOTE 2 For definition of ceramic, see IEC 60050-212:2010, 212-15-25.		
[a] Thermal conditioning of G.13.6.2 followed by the electric strength test of 5.4.9.1. [b] Layers are counted before curing. [c] Electric strength testing is carried out on the finished printed board.		

G.13.6 Tests on coated printed boards

G.13.6.1 Sample preparation and preliminary inspection

Three sample printed boards (or, for coated components in Clause G.14, two components and one board) identified as samples 1, 2 and 3 are required. Either actual boards or specially produced samples with representative coating and minimum separations may be used. Each sample board shall be representative of the minimum separations used, and coated. Each sample is subjected to the full sequence of manufacturing processes, including soldering and cleaning, to which it is normally subjected during equipment assembly.

When visually inspected, the boards shall show no evidence of pinholes or bubbles in the coating or breakthrough of conductive tracks at corners.

G.13.6.2 Test method and compliance criteria

Sample 1 is subjected to the thermal cycling sequence of 5.4.1.5.3.

Sample 2 is aged in a full draught oven at a temperature and for a time duration chosen from the graph shown in Figure G.3 using the temperature index line that corresponds to the maximum operating temperature of the coated board. The temperature of the oven is maintained at the specified temperature ± 2 °C. The temperature used to determine the temperature index line is the highest temperature on the board where safety is involved.

When using Figure G.3, interpolation may be used between the nearest two temperature index lines.

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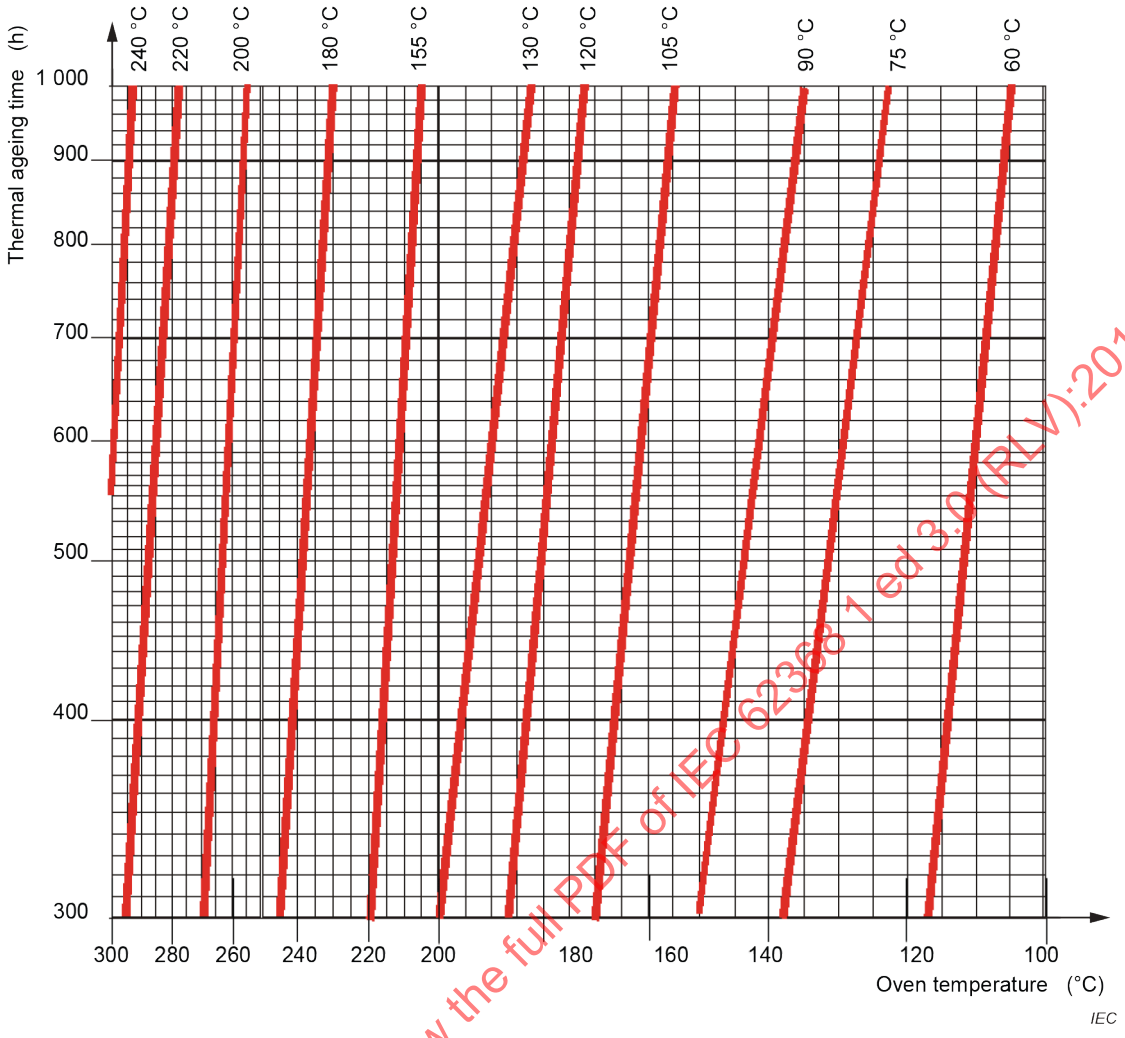


Figure G.3 – Thermal ageing time

Samples 1 and 2 are then subjected to the humidity conditioning of 5.4.8 and shall withstand the electric strength test of 5.4.9.1 between conductors.

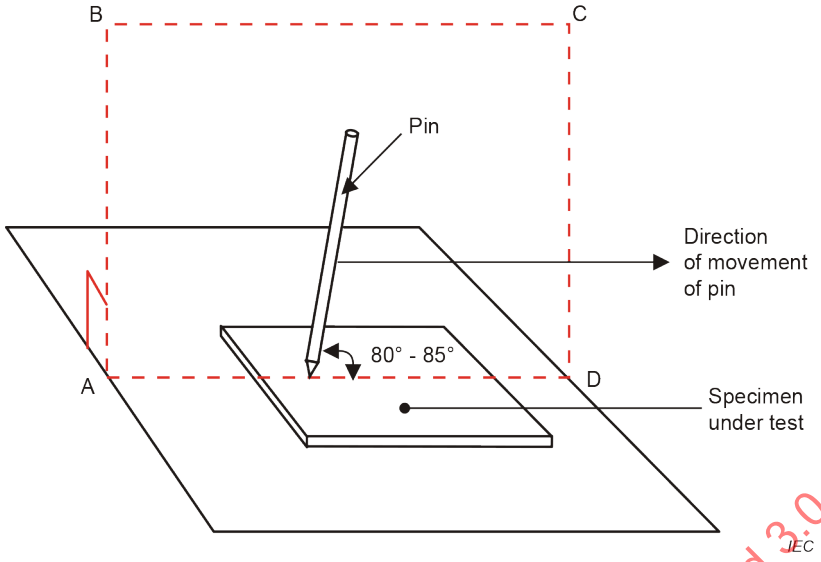
Sample board 3 is subjected to the following abrasion resistance test:

Scratches are made across five pairs of conducting parts and the intervening separations at points where the separations will be subject to the maximum potential gradient during the tests.

The scratches are made by means of a hardened steel pin, the end of which has the form of a cone having a tip angle of 40°, its tip being rounded and polished, with a radius of 0,25 mm ± 0,02 mm.

Scratches are made by drawing the pin along the surface in a plane perpendicular to the conductor edges at a speed of 20 mm/s ± 5 mm/s as shown in Figure G.4. The pin is so loaded that the force exerted along its axis is 10 N ± 0,5 N. The scratches shall be at least 5 mm apart and at least 5 mm from the edge of the specimen.

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NOTE The pin is in the plane ABCD that is perpendicular to the specimen under test.

Figure G.4 – Abrasion resistance test for coating layers

After the test, the coating layer shall neither have loosened nor have been pierced. The coating shall withstand an electric strength test as specified in 5.4.9.1 between conductors. In the case of metal core printed boards, the substrate is one of the conductors.

~~NOTE~~ *If mechanical stress or bending is applied to the board, additional tests to identify cracking may be needed (see IEC 60664-3).*

G.14 Coatings on component terminals

G.14.1 Requirements

The requirements for coatings on component terminals and the like, where the coating is used to reduce **clearances** and **creepage distances** are specified below.

Coatings may be used over external terminations of components to increase effective **clearances** and **creepage distances** (see Figure O.11). The minimum separation distances of Table G.13 apply to the component before coating, and the coating shall meet all the requirements of G.13.3. The mechanical arrangement and rigidity of the terminations shall be adequate to ensure that, during normal handling, assembly into equipment and subsequent use, the terminations will not be subject to deformation that would crack the coating or reduce the separation distances between conductive parts below the values in Table G.13 (see G.13.3).

G.14.2 Test method and compliance criteria

Compliance is checked by inspection taking into account Figure O.11 and by applying the sequence of tests covered by G.13.6. These tests are carried out on a completed assembly including the component(s).

The abrasion resistance test of G.13.6.2 is carried out on a specially prepared sample printed board as described for sample 3 in G.13.6.1, except that the separation between the conductive parts shall be representative of the minimum separations and maximum potential gradients used in the assembly.

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G.15 Pressurized liquid filled components

~~**G.15.1 General**~~

~~Construction and test requirements for pressurized LFCs used inside the equipment where an injury can occur within the meaning of this standard due to leaks of the liquid in the LFC are specified below.~~

~~This subclause does not apply to the following:~~

- ~~an LFC that is sealed but open to the atmosphere in the equipment; or~~
- ~~components containing small amounts of liquids not likely to cause any injury (for example, liquid crystal displays, electrolytic capacitors, liquid cooling heat pipes, etc.); or~~
- ~~wet **cell batteries** (for wet **cell batteries**, see Annex M).~~
- ~~an LFC and its associated parts that comply with P.3.3.~~

G.15.1 Requirements

An LFC located internal to the equipment shall comply with all of the following requirements:

– flammable or conductive liquid shall be stored in a container, and the LFC shall comply with the tests of G.15.2.3, G.15.2.4, G.15.2.5 and G.15.2.6;

– the liquid shall be provided with protection in accordance with Clause 7 (**hazardous substances**);

– non-metallic parts of the container system shall withstand the tests of G.15.2.1 and G.15.2.2; and

– the LFC shall be mounted within the equipment in such a way that the tubing shall not come into contact with sharp edges or any other surface that could damage the tubing and if the LFC bursts or relieves its pressure, the ~~fluid~~ liquid cannot ~~come in contact with ES3 parts~~ defeat a **safeguard**.

The order of tests is not specified. The tests may be performed on separate samples, except after the test of G.15.2.2, the test of G.15.2.1 is conducted.

G.15.2 Test methods and compliance criteria

G.15.2.1 Hydrostatic pressure test

Compliance is checked by evaluation of the available data or by the following test. An LFC that is open to the atmosphere or is non-pressurised (for example, an ink cartridge) is not subjected to this test.

One sample of the LFC is subjected to a hydrostatic pressure test for 2 min at room temperature and at a pressure that is the highest of the following:

– ~~*five*~~ *three times the maximum working pressure specified by the manufacturer at the maximum temperature measured during **normal operating conditions**; and*

– ~~*three*~~ *two times the maximum measured working pressure at the maximum temperature measured during application of the **abnormal operating conditions** of Clause B.3 and **single fault conditions** of Clause B.4.*

G.15.2.2 Creep resistance test

Two samples of the LFC, of which one or more parts are made of non-metallic materials, shall be conditioned for 14 days at a temperature of 87 °C and placed in a full draft air-circulating oven. Following the conditioning, the system shall comply with the test of G.15.2.1 and non-metallic parts shall show no sign of deterioration such as cracking and embrittlement.

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G.15.2.3 Tubing and fittings compatibility test

Ten samples of the test specimens made of the material used for the tubing and associated fittings of the LFC, of which one or more parts are made of non-metallic materials, shall be tested for tensile strength in accordance with the ISO 527 series. Five specimens shall be tested in the condition as received and the remaining five specimens after a conditioning test for 40 days ~~at 38 °C in a full draft air-circulating oven or~~ in a water bath filled with the intended liquid and maintained at 38 °C. The internal pressure of the assemblies is maintained at atmospheric pressure. The tensile strength after conditioning shall not be less than 60 % of the tensile strength before the tests.

Alternatively, the five samples of the finished LFC assembly may be tested as far as the part under test is suitable for the tensile strength test. The samples of finished assembly filled with the intended liquid at the internal pressure maintained at atmospheric pressure is conditioned for 40 days at 38 °C in a full draft air-circulating oven.

G.15.2.4 Vibration test

One sample of the LFC, or the equipment containing the LFC, shall be fastened to the vibration generator in its normal position of use, as specified in IEC 60068-2-6, by means of screws, clamps or straps round the component. The direction of vibration is vertical, and the severities are:

- *duration:* *30 min;*
- *amplitude:* *0,35 mm;*
- *frequency range:* *10 Hz, 55 Hz, 10 Hz;*
- *sweep rate:* *approximately one octave per minute.*

G.15.2.5 Thermal cycling test

*One sample of the LFC is subjected to three cycles of conditioning for 7 h at a temperature that is 10 °C above the maximum temperature obtained during **normal operating conditions**, **abnormal operating conditions** of Clause B.3 and **single fault conditions** of Clause B.4, followed by room temperature for 1 h.*

NOTE The LFC is not energized during the above test.

G.15.2.6 Force test

*One sample of the LFC is subjected to the tests of Clause T.2 (10 N test applied to fittings **accessible** to a **skilled person**) and Clause T.3 (30 N test applied to fittings **accessible** to an **instructed person** or to an **ordinary person**).*

G.15.3 Compliance criteria

Compliance is checked by inspection and evaluation of the available data or by the tests of G.15.2. During and after these tests, there shall be no rupture, no leaks and no loosening of any connection or part.

G.16 IC that includes a capacitor discharge function (ICX)

G.16.1 Requirements

An ICX and any associated components critical to the discharge function of a capacitor (such as the **mains** capacitor) to an **accessible** part are ~~not~~ fault tested ~~if~~ unless one of the following conditions is met:

- the ICX with the associated circuitry as provided in the equipment complies with the tests of G.16.2. Any impulse attenuating components (such as varistors and GDTs) that

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attenuate the impulse to the ICX and the associated circuitry are disconnected~~. If discharge components external to the ICX are necessary, they shall not fail during the tests~~; or

– the ICX tested separately complies with the requirements of G.16.2. If discharge components external to the ICX are necessary:

  - they shall be included in the test of G.16.2, and
  - ~~they shall not fail during the tests, and~~
  - the discharge components used in the equipment shall be within the range tested.

G.16.2 Tests

Where the ICX is tested by itself, the test set up shall be as recommended by the ICX manufacturer.

– *humidity treatment of 5.4.8 for 120 h.*

– *100 positive impulses and 100 negative impulses between line and neutral using a capacitor with the ~~largest~~ smallest capacitance and a resistor with the smallest resistance specified by the manufacturer of the ICX~~; and repeated with a capacitor with the smallest capacitance and the resistor with the largest resistance~~. The time between any two impulses shall not be less than 1 s. The impulse shall be as specified in circuit 2 of Table D.1 with U_c equal to the transient voltage as determined in 5.4.2.3.2.2.*

  *The impulses are to be superimposed on the **mains** voltage. The **mains** voltage is taken as the maximum of:*

  - *the equipment **rated voltage range** when tested in the equipment, or*
  - *the maximum **mains** voltage as specified by the ICX manufacturer when tested separately.*

– *Application of an AC **mains** voltage that is ~~110~~ 120 % of the **rated voltage** for 2,5 min.*

~~– 10 000 cycles of power on and off using a capacitor with the smallest capacitance and a resistor with the largest resistance as specified by the manufacturer of ICX. The power on and off cycles time shall not be less than 1 s.~~

– *10 000 cycles of the connection and disconnection of the **mains**. If the ICX is tested by itself, a capacitor with the largest capacitance and a resistor with the smallest resistance as specified by the manufacturer shall be used. The connection and disconnection cycle time shall not be less than 2 s.*

If any of the associated circuitry components other than those critical for the discharge function fails, it may be replaced with a new component.

G.16.3 Compliance criteria

*Compliance is checked by evaluation of the available data or by conducting the above tests. The capacitor discharge test is conducted after the above tests, ensuring the ICX or the EUT provided with the ICX continues to provide the **safeguard** function.*

NOTE Evaluation of available data ~~should~~ includes information of failure of any associated circuitry components that keeps the discharge mode in the on/stay mode.

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Annex H
(normative)

Criteria for telephone ringing signals

H.1 General

The two alternative methods described in this annex reflect satisfactory experience in different parts of the world. Method A is typical of analogue telephone networks in Europe, and Method B of those in North America. The two methods result in standards of electrical safety that are broadly equivalent.

H.2 Method A

This method requires that the currents I_{TS1} and I_{TS2} flowing through a 5 000 Ω resistor, between any two conductors or between one conductor and protective earth do not exceed the limits specified, as follows:

a) *For **normal operating conditions**, I_{TS1}, the current determined from the calculated or measured current for any single active ringing period t_1 (as defined in Figure H.1), does not exceed:*

   – *for cadenced ringing ($t_1 < \infty$), the current given by the curve of Figure H.2 at t_1;*

   – *for continuous ringing ($t_1 = \infty$), 16 mA.*

   I_{TS1}, in mA, is as given by

$$I_{TS1} = \frac{I_p}{\sqrt{2}} \qquad \text{for } (t_1 \le 600\ \text{ms})$$

$$I_{TS1} = \frac{t_1 - 600}{600} \times \frac{I_{pp}}{2\sqrt{2}} + \frac{1200 - t_1}{600} \times \frac{I_p}{\sqrt{2}} \qquad \text{for } (600\ \text{ms} < t_1 < 1200\ \text{ms})$$

$$I_{TS1} = \frac{I_{pp}}{2\sqrt{2}} \qquad \text{for } (t_1 \ge 1200\ \text{ms})$$

   where:

   I_p *is the peak current, in mA, of the relevant waveform given in Figure H.3;*

   I_{pp} *is the peak-to-peak current, in mA, of the relevant waveform given in Figure H.3;*

   t_1 *is expressed in ms.*

b) *For **normal operating conditions**, I_{TS2}, the average current for repeated bursts of a cadenced ringing signal calculated for one ringing cadence cycle t_2 (as defined in Figure H.1), does not exceed 16 mA RMS*

   I_{TS2} in mA is as given by

$$I_{TS2} = \left[\frac{t_1}{t_2} \times I_{TS1}^2 + \frac{t_2 - t_1}{t_2} \times \frac{I_{dc}^2}{3{,}75^2} \right]^{1/2}$$

   where:

   I_{TS1} *in mA, is as given by H.2 a);*

   I_{dc} *is the DC current in mA flowing through the 5 000 Ω resistor during the non-active period of the cadence cycle;*

   t_1 *and* t_2 *are expressed in ms.*

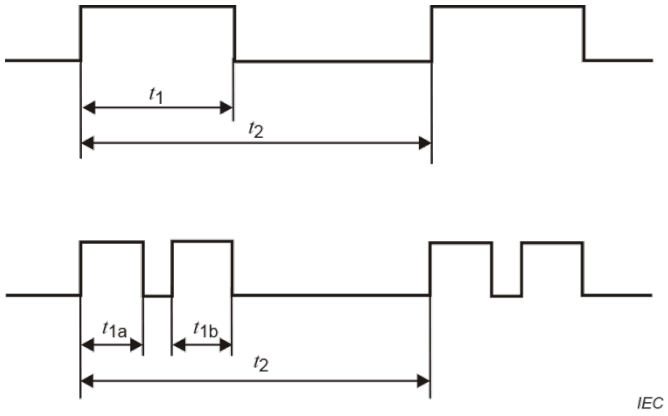
   NOTE The frequencies of telephone ringing voltages are normally within the range of 14 Hz to 50 Hz.

c) *Under **single fault conditions**, including where cadenced ringing becomes continuous:*

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– *I_{TS1} shall not exceed the current given by the curve of Figure H.2, or 20 mA, whichever is greater; and*

– *I_{TS2} shall not exceed a limit of 20 mA.*



Key

t_1 is

– the duration of a single ringing period, where the ringing is active for the whole of the single ringing period;

– the sum of the active periods of ringing within the single ringing period, where the single ringing period contains two or more discrete active periods of ringing, as in the example shown, for which $t_1 = t_{1a} + t_{1b}$.

t_2 is the duration of one complete cadence cycle.

Figure H.1 – Definition of ringing period and cadence cycle

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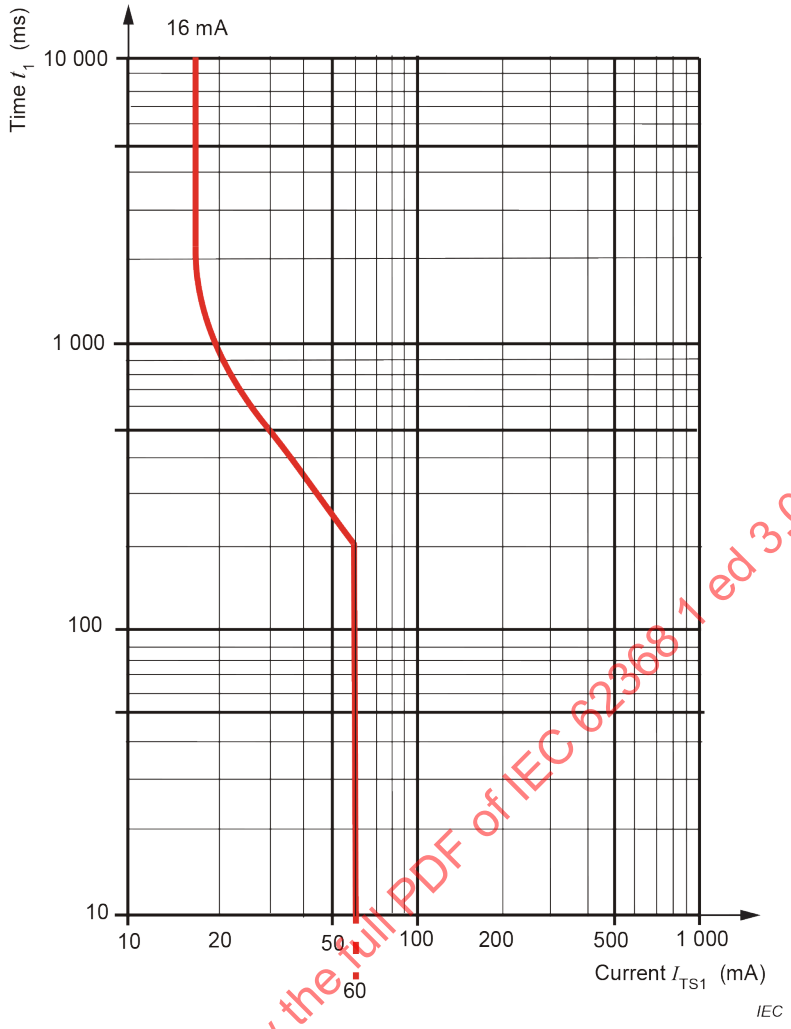


Figure H.2 – I_{TS1} limit curve for cadenced ringing signal

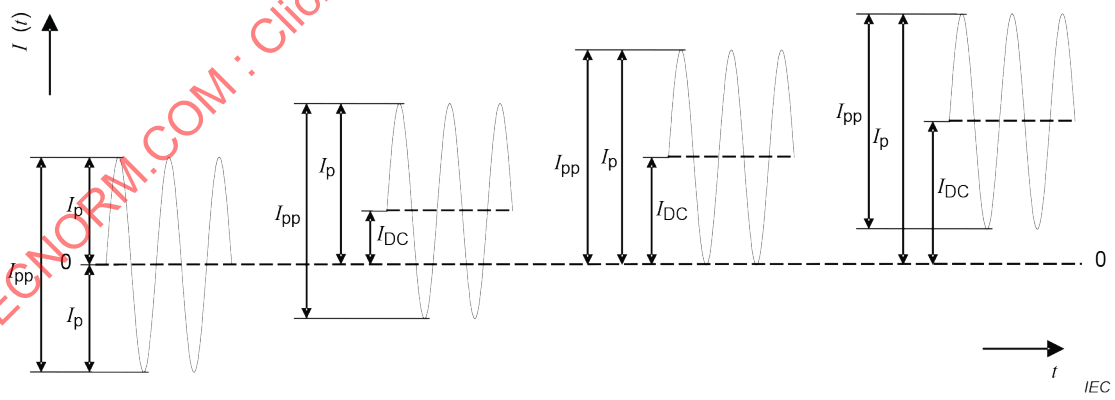


Figure H.3 – Peak and peak-to-peak currents

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H.3 Method B

H.3.1 Ringing signal

H.3.1.1 Frequency

The ringing signal shall use only frequencies whose fundamental component is equal to or less than 70 Hz.

H.3.1.2 Voltage

The ringing voltage shall be less than 300 V peak-to-peak and less than 200 V peak with respect to earth, measured across a resistance of at least 1 MΩ.

H.3.1.3 Cadence

The ringing voltage shall be interrupted to create quiet intervals of at least 1 s duration separated by no more than 5 s. During the quiet intervals, the voltage to earth shall not exceed 60 V DC.

H.3.1.4 Single fault current

Where cadenced ringing becomes continuous as a consequence of a single fault, the current through a 5 000 Ω resistor connected between any two output conductors or between one output conductor and earth shall not exceed 56,5 mA peak-to-peak, as shown in Figure H.3.

H.3.2 Tripping device and monitoring voltage

H.3.2.1 Conditions for use of a tripping device or a monitoring voltage

A ringing signal circuit shall include a tripping device as specified in H.3.2.2, or provide a monitoring voltage as specified in H.3.2.3, or both, depending on the current through a specified resistance connected between the ringing signal generator and earth, as follows:

– if the current through a 500 Ω or greater resistor does not exceed 100 mA peak-to-peak, neither a tripping device nor a monitoring voltage is required;

– if the current through a 1 500 Ω or greater resistor exceeds 100 mA peak-to-peak, a tripping device shall be included. If the tripping device meets the trip criteria specified in Figure H.4 with $R \geq 500\ \Omega$, no monitoring voltage is required. If, however, the tripping device only meets the trip criteria with $R \geq 1\ 500\ \Omega$, a monitoring voltage shall also be provided;

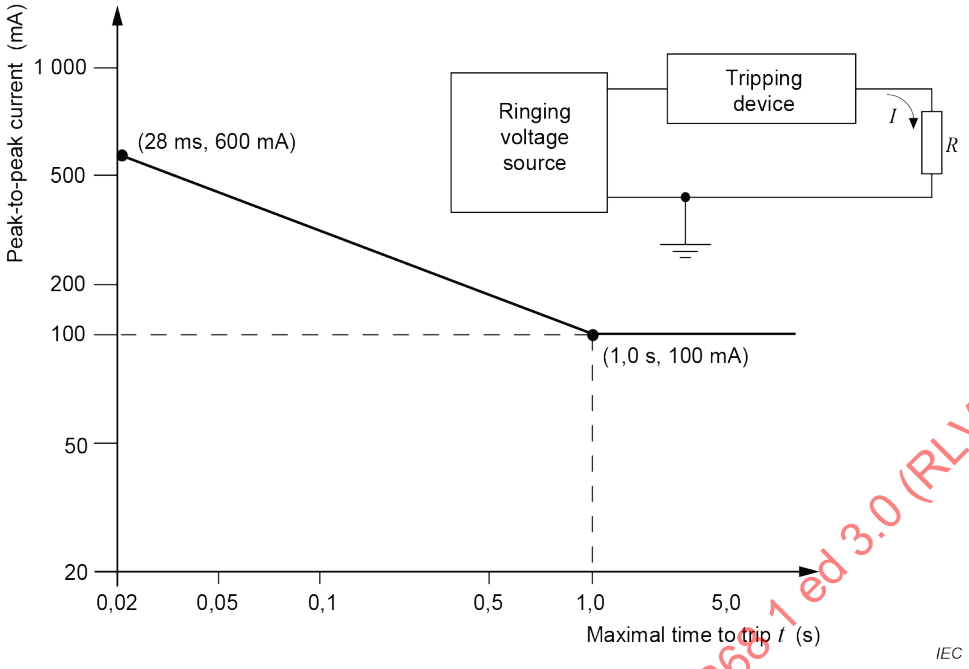
– if the current through a 500 Ω or greater resistor exceeds 100 mA peak-to-peak, but the current through a 1 500 Ω or greater resistor does not exceed this value, either:

  - a tripping device shall be provided, meeting the trip criteria specified in Figure H.4 with $R \geq 500\ \Omega$, or
  - a monitoring voltage shall be provided.

NOTE 1 Tripping devices are, in general, current-sensitive and do not have a linear response, due to the resistance/current characteristics and time delay/response factor in their design.

NOTE 2 In order to minimize testing time, a variable resistor box is normally used.

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NOTE 1 t is measured from the time of connection of the resistor R to the circuit.

NOTE 2 The sloping part of the curve is defined as $I = 100 / \sqrt{t}$.

Figure H.4 – Ringing voltage trip criteria

H.3.2.2 Tripping device

A series current-sensitive tripping device in the ringlead that will trip ringing as specified in Figure H.4.

H.3.2.3 Monitoring voltage

A voltage to earth on the tip or ring conductor with a magnitude of at least 19 V peak, but not exceeding 60 V DC, whenever the ringing voltage is not present (idle state).

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Annex I
(informative)

Overvoltage categories
(see IEC 60364-4-44)

The concept of overvoltage categories is used for equipment energized directly from the AC **mains**.

The largest transient voltage likely to be experienced at the power input interface of equipment connected to the **mains** is known as the **mains transient voltage**. In this document, minimum **clearances** for insulation in circuits connected to the **mains** are based on the **mains transient voltage**.

According to IEC 60664-1, the value of the **mains transient voltage** is determined from the **mains** voltage and the Overvoltage Category, I to IV (see Table 12 of this document).

The overvoltage category therefore shall be identified for each equipment intended to be connected to the **mains** (see Table I.1).

The overvoltage categories have a probabilistic implication rather than the meaning of physical attenuation of the transient voltage downstream in the installation.

NOTE 1 This concept of overvoltage categories is used in IEC 60364-4-44:2007, section 443.

NOTE 2 The term overvoltage category in this document is synonymous with impulse withstand category used in IEC 60364-4-44:2007, section 443.

The term overvoltage category is not used in connection with DC power distribution systems in this document.

Table I.1 – Overvoltage categories

Overvoltage category	Equipment and its point of connection to the **AC** mains	Examples of equipment
IV	Equipment that will be connected to the point where the **mains** supply enters the building	• Electricity meters • Communications ITE for remote electricity metering
III	Equipment that will be an integral part of the building wiring	• Socket outlets, fuse panels and switch panels • Power monitoring equipment
II	Pluggable or **permanently connected equipment** that will be supplied from the building wiring	• Household appliances, portable tools, home electronics • Most ITE used in the building
I	Equipment that will be connected to a special **mains** in which measures have been taken to reduce transients	• ITE supplied via an external filter or a motor driven generator

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Annex J
(normative)

Insulated winding wires for use without interleaved insulation

J.1 General

Requirements for winding wires whose insulation may be used to provide **basic insulation**, **supplementary insulation**, **double insulation** or **reinforced insulation** in wound components without interleaved insulation are specified below.

This annex applies to:

– solid round winding wires having diameters between 0,01 mm and 5,0 mm, and stranded winding wires with equivalent cross-sectional areas; and

– solid square and solid rectangular (flatwise bending) winding wires with cross-sectional areas of ~~0,000 079~~ 0,03 mm^2 to 19,6 mm^2.

NOTE See G.6.1 for the minimum number of overlapping layers.

J.2 Type tests

J.2.1 General

*Unless otherwise specified, the winding wire shall pass the following **type tests**, carried out at a temperature between 15 °C and 35 °C and a relative humidity between 45 % and 75 %.*

J.2.2 Electric strength

J.2.2.1 Solid round winding wires and stranded winding wires

J.2.2.1.1 Wires with a nominal conductor diameter up to and including 0,1 mm

The test specimen is prepared according to 4.3 of IEC 60851-5:2008. The specimen is then subjected to the electric strength test of 5.4.9.1, between the conductor of the wire and the cylinder, with a minimum test voltage of:

– *3 kV RMS or 4,2 kV peak for **reinforced insulation**; or*

– *1,5 kV RMS or 2,1 kV peak for **basic insulation** or **supplementary insulation**.*

J.2.2.1.2 Wires with a nominal conductor diameter over 0,1 mm up to and including 2,5 mm

The test specimen is prepared according to 4.4.1 of IEC 60851-5:2008 ~~(twisted pair)~~. The specimen is then subjected to the electric strength test of 5.4.9.1 with a test voltage that is not less than twice the appropriate voltage of 5.4.9.1, with a minimum of:

– *6 kV RMS or 8,4 kV peak for **reinforced insulation**; or*

– *3 kV RMS or 4,2 kV peak for **basic insulation** or **supplementary insulation**.*

J.2.2.1.3 Wires with a nominal conductor diameter over 2,5 mm

The test specimen is prepared according to 4.5.1 of IEC 60851-5:2008. The specimen is then subjected to the electric strength test of 5.4.9.1 between the conductor of the wire and the shot, with a minimum test voltage of:

– *3 kV RMS or 4,2 kV peak for **reinforced insulation**; or*

– *1,5 kV RMS or 2,1 kV peak for **basic insulation** or **supplementary insulation**.*

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J.2.2.2 Square or rectangular wires

The test specimen is prepared according to 4.7.1 of IEC 60851-5:2008 (single conductor surrounded by metal shots). The specimen is then subjected to the electric strength test of 5.4.9.1, with a minimum test voltage of:

– *3 kV RMS or 4,2 kV peak for **reinforced insulation**; or*

– *1,5 kV RMS or 2,1 kV peak for **basic insulation** or **supplementary insulation**.*

J.2.3 Flexibility and adherence

Clause 5.1.1 (in Test 8) of IEC 60851-3:2009 shall be used, using the mandrel diameters of Table J.1.

The test specimen is then examined in accordance with 5.1.1.4 of IEC 60851-3:2009, followed by the electric strength test of 5.4.9.1 in this document, with minimum test voltage of:

– *3 kV RMS or 4,2 kV peak for **reinforced insulation**; or*

– *1,5 kV RMS or 2,1 kV peak for **basic insulation** or **supplementary insulation**.*

The test voltage is applied between the wire and the mandrel.

Table J.1 – Mandrel diameter

Nominal conductor diameter or thickness mm	Mandrel diameter mm
less than 0,35	4,0 ± 0,2
less than 0,50	6,0 ± 0,2
less than 0,75	8,0 ± 0,2
less than 2,50	10,0 ± 0,2
less than 5,00	Four times the conductor diameter or thickness [a]
[a] In accordance with IEC 60317-43.	

The tension to be applied to the wire during winding on the mandrel is calculated from the wire diameter to be equivalent to 118 MPa ± 10 % (118 N/mm^2 ± 10 %).

Edgewise bending on the smaller dimension side (width) is not required for rectangular wire.

For mandrel winding test of the square and rectangular wire, two adjacent turns do not need to contact each other.

J.2.4 Heat shock

The test specimen shall be prepared in accordance with ~~3.1.1 (in Test 9) of IEC 60851-6:1996~~ 5.1.1 (in Test 8) of IEC 60851-3:2009, followed by the electric strength test of 5.4.9.1 in this document, with a minimum test voltage of:

– *3 kV RMS or 4,2 kV peak for **reinforced insulation**; or*

– *1,5 kV RMS or 2,1 kV peak for **basic insulation** or **supplementary insulation**.*

The test voltage is applied between the wire and the mandrel. The oven temperature is the relevant temperature of the thermal class of insulation in Table J.2. The mandrel diameter and tension applied to the wire during winding on the mandrel are as specified in ~~Table J.1~~ J.2.3. The electric strength test is conducted at room temperature after removal from the oven.

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Table J.2 – Oven temperature

Thermal class	Class 105 (A)	Class 120 (E)	Class 130 (B)	Class 155 (F)	Class 180 (H)	Class 200 (N)	Class 220 (R)	Class 250 -
Oven temperature °C	200	215	225	250	275	295	315	345
Oven temperatures shall be maintained within ± 5° of the specified temperature. The classes are related to the classification of electrical insulating materials and EISs in accordance with IEC 60085. The assigned letter designations are given in parentheses.								

Edgewise bending on the smaller dimension side (width) is not required for rectangular wire.

~~NOTE Subclause 3.1.2 in Test 9 of IEC 60851-6:1996 is not used for solid square and solid rectangular winding wires.~~

J.2.5 Retention of electric strength after bending

Five specimens are prepared as in J.2.3 and tested as follows. Each specimen is removed from the mandrel, placed in a container and positioned so that it can be surrounded by at least 5 mm of metal shot. The ends of the conductor in the specimen shall be sufficiently long to avoid flash over. The shot shall be not more than 2 mm in diameter and shall consist of balls of stainless steel, nickel or nickel plated iron. The shot is gently poured into the container until the specimen under test is covered by at least 5 mm of shot. The shot shall be cleaned periodically with a suitable solvent.

NOTE The above test procedure is reproduced from 4.6.1 c) of IEC 60851-5:1996, now withdrawn. It is not included in the fourth edition (2008) of that standard.

The specimen shall be subjected to the electric strength test of 5.4.9.1, with a minimum test voltage of:

- *3 kV RMS or 4,2 kV peak for **reinforced insulation**; or*
- *1,5 kV RMS or 2,1 kV peak for **basic insulation** or **supplementary insulation**.*

The mandrel diameter and tension applied to the wire during winding on the mandrel are as in Table J.1.

J.3 Testing during manufacturing

J.3.1 General

~~*The wire shall be subjected by the wire manufacturer to electric strength tests during manufacture as specified in J.3.2 and J.3.3.*~~

The wire manufacturer shall subject the wire to a spark test during manufacture according to IEC 62230 as specified in J.3.2 and J.3.3.

J.3.2 ~~Routine~~ Spark test

The test voltage for ~~routine~~ the spark test shall be in accordance with the electric strength test of 5.4.9.1, with a minimum of:

- *3 kV RMS or 4,2 kV peak for **reinforced insulation**; or*
- *1,5 kV RMS or 2,1 kV peak for **basic insulation** or **supplementary insulation**.*

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J.3.3 Sampling test

*The **sampling test** shall be conducted according to the suitable test specified in J.2.2.*

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Annex K
(normative)

Safety interlocks

K.1 General

K.1.1 General requirements

Safety interlocks shall be so designed that, for an **ordinary person**, the class 2 energy sources and class 3 energy sources will be removed before the cover, door, etc. is in a position that those parts become **accessible** as a class 1 energy source.

Safety interlocks shall be so designed that, for an **instructed person**, the class 3 energy sources will be removed before the cover, door, etc. is in a position that this part becomes **accessible** as a class 2 energy source or less.

The interlock shall either:

– necessitate previous de-energization of such parts; or

– automatically initiate disconnection of the supply to such parts, and to reduce to a:

  • class 1 energy source within 2 s for an **ordinary person**, and

  • class 2 energy source within 2 s for an **instructed person**.

If reduction of the energy source class takes longer than 2 s, then an **instructional safeguard** shall be provided in accordance with Clause F.5, except that:

– element 1a shall be placed on the door, cover or other part that initiates the interlock action and is opened or removed to gain access; and

– element 3 is optional.

The elements of the **instructional safeguard** shall be as follows:

– element 1a:  , IEC 60417-6057 (2011-05) for moving parts or

 , IEC 60417-5041 (2002-10) for hot parts

– element 2: not specified

– element 3: not specified

– element 4: the time when the energy source will be reduced to the required class

K.1.2 Test method and compliance criteria

The energy level of class 2 or class 3 energy source parts are monitored.

Compliance is checked by inspection, measurement and use of the ~~rigid~~ straight unjointed version of the test ~~finger~~ probe according to Annex V.

K.2 Components of the safety interlock safeguard mechanism

The components comprising the **safety interlock** mechanism shall be considered **safeguards**, and shall comply with ~~applicable **safeguard** requirements and shall be subject to applicable requirements of~~ Annex G or K.7.1 where applicable.

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Compliance is checked in accordance with Annex G or K.7.1 and by inspection.

K.3 Inadvertent change of operating mode

A **safety interlock** shall not be operable by means of probes specified in Figure V.1 or Figure V.2, as applicable so as to change the energy class within the area, space or access point being controlled to a class 3 energy source for an **instructed person**, or to a class 2 energy source or a class 3 energy source for an **ordinary person**.

Compliance is checked in accordance with Annex V and by inspection.

K.4 Interlock safeguard override

A **safety interlock** may be overridden by a **skilled person**. The **safety interlock** override system:

– shall require an intentional effort to operate; and

– shall reset automatically to normal operation when servicing is complete, or prevent normal operation unless the **skilled person** has carried out restoration; and

– if located in an area **accessible** to an **ordinary person** or, if applicable, an **instructed person**, shall not be operable by means of probes specified in Annex V, and shall require a **tool** for operation.

Compliance is checked in accordance with Annex V and by inspection.

K.5 Fail-safe

K.5.1 Requirement

In the event of any **single fault condition** in the **safety interlock** system, the space controlled by the **safety interlock** shall:

– revert to a class 1 energy source for an **ordinary person** or a class 2 energy source for an **instructed person**; or

– be locked in the **normal operating condition** and comply with applicable requirements for a class 3 energy source.

K.5.2 Test method and compliance criteria

*Compliance is checked by introduction of electrical, electro-mechanical, and mechanical component faults, one at a time. **Single fault conditions** are described in Clause B.4. For each fault, the space controlled by the **safety interlock** shall comply with the applicable requirements for **single fault conditions** for the respective energy source.*

*The components and parts of the **safety interlock** used as a **safeguard** mechanism are not subjected to **single fault conditions** if they comply with K.2 or K.6 as applicable.*

*Fixed separation distances in **safety interlock** circuits (for example, those associated with printed boards) are not subjected to simulated **single fault conditions** if the separation distances comply with K.7.1.*

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K.6 Mechanically operated safety interlocks

K.6.1 Endurance requirement

Moving mechanical parts in mechanical and electromechanical **safety interlock** systems shall have adequate endurance.

K.6.2 Test method and compliance criteria

*Compliance is checked by inspection of the **safety interlock** system, available data and, if necessary, by cycling the **safety interlock** system through 10 000 operating cycles. In the event of any fault during or after the 10 000 operating cycles in the **safety interlock** system, the space controlled by the **safety interlock** shall:*

– *revert to a class 1 energy source for an **ordinary person** or a class 2 energy source for an **instructed person**; or*

– *be locked in the **normal operating condition** and comply with applicable requirements for a class 3 energy source.*

NOTE The above test is conducted to check the endurance of moving parts other than those in **safety interlock** systems, switches and relays. **Safety interlock** systems, switches and relays, if any, are subject to Annex G or K.7.1.

K.7 Interlock circuit isolation

K.7.1 Separation distances for contact gaps and interlock circuit elements

Separation distances for contact gaps and interlock circuit elements shall comply with the following requirements as applicable.

a) If the switch or relay disconnects a circuit conductor in a circuit connected to the **mains**, the separation distances for contact gaps and their related circuits shall be not less than that for a **disconnect device** (see Annex L).

b) If the switch or relay is in a circuit isolated from the **mains**, the separation distances for contact gaps shall be not less than the relevant minimum **clearance** value for **basic insulation** for isolation of class 2 energy sources. Interlock circuit elements, the failure of which can defeat the interlock system, such as the fixed separation distances in a **safety interlock** circuit, shall ~~have~~ comply with the requirements of 5.4.2 for **basic insulation.** The **temporary overvoltage** is not taken into account to determine the voltage to be used in Table 10 and Table 11 unless the circuit is subject to a **temporary overvoltage.**

c) If the switch or relay is in a circuit isolated from the **mains**, the separation distances for contact gaps shall be not less than the relevant minimum **clearance** value for **reinforced insulation** for isolation of class 3 energy sources. Interlock circuit elements, the failure of which can defeat the interlock system, such as the fixed separation distances in a **safety interlock** circuit, shall comply with the requirement of 5.4.2 for **basic insulation**, except that if a life threatening hazard is involved in the interlocked space, the fixed separation distances shall ~~have~~ comply with the requirement for **reinforced insulation**. The **temporary overvoltage** is not taken into account to determine the voltage to be used in Table 10 and Table 11 unless the circuit is subject to a **temporary overvoltage.**

~~Alternatively, the separation gap between contacts in the off position shall withstand the electric strength test of 5.4.9.1 at a test voltage required for **basic insulation** or **reinforced insulation**, as applicable. The contact gap shall comply with the above requirements before and after the 10 000 cycle endurance test of K.6.2. The endurance test condition shall represent the maximum **normal operating condition** within the equipment with respect to voltage and current that the contacts interrupt.~~

~~The contact gap **clearance** shall comply with the applicable distance from Table 15, provided the switch or relay complies with K.7.2, K.7.3 and K.7.4.~~

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As an alternative to a), b) and c), the separation distances for the contact gap between contacts in the off position shall withstand the electric strength test of 5.4.9.1 required for **basic insulation** or **reinforced insulation**, as applicable. The contact gap shall comply with the above requirements before and after the test of K.7.2.

The altitude multiplication factor of Table 16 does not need to be taken into account.

The separation distances for the contact gap of the switch or relay shall comply with K.7.3 and K.7.4 in addition to the above requirements, unless the switch or relay complies with G.1 and G.2 respectively. The endurance test condition shall represent the maximum **normal operating condition** within the equipment with respect to voltage and current that the contacts interrupt.

Two independent interlock systems, in series, using **basic insulation** may be used as an alternative to the provision of **reinforced insulation**.

K.7.2 Overload test

*The contact of a switch or relay in the **safety interlock** system is subjected to an overload test consisting of 50 cycles of operation at the rate of 6 to 10 cycles per minute, making and breaking 150 % of the current imposed in the application, except that where a switch or relay contact switches a motor load, the test is conducted with the rotor of the motor in a locked condition.*

*After the test, the **safety interlock** system, including the switch or relay, shall still be functional.*

K.7.3 Endurance test

*The contact of a switch or relay in the **safety interlock** system is subjected to an endurance test, making and breaking 100 % of the current imposed in the application at a rate of 6 to 10 cycles of operation per minute. A higher rate of cycling may be used if requested by the manufacturer.*

*For reed switches used in a **safety interlock** system in ES1 or ES2, the test is 100 000 operating cycles. For other switches and relays in a **safety interlock** system, the test is 10 000 operating cycles.*

*After the test, the **safety interlock** system, including the switch or relay, shall still be functional.*

K.7.4 Electric strength test

*Except for reed switches in ES1 or ES2, an electric strength test as specified in 5.4.9.1 is applied between the contacts after the tests of K.7.3. If the contact is in a circuit connected to the **mains**, the test voltage is as specified for **reinforced insulation**. If the contact is in a circuit isolated from the **mains**, the test voltage is as specified for **basic insulation** in a circuit connected to the **mains**.*

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Annex L
(normative)

Disconnect devices

L.1 General requirements

A **disconnect device** shall be provided to disconnect the equipment from the supply. If a **disconnect device** interrupts the neutral conductor, it shall simultaneously interrupt all phase conductors.

A **disconnect device** may be:

– the plug on the power supply cord; or
– an appliance coupler; or
– an isolating switch; or
– a circuit breaker; or
– any equivalent means for disconnection.

For equipment intended to be powered from an AC **mains** that is Overvoltage Category I, Overvoltage Category II or Overvoltage Category III, or from a DC **mains** that is ES3, a **disconnect device** shall have a contact separation of at least 3 mm. For an AC **mains** that is Overvoltage Category IV, IEC 60947-1 shall apply. When incorporated in the equipment, the **disconnect device** shall be connected as closely as practicable to the incoming supply.

For equipment intended to be powered from a DC **mains** that is not at ES3,

– a **disconnect device** shall have a contact separation at least equal to the minimum **clearance** for **basic insulation**; and
– a removable fuse may be used as a **disconnect device**, provided that it is **accessible** only to an **instructed person** or to a **skilled person**.

L.2 Permanently connected equipment

For **permanently connected equipment** the **disconnect device** shall be incorporated in the equipment, unless the equipment is accompanied by installation instructions stating that an appropriate **disconnect device** shall be provided as part of the building installation.

NOTE External **disconnect devices** will not necessarily be supplied with the equipment.

L.3 Parts that remain energized

Parts on the supply side of a **disconnect device** in the equipment, that remain energized when the **disconnect device** is switched off, shall be guarded to reduce the risk of accidental contact by **skilled persons**.

As an alternative, instructions shall be provided in the service manual.

L.4 Single-phase equipment

For single-phase equipment, the **disconnect device** shall disconnect both poles simultaneously, except that a single-pole **disconnect device** can be used to disconnect the phase conductor when it is possible to rely on the identification of the neutral in the **mains**. If only a single pole **disconnect device** is provided in the equipment, instructions shall be given

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for the provision of an additional two-pole **disconnect device** in the building installation when the equipment is used where identification of the neutral in the **mains** is not possible.

EXAMPLE Cases where a two-pole **disconnect device** is required are:

– on equipment supplied from an IT power system;

– on pluggable equipment supplied through a reversible appliance coupler or a reversible plug (unless the appliance coupler or plug itself is used as the **disconnect device**;

– on equipment supplied from a socket-outlet with indeterminate polarity.

L.5 Three-phase equipment

For three-phase equipment, the **disconnect device** shall disconnect simultaneously all phase conductors of the supply. For equipment requiring a neutral connection to an IT power system, the **disconnect device** shall be a four-pole device and shall disconnect all phase conductors and the neutral conductor. If this four-pole device is not provided in the equipment, the installation instructions shall specify the need for its provision as part of the building installation.

L.6 Switches as disconnect devices

Where the **disconnect device** is a switch incorporated in the equipment, the on and off positions shall be marked in accordance with F.3.5.2.

L.7 Plugs as disconnect devices

Where a plug on the power supply cord is used as the **disconnect device**, the installation instructions shall state that for pluggable equipment, the socket-outlet shall be easily **accessible**. For pluggable equipment intended for installation by an **ordinary person**, the installation instructions shall be made available to the **ordinary person**.

L.8 Multiple power sources

Where a unit receives power from more than one source (for example, different voltages/frequencies or as redundant power), there shall be a prominent **instructional safeguard** in accordance with Clause F.5 ~~at~~ near each **disconnect device** giving adequate instructions for the removal of all power from the unit.

One **instructional safeguard** may be used for more than one **disconnect device**, as long as it is clearly visible from the disconnect points.

The elements of the **instructional safeguard** shall be as follows:

– element 1a:  , IEC 60417-6042 (2010-11); and

 , IEC 60417-6172 (2012-09)

– element 2: “Caution” or equivalent word or text, and “Shock hazard” or equivalent text

– element 3: optional

– element 4: “Disconnect all power sources” or equivalent text

~~If more than one such **disconnect device** is provided on a unit, all these devices shall be grouped together. It is not necessary that the devices be mechanically linked.~~

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Equipment incorporating an internal UPS shall have provisions for reliably disabling the UPS and disconnecting its output prior to servicing the equipment. Instructions for disconnection of the UPS shall be provided. The internal energy source of the UPS shall be marked appropriately and guarded against accidental contact by a **skilled person**.

L.9 Compliance criteria

Compliance is checked by inspection.

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Annex M
(normative)

Equipment containing batteries and their protection circuits

M.1 General requirements

This annex provides additional requirements for equipment that contains **batteries**. Use of **batteries** in the equipment may require **safeguards** that have not been addressed in other parts of this document. This annex does not cover requirements for external **batteries**, installation of external **batteries** or **battery** maintenance other than **battery** replacement by an **ordinary person** or an **instructed person**. ~~Also, this annex does not cover equipment that charges external **batteries**.~~

Where a **battery** safety standard contains equivalent requirements to the requirements in this annex, a **battery** in compliance with that **battery** standard is considered to fulfil the corresponding requirements of this annex, and tests that are part of the **battery** safety standard need not be repeated under this annex.

~~For equipment containing a **battery** that is replaceable by an **ordinary person**, an **instructional safeguard** shall be provided in accordance with Clause F.5, except that the complete **instructional safeguard** may be provided in the instructions.~~

~~The elements of the **instructional safeguard** shall be as follows:~~

- ~~element 1a: not available~~
- ~~element 2: "CAUTION" or equivalent word or text~~
- ~~element 3: "Risk of explosion if the battery is replaced by an incorrect type" or equivalent text~~
- ~~element 4: optional~~

For consumer grade, non-rechargeable carbon-zinc or alkaline **batteries**, M.3 and M.10 apply.

M.2 Safety of batteries and their cells

M.2.1 Requirements

Batteries and their **cells** shall comply with the relevant IEC standards for **batteries** as listed below.

IEC 60086-4, IEC 60086-5, IEC 60896-11, IEC 60896-21, IEC 60896-22, IEC 61056-1 and IEC 61056-2, IEC 61427 (all parts), IEC TS 61430, IEC 61434, IEC 61959, IEC 62133 (all parts), IEC 62133-1, IEC 62133-2, IEC 62281, IEC 62485-2 and IEC 62619.

NOTE Other **battery** safety standards are under development, and are intended to be included in future.

M.2.2 Compliance criteria

Compliance is checked by inspection or evaluation based on data provided by the manufacturer.

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M.3 Protection circuits for batteries provided within the equipment

M.3.1 Requirements

Protection circuits or construction for **batteries** provided within the equipment and that are not an integral part of the **battery** shall be so designed that:

– **safeguards** are effective during **normal operating conditions**, **abnormal operating conditions**, **single fault conditions**, installation conditions and transportation conditions; and

– the output characteristics of a **battery** charging circuit are compatible with its rechargeable **battery**; and

– for non-rechargeable **batteries**, discharging at a rate exceeding the **battery** manufacturer's recommendations and unintentional charging are prevented; and

– for rechargeable **batteries**, charging and discharging at a rate exceeding the **battery** manufacturer's recommendations, and reversed charging are prevented; and

– **batteries** in **hand-held equipment**, **direct plug-in equipment** and **transportable equipment** that are replaceable by an **ordinary person** shall be inherently protected to avoid creating a class 2 energy source or a class 3 energy source; and

– for **batteries** that are replaceable by an **ordinary person**, reverse polarity installation shall be prevented if this could create a class 2 or class 3 energy source (see also B.3.6).

NOTE Reversed charging of a rechargeable **battery** occurs when the polarity of the charging circuit is reversed, aiding the discharge of the **battery**.

M.3.2 Test method

*Protection circuits for **batteries** are checked by inspection and by evaluation of the data provided by the equipment manufacturer and **battery** manufacturer for charging and discharging rates.*

*When appropriate data is not available, compliance is checked by test. However, **batteries** that are inherently safe for the conditions given are not tested under those conditions. Consumer grade, non-rechargeable carbon-zinc or alkaline **batteries** are considered safe under short-circuiting conditions and therefore are not tested for discharge; nor are such **batteries** tested for leakage under storage conditions.*

*The **battery** used for the following tests is either a new non-rechargeable **battery** or a fully charged rechargeable **battery** as provided with the equipment, or recommended by the manufacturer for use with the equipment. The test for **battery** protection circuits in the equipment may be performed using a **battery** simulator replacing the **battery** itself. The temperature test is conducted in a temperature controlled chamber. A control signal simulating the actual signal from the temperature sensor in the **battery** may be used in order to perform the test.*

– *Overcharging of a rechargeable **battery**. The **battery** is charged while briefly subjected to the simulation of any **single fault condition** that is likely to occur in the charging circuit and that results in overcharging of the **battery**. To minimize testing time, the failure is chosen that causes the worst-case overcharging condition. The **battery** is then charged for a single period of 7h with the simulated failure in place.*

– *Excessive discharging. The **battery** is subjected to rapid discharge by open-circuiting or short-circuiting any current limiting or voltage limiting component in the load circuit of the **battery** under test (one component at a time).*

– *Unintentional charging of a non-rechargeable **battery**. The **battery** is charged while briefly subjected to the simulation of any single component failure that is likely to occur in the circuit and that would result in unintentional charging of the **battery**. To minimize testing time, the failure is chosen that causes the highest charging current. The **battery** is then charged for a single period of 7 h with the simulated failure in place.*

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*Where more than one **cell** is provided in a **battery**, all **cells** shall be tested as a unit.*

NOTE Some of the tests specified can be hazardous to the persons performing the tests. Use appropriate measures to protect such persons against possible chemical or **explosion** hazards.

*For equipment where the **battery** can be removed from the equipment by an **ordinary person**, the following additional test~~s~~ appli~~y~~es:*

– *Reverse charging of a rechargeable **battery**. Check whether the equipment containing a **battery** has such construction design that the **battery** may be placed into the equipment in the manner causing reverse charging. Also it will be checked if the electrical connection is made. If a reverse charging is judged possible by the inspection, the following test is applied. However, when relevant IEC **battery** standards cover this requirement, the test is considered to be performed.*

  *The **battery** is installed in the reverse orientation and then the charging circuit is subject to simulation of any single component failure. To minimize testing time, the failure is chosen that causes the highest reverse charging current. The **battery** is then reverse charged for a single period of 7 h with the simulated failure in place.*

~~*Unintentional charging of a non-rechargeable **battery**. The **battery** is charged while briefly subjected to the simulation of any single component failure that is likely to occur in the charging circuit and that would result in unintentional charging of the **battery**. To minimize testing time, the failure is chosen that causes the highest charging current. The **battery** is then charged for a single period of 7 h with the simulated failure in place.*~~

M.3.3 Compliance criteria

These tests shall not result in any of the following:

– *chemical leakage caused by cracking, rupturing or bursting of the **battery** jacket, if such leakage could adversely affect a **safeguard**; or*

– *spillage of liquid from any pressure relief device in the **battery**, unless such spillage is contained by the equipment without risk of damage to a **safeguard** or harm to an **ordinary person** or an **instructed person**; or*

– ***explosion** of the **battery**, if such **explosion** could result in injury to an **ordinary person** or an **instructed person**; or*

– *emission of flame or expulsion of molten metal to the outside of the equipment **enclosure**.*

Throughout the tests:

– *the **battery** temperature shall not exceed the allowable temperature of the **battery** as specified by the **battery** manufacturer; and*

– *the maximum current drawn from the **battery** shall be within the range of the specification of the **battery**.*

M.4 Additional safeguards for equipment containing a portable secondary lithium battery

M.4.1 General

Equipment designed to be operated while incorporating one or more portable sealed **secondary lithium batteries** are subject to the requirements in this clause.

M.4.2 Charging safeguards

M.4.2.1 Requirements

Under **normal operating conditions**, **abnormal operating conditions** or **single fault conditions** the charging voltage per **secondary lithium battery** and the charging current per

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secondary lithium battery shall not exceed the **maximum specified charging voltage** and **maximum specified charging current**.

Under **abnormal operating conditions**, the **battery** charging circuit shall:

– stop charging when the temperature of the **battery** exceeds the **highest specified charging temperature**; and

– limit the current to the value specified by the **battery** manufacturer when the **battery** temperature is lower than the **lowest specified charging temperature**.

M.4.2.2 Compliance criteria

*Compliance is checked by measuring the charging voltage, the charging current and the temperature of each individual **cell** of the **secondary lithium battery** under **normal operating conditions**, **abnormal operating conditions** and **single fault conditions**. The **cell** temperature shall be measured at the points specified by the **battery** manufacturer. **Single fault conditions** that may affect the charging voltage or charging current or the temperature shall be applied in accordance with Clause B.4.*

NOTE 1 For potted assemblies, thermocouples could be attached to the **cell** surface before potting.

*A higher charging voltage than the **maximum specified charging voltage** or a higher charging current than the **maximum specified charging current**, that occurs just after the introduction of an **abnormal operating condition** or a **single fault condition**, may be ignored if the operation of a protective device or circuitry, provided in addition to the normal regulating circuitry, prevents an unsafe condition of the **battery**.*

*Where appropriate, for the purpose of the measurement, the **battery** may be replaced by a circuit simulating the **battery** load.*

*The charging voltage shall be measured when the **secondary lithium battery** becomes fully charged. The charging current shall be measured during the entire charging cycle up to the **maximum specified charging voltage**.*

*During and after the test, ~~no fire or **explosion** (other than venting) of **secondary lithium battery** shall occur~~ the following applies:*

– *The charging voltage shall not exceed the **maximum specified charging voltage**.*

– *The charging current shall not exceed the **maximum specified charging current**.*

– *The charging of the **battery** shall ~~be stopped~~ stop when the temperature of the **battery** exceeds the **highest specified charging temperature**.*

– *The **battery** charging circuit shall limit the current to the value specified by the **battery** manufacturer when the **battery** temperature is lower than the **lowest specified charging temperature**.*

~~NOTE 2 Venting without flame, fire or expulsion of solid materials is a **safeguard** of a **secondary lithium battery**.~~

*In addition, for equipment where the **battery** can be removed from the equipment by an **ordinary person**, compliance is checked by measuring the charging voltage and the charging current, and by evaluating the temperature control function of the equipment under **normal operating conditions**, **abnormal operating conditions** and **single fault conditions**.*

*All parameters controlled by the protection circuit for the **battery** shall be within those specified in the relevant IEC **battery** standard, and shall cover the following:*

– *the maximum current drawn from the **battery** shall be within the range of the specification of the **battery**; and*

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– *throughout the tests, the **battery** temperature shall not exceed the allowable temperature of the **battery** as specified by the **battery** manufacturer.*

NOTE ~~3~~ 2 The controlling elements are voltage, current, and temperature.

M.4.3 Fire enclosure

Secondary lithium ~~battery~~ batteries shall be provided with a **fire enclosure** according to 6.4.8. The **fire enclosure** may be that of the **secondary lithium battery** itself, of the **cell** or of a combination of **cells** or that of the equipment containing the **secondary lithium battery**.

~~Equipment with **batteries** are exempted from the above requirement, provided that:~~

~~– the **battery** complies with PS1 circuit limits; or~~

~~– the equipment with the **battery** complies with the **supplementary safeguard** requirements of 6.4.5.2.~~

Equipment with **batteries** are exempt from the above requirement if the equipment uses a **cell** that complies with PS1.

*Compliance is checked by inspection of the relevant material or by evaluation of the **secondary lithium battery** data sheet.*

M.4.4 Drop test of equipment containing a secondary lithium battery

M.4.4.1 General

The tests for **direct plug-in equipment**, **hand-held equipment** and **transportable equipment** that contain a **secondary lithium battery** are specified below. These tests are specified to verify that mechanical shock will not compromise a **safeguard** within the **battery** or the equipment.

M.4.4.2 Preparation and procedure for the drop test

The drop test is conducted in the following order:

– *Step 1: drop of the equipment containing a **battery** as specified in M.4.4.3.*

– *Step 2: check the charge and discharge function of the dropped equipment as specified in M.4.4.4.*

– *Step 3: conduct a charge and discharge cycle test of the dropped **battery** as specified in M.4.4.5.*

*As a preparation of the drop test, two **batteries** are fully charged at the same time under the same charging conditions. The open circuit voltages of both **batteries** are measured to confirm the initial voltages are the same. One **battery** is used for the drop test and the other is used as a reference.*

M.4.4.3 Drop

*The equipment with a fully charged **battery** installed shall be subjected to the drop test of Clause T.7.*

*After the drop test, the **battery** is removed from the equipment. The open circuit voltages of the dropped **battery** and the reference (undropped) **battery** are periodically monitored during the following 24 hour period. The voltage difference shall not exceed 5 %.*

M.4.4.4 Check of the charge / discharge function

The charging/discharging circuit functions (charging- control voltage, charging control current, and temperature control) are checked to determine that they continue to operate and that all

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safeguards *are effective. A dummy* ***battery*** *or appropriate measurement tool that represents the* ***battery*** *characteristics may be used for this examination in order to differentiate between* ***battery*** *damage and equipment malfunctions.*

If the charge/discharge function does not operate, the test is terminated, continuation with step 3 is not necessary and compliance is determined by M.4.4.6.

M.4.4.5 Charge / discharge cycle test

If the dropped equipment is still functioning, the dropped equipment with the dropped ***battery*** *installed is subject to three complete discharge and charge cycles under* ***normal operating conditions****.*

M.4.4.6 Compliance criteria

During the tests, fire or ***explosion*** *of the* ***battery*** *shall not occur unless an appropriate* ***safeguard*** *is provided that contains the* ***explosion*** *or fire. If venting occurs, any electrolyte leakage shall not defeat a* ***safeguard****.*

When a protection circuitry for charging or discharging in the equipment or the ***battery*** *detects an abnormality in the* ***battery*** *and stops charging or discharging, the result is considered to be acceptable.*

M.5 Risk of burn due to short-circuit during carrying

M.5.1 Requirements

Battery terminals shall be protected from the possible burn that may occur to an **ordinary person** or an **instructed person** during the carrying of a **battery** with exposed bare conductive terminals (such as in the user's carrying bag) due to a short-circuit caused by metal objects, such as clips, keys and necklaces.

M.5.2 Test method and compliance criteria

If the ***battery*** *is designed to be carried with bare conductive terminals, the* ***battery*** *shall comply with the test of P.2.3.*

The compliance criteria of M.3.3 apply.

M.6 ~~Prevention of short-circuits and protection from other effects of electric current~~ Safeguards against short-circuits

~~M.6.1 Short-circuits~~

M.6.1~~.1 General~~ requirements

The electric energy stored in **cells** or **batteries** may be released in an inadvertent and uncontrolled manner due to external short-circuiting of the terminals or an internal **safeguard** failure, such as a metal contaminant bridging the insulation. As a result, the considerable amount of energy, heat and pressure generated by the high current can produce molten metal, sparks, **explosion** and vaporisation of electrolyte.

To address external faults, the main connections from the **battery** terminals shall either:

– be provided with a sufficient overcurrent protective device to prevent any accidental short-circuit inducing conditions as mentioned above; or

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– the **battery** connections up to the first overcurrent protective device shall be constructed so that a short-circuit is not likely to occur and connections shall be designed to withstand the electromagnetic forces experienced during a short-circuit.

NOTE 1 Where terminals and conductors are not insulated, by design or for maintenance purposes, only insulated **tools** are to be used in that area.

Unless internal fault testing has been conducted on the ~~**battery**~~ **cell** as part of compliance with an IEC **battery** standard in M.2.1, the internal fault testing as described below is required.

NOTE 2 Not all **battery** standards in M.2.1 contain a similar internal fault test.

Each **cell** in a **battery** shall be faulted to ensure that each **cell** vents safely without introducing an **explosion** or fire. Where a **cell** is incorporated into a **battery** or the equipment, sufficient spacing shall be allowed for the proper vent operation of each **cell**.

M.6.2 Compliance criteria

For external faults, compliance may be checked by inspection.

The sample shall not explode or emit molten material at any time during any of the tests.

~~**M.6.2 Leakage currents**~~

~~To be resistant against effects of ambient influences like temperature, dampness, dust, gasses, steam, mechanical stress, and to avoid the risk of fire or corrosion, **batteries** shall be kept clean and dry.~~

~~The **battery** system should be isolated from the fixed installation before this measurement is carried out.~~

~~NOTE Before carrying out any test, consider the presence of ES2 or ES3 voltages between the **battery** and the associated rack or **enclosure**.~~

~~*Compliance is checked by measuring the insulation resistance between the **battery**'s circuit and other local conductive parts. The insulation resistance shall be greater than 100 Ω per volt (of **battery** nominal voltage), corresponding to a leakage current less than 10 mA.*~~

M.7 Risk of explosion from lead acid and NiCd batteries

M.7.1 Ventilation preventing an explosive gas concentration

Where **batteries** are provided within an equipment such that emitted gases may concentrate in a confined equipment space, the **battery** construction, air flow or ventilation shall be such that the atmosphere within the equipment does not reach an **explosive** concentration.

In a compartment containing both a **battery** and electrical components, the risk of ignition of local concentrations of hydrogen and oxygen by adjacent operational arcing parts, such as contactors and switches close to **battery** vents or valves, shall be controlled. This shall be achieved, for example, by the use of fully enclosed components, separation of **battery** compartments or adequate ventilation.

The ventilation system shall be so constructed that any potential fault, including distortion of the **battery** cases due to overheating or thermal runaway, does not result in the ventilation system failing to vent **explosive** gasses.

If ventilation tubes are used for conducting **explosive** gas from the **battery** cases to the outside air, they shall not be the only means of eliminating the build-up of gas from the

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cabinet. An independent means of natural ventilation that adequately ventilates the **enclosure** containing the **batteries** shall be provided.

If mechanical or forced-air ventilation is used, adequate ventilation shall continue to be provided under **single fault conditions**.

Enclosures with mechanical or electromechanical dampers shall continue to provide adequate ventilation when the damper is in the closed position.

Clause M.7 is applied for open type **batteries** and valve regulated type **batteries**. Sealed type **batteries** with a mechanism of reducing gas are considered to comply with this requirement.

If it can be shown that the ventilation capability of the **enclosure** is compliant with the calculated required ventilation air flow (Q) according to M.7.2, the equipment is in compliance with Clause M.7. Unless it can be demonstrated under a **single fault condition** in the charging circuitry that the charge voltage cannot exceed the values for float charging in Table M.1, or if the **battery enclosure** contains no internal charging capability, calculations shall be conducted for boost charge condition for the **battery** types and maximum capacity specified and approved by the manufacturer. If the ventilation cannot be adequately shown, one of the ventilation tests in M.7.3 shall be conducted in order to ensure adequate ventilation.

The hydrogen generation (flow rate for testing) for the maximum supported **battery** capacity and supported **battery** types shall be calculated using data from the **battery** manufacturer, or the values for I_{float} and I_{boost} with supporting data as given in Table M.1 or by the following:

$$q_{Batt} = 0{,}45 \times 10^{-3} \frac{m^3}{Ah} \times I_{gas} \times C_{rt} \times n$$

with I_{gas}, C_{rt}, and n as described in M.7.2.

M.7.2 Test method and compliance criteria

The purpose of ventilating a **battery** location or **enclosure** is to maintain the hydrogen concentration below the **explosive** 4 $\%_{vol}$ hydrogen LEL threshold. ~~*The hydrogen concentration in the **battery** location shall not exceed 1 $\%_{vol}$ hydrogen.*~~ *The hydrogen gas concentration shall not exceed 1 % by volume if the mixture is in proximity to an ignition source, and not exceed 2 % by volume if the mixture is not in proximity to an ignition source.*

NOTE 1 When a **cell** reaches its fully charged state, water electrolysis occurs according to the Faraday's law.

Under standard conditions of normal temperature and pressure where T = 273 K, P = 1 013 hPa:

– *1 Ah decomposes H_2O into 0,42 l H_2 + 0,21 l O_2,*

– *decomposition of 1 cm^3 (1 g) H_2O requires 3 Ah,*

– *26,8 Ah decomposes H_2O into 1 g H_2 + 8 g O_2.*

*When the charging operation is stopped, the emission of gas from the **cells** can be regarded as having come to an end 1 h after having switched off the charging current.*

*The minimum air flow rate for ventilation of a **battery** location or compartment shall be calculated by the following formula:*

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$$Q = v \times q \times s \times n \times I_{gas} \times C_{rt} \times 10^{-3} \quad \left[m^3/h\right]$$

where:

Q *is the ventilation air flow in m3/h;*

v *is the necessary dilution of hydrogen:*

$\frac{(100-4)\,\%}{4\,\%} = 24$;

q = $0{,}45 \times 10^{-3}$ $\left[m^3/Ah\right]$ *generated hydrogen at 20 °C;*

s *= 5, general safety factor;*

n *is the number of* ***cells****;*

I_{gas} *is the current producing gas in mA / Ah rated capacity for the float charge current* I_{float} *or the boost charge current* I_{boost}*;*

C_{rt} *is the capacity* C_{10} *for lead acid* ***cells*** *(Ah) or capacity* C_5 *for NiCd* ***cells*** *(Ah)*

NOTE 2 C_{10} is the 10 h rate with current I_{10} for lead acid **cells**: (Ah) to U_{final} = 1,80 V/**cell** at 20 °C.

C_5 is the 5 h rate with current I_5 for NiCd **cells**: (Ah) to U_{final} = 1,00 V/**cell** at 20 °C.

with $v \times q \times s = 0{,}05\left[m^3/Ah\right]$ *the ventilation air flow calculation formula is:*

$$Q = 0{,}05 \times n \times I_{gas} \times C_{rt} \times 10^{-3} \quad \left[m^3/h\right]$$

The current I_{gas} *in mA producing gas is determined by one of the following formulas:*

$$I_{gas} = I_{float} \times f_g \times f_s \left[mA/Ah\right] \text{ or}$$

$$I_{gas} = I_{boost} \times f_g \times f_s \left[mA/Ah\right]$$

where:

I_{gas} *is the current producing gas in mA / Ah rated capacity for the float charge current* I_{float} *or the boost charge current* I_{boost}*;*

I_{float} *is the float charge current under fully charged condition at a defined float charge voltage at 20 °C;*

I_{boost} *is the boost charge current under fully charged condition at a defined boost charge voltage at 20 °C;*

f_g *is the gas emission factor, proportion of current at fully charged state producing hydrogen (see* Table M.1*);*

f_s *is the safety factor, to accommodate faulty* ***cells*** *in a* ***battery*** *and an aged* ***battery*** *(see* Table M.1*).*

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Table M.1 – Values of f_g and f_s

	Lead-acid batteries vented cells Sb < 3 %	Lead-acid batteries VRLA cells	NiCd batteries vented cells
gas emission factor f_g	1	0,2	1
gas emission safety factor f_s (including 10 % faulty cells and ageing)	5	5	5

For outdoor equipment, Clause 11 of IEC 60950-22:2005 applies.

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Table M.1 – Values for current I_{float} and I_{boost}, factors f_g and f_s, and voltages U_{float} and U_{boost}

Parameter	Lead-acid batteries vented cells Sb < 3 % [a]	Lead-acid batteries VRLA cells	NiCd batteries vented cells [b]
Gas emission factor f_g	1	0,2	1
Gas emission safety factor f_s (incl. 10 % faulty **cells** and ageing)	5	5	5
Float charge voltage U_{float} [c] V/**cell**	2,23	2,27	1,40
Typical float charge current I_{float} A/Ah	1	1	1
Current (float) I_{gas} mA/Ah (under float charge conditions relevant for air flow calculation)	5	1	5
Boost charge voltage U_{boost} [c] V/**cell**	2,40	2,40	1,55
Typical boost charge current I_{boost} mA/Ah	4	8	10
Current (boost) I_{gas} mA/Ah (under boost charge conditions relevant for air flow calculation)	20	8	50

[a] For an antimony (Sb) content higher than 3 %, the current used for calculations shall be doubled.

[b] For recombination type NiCd **cells** consult the manufacturer.

[c] Float and boost charge voltage can vary with the specific gravity of electrolyte in lead-acid **cells**.

The values of float and boost charge current increase with temperature. The consequences of an increase in temperature, up to a maximum of 40 °C, have been accommodated in the values in Table M.1.

In case of use of gas recombination vent plugs, the gas producing current I_{gas} the values for vented cells can be reduced to 50 % of the values for vented **cells**.

The ventilation air volume requirements, for example, for two 48 V strings of VRLA **cells** in the same **battery** cabinet and each with 120 Ah rated C_{10} capacity amount, under float and under boost charge service conditions are:

– service with float charge condition only: Q = 0,05 × 24 × 1 × 120 × 0,001 = 0,144 m^3/h per string or 288 l/h total;

– service with boost charge condition: Q = 0,05 × 24 × 8 × 120 × 0,001 = 1,15 m^3/h per string or 2 300 l/h total.

*For recombinant NiCd cells, or for lead-acid **battery** types where the gassing rate in volts per cell per hour (per ampere-hour) is published by the manufacturer, it is permitted to determine the minimum air flow rate Q using the measure gas emissions at boost-charge volts per cell charging, unless it can be verified that the output voltage of the charging circuit cannot exceed the float voltage under any conditions required by this document. The equation for Q becomes:*

$$Q = v \times s \times n \times r\ (\times C_{rt}) \times 10^{-3}\ (m^3/h)$$

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where:

v = 24, *the necessary dilution of hydrogen:*

s = 5, *general safety factor;*

n *is the number of* ***cells****;*

r *is the outgassing rate at a given voltage per cell per hour (may be per ampere-hour rating);*

C_{rt} *is the capacity* C_{10} *for lead acid* ***cells*** *(Ah) or capacity* C_5 *for NiCd* ***cells*** *(Ah).*

NOTE C_{rt} is not required for determining Q if the gassing rate r is provided in ml/(h-***cell***) or the equivalent.

For the purpose of calculating the area of ventilation openings required for natural ventilation, the air velocity is assumed to be 0,1 m/s.

Alternately, the following equation can be used:

$$A = 28 \times Q$$

where:

Q *is the ventilation rate of fresh air* (m^3/h);

A *is the free area of openings in air inlet and outlet* (cm^2).

M.7.3 Ventilation tests

M.7.3.1 General

The test shall be performed with the EUT stabilized at 25 °C. If forced air ventilation is used, it shall be run under ***single fault conditions****. Movable mechanical or electro-mechanical dampers shall be closed or in the unpowered position. The air movement around the cabinet shall be minimized, or the EUT shall be placed in a cabinet to prevent air movement around the EUT during testing.*

M.7.3.2 Ventilation test – alternative 1

Samples of the atmosphere within the ***battery*** *compartment are to be taken after 7 h of operation. The samples are to be taken at locations where the greatest concentration of hydrogen gas is likely. The hydrogen gas concentration shall not exceed 1 % by volume if the mixture is in proximity to an ignition source, and not exceed 2 % by volume if the mixture is not in proximity to an ignition source. See M.3.2 for evaluating the overcharging of a rechargeable* ***battery****.*

M.7.3.3 Ventilation test – alternative 2

The performance of the EUT ***battery*** *ventilation system shall be verified by conducting a test utilizing hydrogen, or helium to represent hydrogen.*

The test will determine if the EUT is capable of ventilating the calculated hydrogen generation rate.

Step 1 *Helium or hydrogen sensors (depending on the chosen gas) shall be placed in all cabinet compartments that are subjected to hydrogen evolution from the* ***battery*** *compartment.*

Step 2 *Helium or hydrogen shall be injected into the* ***battery*** *compartment until a concentration of 1 % or 2 % as required below is reached. The rate of helium or hydrogen injection required to maintain the concentration under steady state conditions shall be reported. Steady state shall be defined as a maximum variation of ± 0,25 % over a period of 1 h.*

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Step 3 Compare the rate of helium or hydrogen obtained in Step 2 with the calculated hydrogen generation rate in M.7.1.

*If the calculated hydrogen generation rate for the maximum **battery** capacity as specified by the manufacturer exceeds the amount of helium or hydrogen that was being injected by more than 1 % by volume if the mixture is in proximity to an ignition source, or exceeds 2 % by volume if the mixture is not in proximity to an ignition source, the EUT compartment ventilation system is not in compliance with this requirement.*

*If the calculated hydrogen generation rate, for the maximum **battery** capacity as specified by the manufacturer, is less than or equal to the rate of helium or hydrogen that was being injected, the EUT compartment ventilation system is in compliance with this requirement.*

M.7.3.4 Ventilation test – alternative 3

*The test shall be performed as described in M.7.3.1 with a hydrogen or helium source used to inject a flow rate described in M.7.1. Samples of the atmosphere within the **battery** compartment or other area where hydrogen may accumulate is continuously monitored for 7 h or until the levels are stable. Steady state shall be defined as a maximum variation of ±0,25 % over a period of 1 h. The gas monitored in this manner is to be returned to the EUT under test. The hydrogen gas concentration shall not exceed 1 % by volume if the mixture is in proximity to an ignition source, and not exceed 2 % by volume if the mixture is not in proximity to an ignition source. The sampling method in the original test may also be used, however, if hydrogen is used, care should be taken to establish that safe levels exist in the EUT prior to injecting for 7 h.*

NOTE This method is particularly suited to evaluating mixed or complex systems or ventilation patterns.

M.7.4 Marking requirement

Unless the **batteries** are provided with the equipment, the compartment shall be marked either with the supported **battery** types and the maximum capacities or “Use only batteries approved by the manufacturer”, provided that this information is specified in the installation/service instructions.

M.8 Protection against internal ignition from external spark sources of batteries with aqueous electrolyte

M.8.1 General

The requirements specified below apply to rechargeable **batteries** providing a venting system.

NOTE For example, a **battery** used in a UPS.

The level of air ventilation rate shall ensure that a risk of **explosion** does not exist by keeping the hydrogen content in air below 1 $\%_{vol}$ at the **PIS**.

The use of an effective flame arrester in the **battery** venting system will prevent an external **explosion** propagating into the **battery**.

Clause M.8 is applied for open type **batteries** and valve regulated type **batteries**. Sealed type **batteries** with a mechanism of reducing gas are considered to comply with this requirement.

M.8.2 Test method

M.8.2.1 General

The test shall be carried out according to IEC 60896-21:2004, 6.4.

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NOTE 1 This test is designed to reveal the protection afforded by the valve unit against the ignition of the gases within a **cell** by an external ignition source. During this test, use proper precautions to **safeguard** persons and equipment from **explosion** and burns.

A minimum distance d extending through air shall be maintained within which a maximum surface temperature of 300 °C shall not be exceeded (no flames, sparks, arcs or glowing devices).

NOTE 2 When calculating the minimum distance d to protect against **explosion** in close proximity to the source of release of a **cell** or **battery**, the dilution of **explosive** gases is not always ensured. The dispersion of **explosive** gas depends on the gas release rate and the ventilation characteristics close to the source of release.

*The minimum distance d can be estimated by calculating the dimensions of a hypothetical volume V_z of potentially **explosive** gas around the source of release, outside of which the concentration of hydrogen is below the safe concentration of the LEL.*

$$d = 28{,}8 \times \sqrt[3]{I_{gas}} \times \sqrt[3]{C_{rt}} \quad [\text{mm}]$$

where:

I_{gas} *is the current producing gas [mA / Ah];*

C_{rt} *is the rated capacity [Ah].*

NOTE 3 The required distance d can be achieved by the use of a partition wall between the **battery** and sparking device.

*Where **batteries** form an integral part of a power supply system (for example, in a UPS system), the distance d, where d is the minimum distance (**clearance**) between the ventile of the **battery** and the electronic equipment that may exhibit flames, sparks, arcs or glowing devices (maximum surface temperature 300 °C), may be reduced according to the equipment manufacturer's calculations or measurements. The level of air ventilation rate should ensure that a risk of **explosion** does not exist by keeping the hydrogen content in air below 1 $\%_{vol}$ plus a margin at the **PIS.***

M.8.2.2 Estimation of hypothetical volume V_z

The theoretical minimum ventilation flow rate to dilute the flammable gas (hydrogen) to a concentration below the LEL can be calculated by means of the formula:

$$\left(\frac{dV}{dt}\right)_{min} = \frac{(dG/dt)_{max}}{k \times \text{LEL}} \times \frac{T}{293}$$

where:

dV/dt_{min} is the minimum volumetric flow rate of fresh air required to dilute the gas (m^3/s);

dG/dt_{max} is the maximum gas release rate (kg/s);

LEL is 4 $\%_{vol}$ for hydrogen (kg/m^3);

k is the factor applied to the LEL; k = 0,25 is chosen for dilution of hydrogen gas;

T is the ambient temperature in kelvin (293 K = 20 °C).

The volume V_z represents the volume over which the mean concentration of flammable gas will be 0,25 times the LEL. This means that at the extremities of the hypothetical volume, the concentration of gas will be significantly below the LEL (for example, the hypothetical volume where the concentration is above LEL would be less than V_z).

NOTE See B.4.2.2 in IEC 60079-10:2002 for the calculation of LEL.

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M.8.2.3 Correction factors

With a given number of air changes per unit time, c, related to the general ventilation the hypothetical volume V_z of potentially **explosive** atmosphere around the source of release can be estimated as follows:

$$V_z = \left(\frac{dV}{dt}\right)_{min} / \ c$$

where c is the number of fresh air changes per unit time (s^{-1}).

The above formula holds for an instantaneous and homogenous mixing at the source of release given ideal flow conditions of fresh air. In practice, ideal conditions rarely exist. Therefore a correction factor f is introduced to denote the effectiveness of the ventilation.

$$V_z = f \times \left(\frac{dV}{dt}\right)_{min} / \ c$$

where f is the ventilation effectiveness factor, denoting the efficiency of the ventilation in terms of its effectiveness in diluting the **explosive** atmosphere, f ranging from 1 (ideal) to typically 5 (impeded air flow). For **battery** installations the ventilation effectiveness factor is f = 1,25.

M.8.2.4 Calculation of distance d

The term $\left(\frac{dV}{dt}\right)_{min}$ including all factors corresponds with the hourly ventilation air flow Q (in m^3/h) for secondary **batteries** calculated under

$$Q = f \times \left(\frac{dV}{dt}\right)$$

$$Q = 0{,}05 \times (N) \times I_{gas} \times C_{rt} \times 10^{-3} \quad [m^3/h]$$

This hourly ventilation air flow Q can be used to define a hypothetical volume. Assuming a hemispherical dispersal of gas, a volume of a hemisphere V_z = 2/3 π d^3 can be defined, where d is the distance from the source of release.

This results in the calculation formula for the distance d, with c = 1 air change per hour within the hemisphere:

$$d^3 = \frac{3}{2\pi} \times 0{,}05 \times 10^6 \times (N) \times I_{gas} \times C_{rt} \quad [mm^3]$$

$$d = 28{,}8 \times \left(\sqrt[3]{N}\right) \times \sqrt[3]{I_{gas}} \times \sqrt[3]{C_{rt}} \quad [mm]$$

Depending on the source of gas release, the number of **cells** per monobloc **battery** (N) or vent openings per **cell** involved ($1/N$) shall be taken into consideration (for example, by the factor $\sqrt[3]{N}$, respectively $\sqrt[3]{1/N}$).

The distance d as a function of the rated capacity for various charge currents I (mA/Ah) is shown in Figure M.1.

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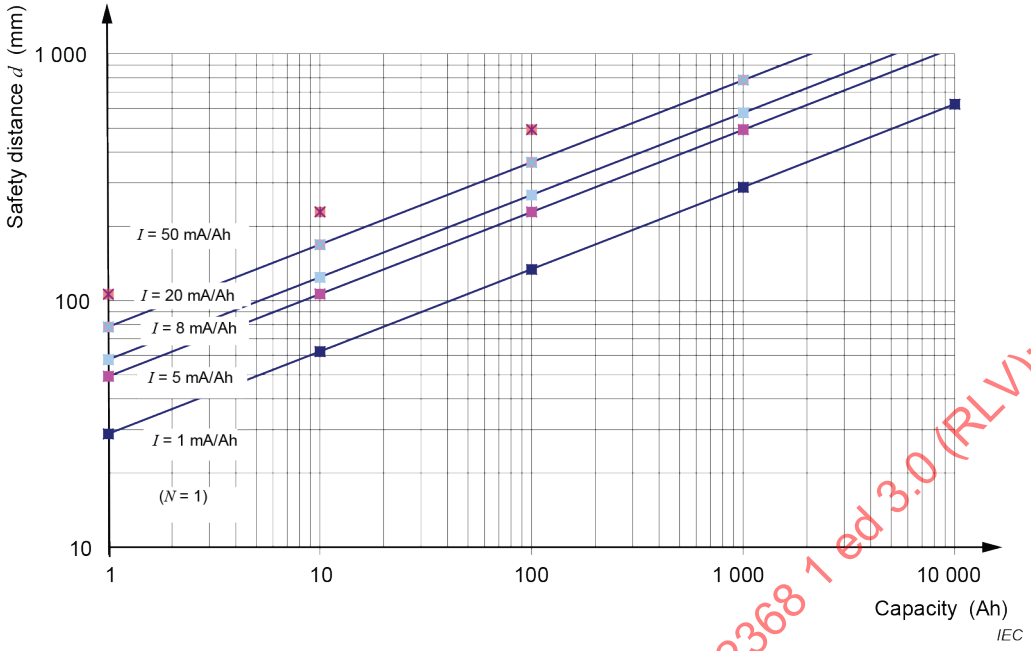


Figure M.1 – Distance d as a function of the rated capacity for various charge currents I (mA/Ah)

M.9 Preventing electrolyte spillage

M.9.1 Protection from electrolyte spillage

Equipment shall be constructed so that spillage of electrolyte from **batteries**, that may have an adverse effect on skin, eye and other human body parts, other **safeguards** or the premises, is unlikely. All possible operating modes during maintenance should be taken into account, including replacement of the **battery** and refilling of consumed material.

Compliance is checked by inspection.

M.9.2 Tray for preventing electrolyte spillage

If **cell** failure could result in the spillage of electrolyte, the spillage shall be contained (for example, by use of a retaining tray adequate to contain the electrolyte) taking into account the maximum possible spillage amount.

This requirement is applicable to **stationary equipment** and does not apply if the construction of the **battery** is such that leakage of the electrolyte from the **battery** is unlikely, or if spillage of electrolyte does not adversely affect required insulation.

NOTE An example of a **battery** construction where leakage of the electrolyte is considered to be unlikely is the sealed **cell** valve-regulated type.

Compliance is checked by inspection.

M.10 Instructions to prevent reasonably foreseeable misuse

A **battery** incorporated in the equipment and a **battery** together with its associated components (including **cells** and electric power generators) shall be so constructed that an electric shock or fire **safeguard** failure (for example, flammable chemical leakage causing fire

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or insulation damage) is unlikely, taking all reasonably foreseeable conditions into account. If applicable, this shall include extreme conditions as specified by the manufacturer, such as:

– high or low extreme temperatures that a **battery** can be subjected to during use, storage or transportation; and

– low air pressure at high altitude.

Where providing safety devices or design in a **battery** or equipment is not reasonably practical considering the functional nature of the **battery** or equipment containing a **battery**, **instructional safeguards** in accordance with Clause F.5 shall be provided to protect the **battery** from extreme conditions or user's abuse. Examples that shall be considered include:

– replacement of a **battery** with an incorrect type that can defeat a **safeguard** (for example, in the case of some lithium **battery** types);

– disposal of a **battery** into fire or a hot oven, or mechanically crushing or cutting of a **battery**, that can result in an **explosion**;

– leaving a **battery** in an extremely high temperature surrounding environment that can result in an **explosion** or the leakage of flammable liquid or gas; and

– a **battery** subjected to extremely low air pressure that may result in an **explosion** or the leakage of flammable liquid or gas.

For equipment containing a **battery** that is replaceable by an **ordinary person**, an **instructional safeguard** shall be provided in accordance with Clause F.5, except that the complete **instructional safeguard** may be provided in the instructions.

The elements of the **instructional safeguard** shall be as follows:

– elements 1a or 1b: not required

– element 2: "CAUTION" or equivalent word or text

– element 3: "Risk of fire or explosion if the battery is replaced by an incorrect type" or equivalent text

– element 4: optional

Compliance is checked by inspection or by evaluation of available data provided by the manufacturer~~, and, if required, by **abnormal operating condition** tests according to B.3.6 considering all possible installation, transportation and use conditions~~.

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Annex N
(normative)

Electrochemical potentials (V)

Magnesium, magnesium alloys	Zinc, zinc alloys	80 tin/20 zinc on steel, zinc on iron or steel l	Aluminium	Cadmium on steel	Aluminium/magnesium alloy	Mild steel	Duralumin	Lead	Chromium on steel, soft solder	Cr on Ni on steel, tin on steel, 12 % Cr stainless steel	High chromium stainless steel	Copper, copper alloys	Silver solder, austenitic stainless steel	Nickel on steel	Silver	Rhodium on silver on copper, silver/gold alloy	Carbon	Gold, platinum	
0	0,5	0,55	0,7	0,8	0,85	0,9	1,0	1,05	1,1	1,15	1,25	1,35	1,4	1,45	1,6	1,65	1,7	1,75	Magnesium, magnesium alloys
	0	0,05	0,2	0,3	0,35	0,4	0,5	0,55	0,6	0,65	0,75	0,85	0,9	0,95	1,1	1,15	1,2	1,25	Zinc, zinc alloys
		0	0,15	0,25	0,3	0,35	0,45	0,5	0,55	0,6	0,7	0,8	0,85	0,9	1,05	1,1	1,15	1,2	80 tin/20 zinc on steel, zinc on iron or steel
			0	0,1	0,15	0,2	0,3	0,35	0,4	0,45	0,55	0,65	0,7	0,75	0,9	0,95	1,0	1,05	Aluminium
				0	0,05	0,1	0,2	0,25	0,3	0,35	0,45	0,55	0,6	0,65	0,8	0,85	0,9	0,95	Cadmium on steel
					0	0,05	0,15	0,2	0,25	0,3	0,4	0,5	0,55	0,6	0,75	0,8	0,85	0,9	Aluminium/magnesium alloy
						0	0,1	0,15	0,2	0,25	0,35	0,45	0,5	0,55	0,7	0,75	0,8	0,85	Mild steel
							0	0,05	0,1	0,15	0,25	0,35	0,4	0,45	0,6	0,65	0,7	0,75	Duralumin
								0	0,05	0,1	0,2	0,3	0,35	0,4	0,55	0,6	0,66	0,7	Lead
									0	0,05	0,15	0,25	0,3	0,35	0,5	0,55	0,6	0,65	Chromium on steel, soft solder
Cr = Chromium Ni = Nickel										0	0,1	0,2	0,25	0,3	0,45	0,5	0,55	0,6	Cr on Ni on steel, tin on steel, 12 % Cr stainless steel
											0	0,1	0,15	0,2	0,35	0,4	0,45	0,5	High chromium stainless steel
												0	0,05	0,1	0,25	0,3	0,35	0,4	Copper, copper alloys
													0	0,05	0,2	0,25	0,3	0,35	Silver solder, austenitic stainless steel
														0	0,15	0,2	0,25	0,3	Nickel on steel
															0	0,05	0,1	0,15	Silver
																0	0,05	0,1	Rhodium on silver on copper, silver/gold alloy
																	0	0,05	Carbon
																		0	Gold, platinum

Corrosion due to electrochemical action between dissimilar metals that are in contact is minimized if the combined electrochemical potential is below about 0,6 V. In the table the combined electrochemical potentials are listed for a number of pairs of metals in common use; combinations above the dividing line should be avoided.

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Annex O
(normative)

Measurement of creepage distances and clearances

In the following Figures O.1 to ~~O.20~~ O.16, the value of X is given in Table O.1. Where the distance shown is less than X, the depth of the gap or groove is disregarded when measuring a **creepage distance**.

If the required minimum **clearance** is more than 3 mm, the value of X is given in Table O.1.

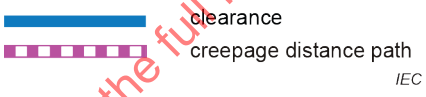
If the required minimum **clearance** is less than 3 mm, the value of X is the smaller of:

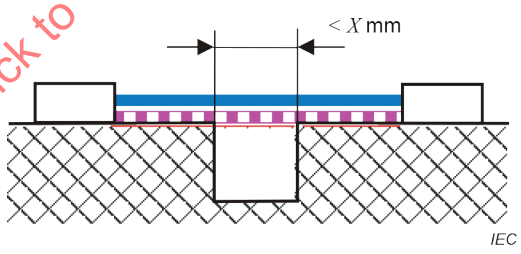
– the relevant value in Table O.1; or
– one third of the required minimum **clearance**.

Table O.1 – Value of X

Pollution degree (see 5.4.1.5)	X mm
1	0,25
2	1,00
3	1,50

NOTE Throughout this annex, the following convention is used:



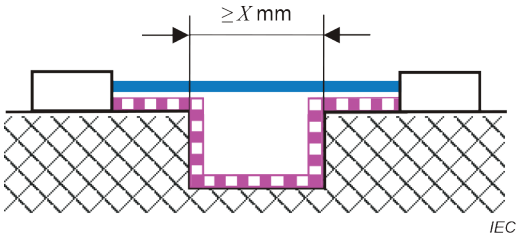


Condition: Path under consideration includes a parallel or converging-sided groove of any depth with width less than X mm.

Rule: **Creepage distance** and **clearance** are measured directly across the groove.

Figure O.1 – Narrow groove

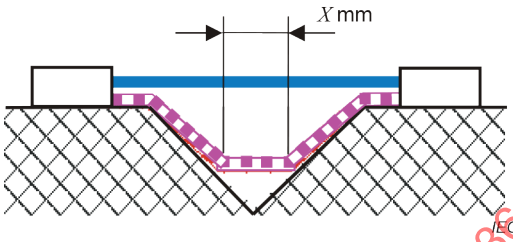
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Condition: Path under consideration includes a parallel-sided groove of any depth, and equal to or more than X mm wide.

Rule: **Clearance** is the "line of sight" distance. **Creepage distance** path follows the contour of the groove.

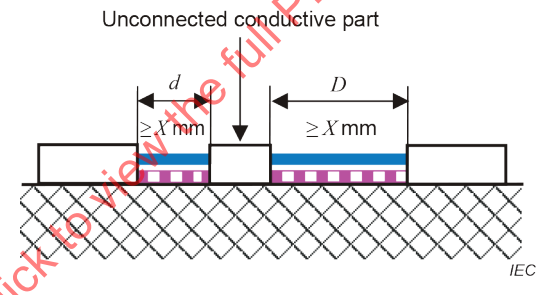
Figure O.2 – Wide groove



Condition: Path under consideration includes a V-shaped groove with an internal angle of less than 80° and a width greater than X mm.

Rule: **Clearance** is the "line of sight" distance. **Creepage distance** path follows the contour of the groove but "short-circuits" the bottom of the groove by X mm link.

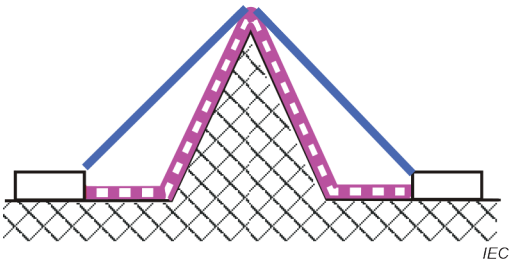
Figure O.3 – V-shaped groove



Condition: Insulation distance with intervening, unconnected conductive part.

Rule: **Clearance** is the distance $d + D$, **creepage distance** is also $d + D$. Where the value of d or D is smaller than X mm it shall be considered as zero.

Figure O.4 – Intervening unconnected conductive part

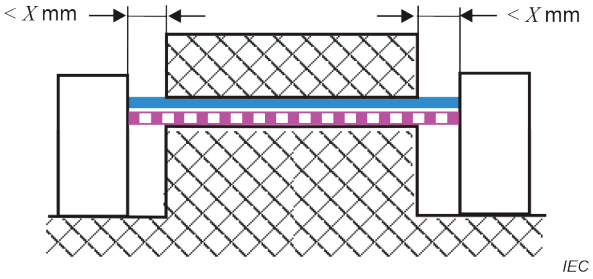


Condition: Path under consideration includes a rib.

Rule: **Clearance** is the shortest direct air path over the top of the rib. **Creepage distance** path follows the contour of the rib.

Figure O.5 – Rib

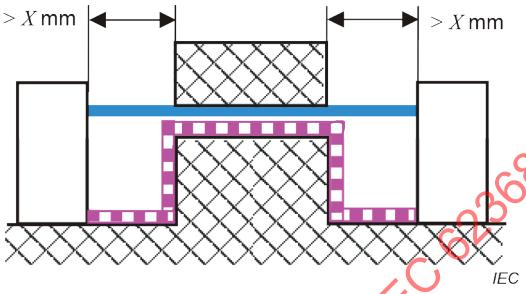
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Condition: Path under consideration includes an uncemented joint with grooves less than X mm wide on either side.

Rule: **Clearance** and **creepage distance** path is the "line of sight" distance shown.

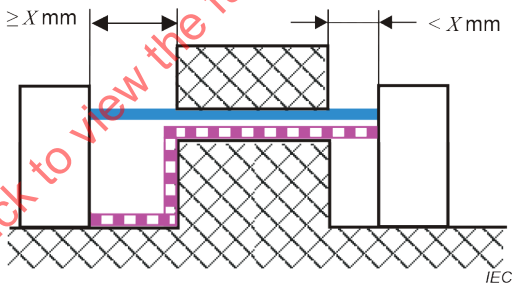
Figure O.6 – Uncemented joint with narrow groove



Condition: Path under consideration includes an uncemented joint with a groove equal to or more than X mm wide each side.

Rule: **Clearance** is the "line of sight" distance. **Creepage distance** path follows the contour of the groove.

Figure O.7 – Uncemented joint with wide groove

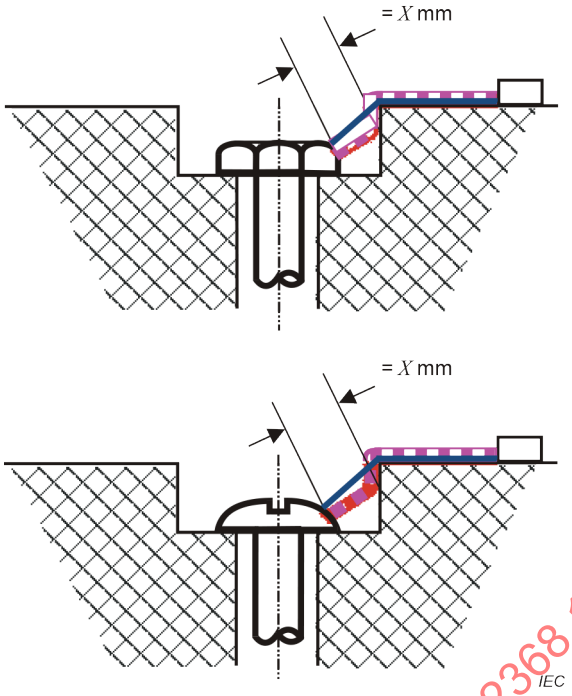


Condition: Path under consideration includes an uncemented joint with grooves on one side less than X mm wide, and a groove on the other equal to or more than X mm wide.

Rule: **Clearance** and **creepage distance** path are as shown.

Figure O.8 – Uncemented joint with narrow and wide grooves

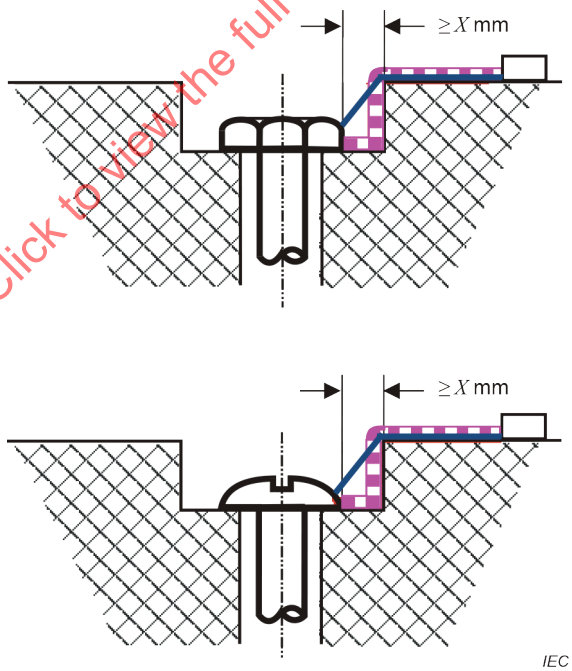
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Gap between head of screw and wall of recess too narrow to be taken into account.

Where the gap between the head of the screw and the wall of recess is smaller than X mm, the measurement of **creepage distance** is made from the screw to the wall at the place where the distance is equal to X mm.

Figure O.9 – Narrow recess



Gap between head of screw and wall of recess wide enough to be taken into account.

Figure O.10 – Wide recess

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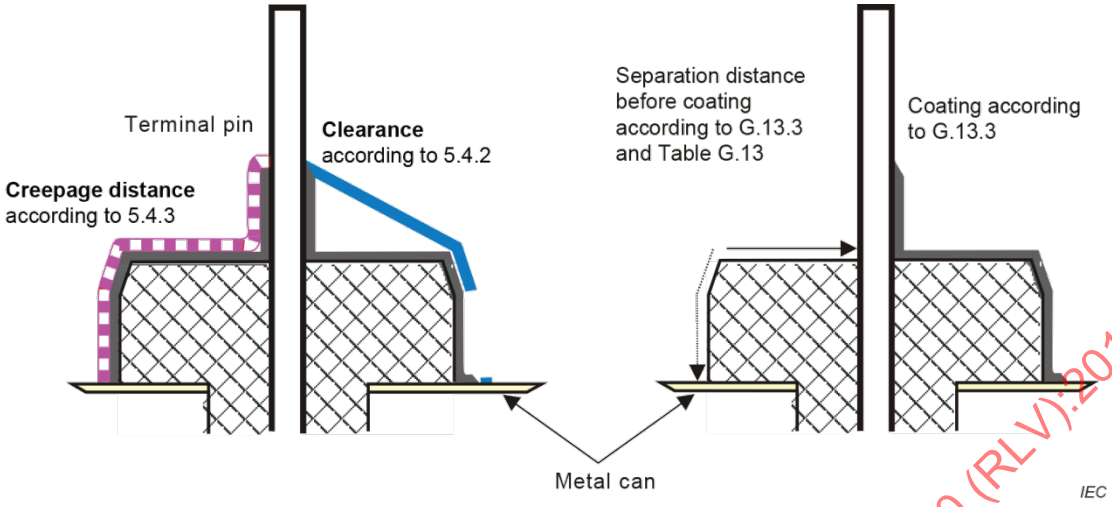


Figure O.11 – Coating around terminals

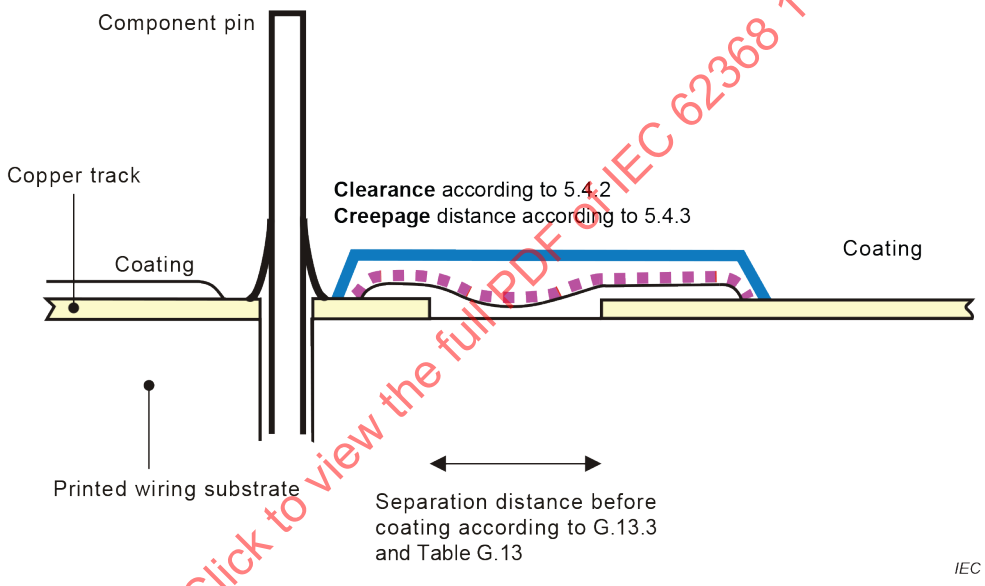


Figure O.12 – Coating over printed wiring

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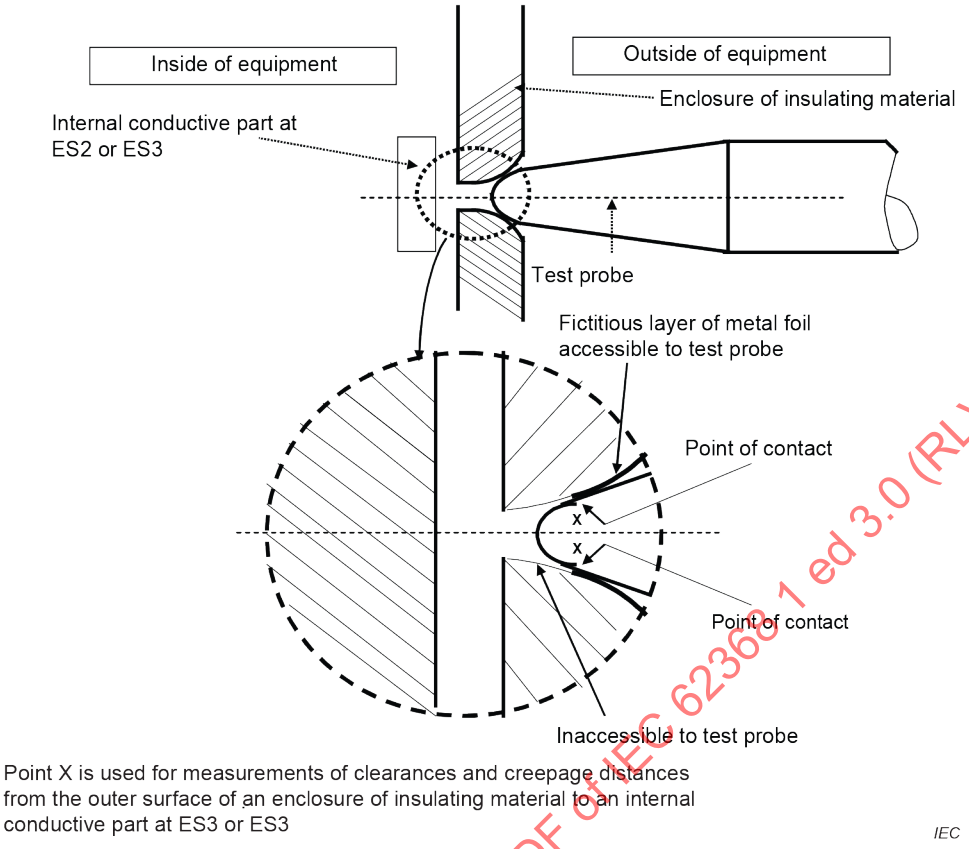


Figure O.13 – Example of measurements in an enclosure of insulating material

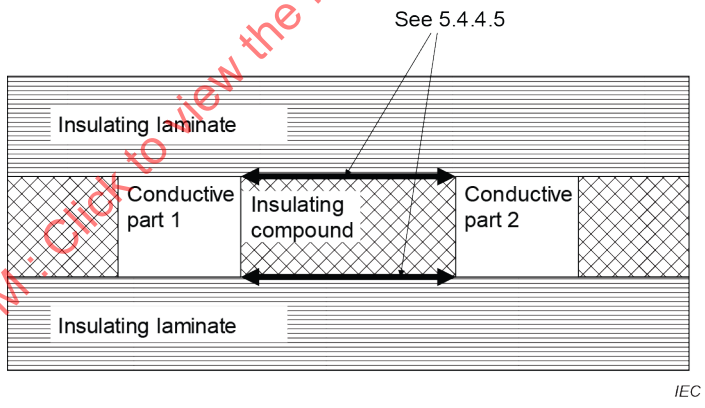


Figure O.14 – Cemented joints in multi-layer printed boards

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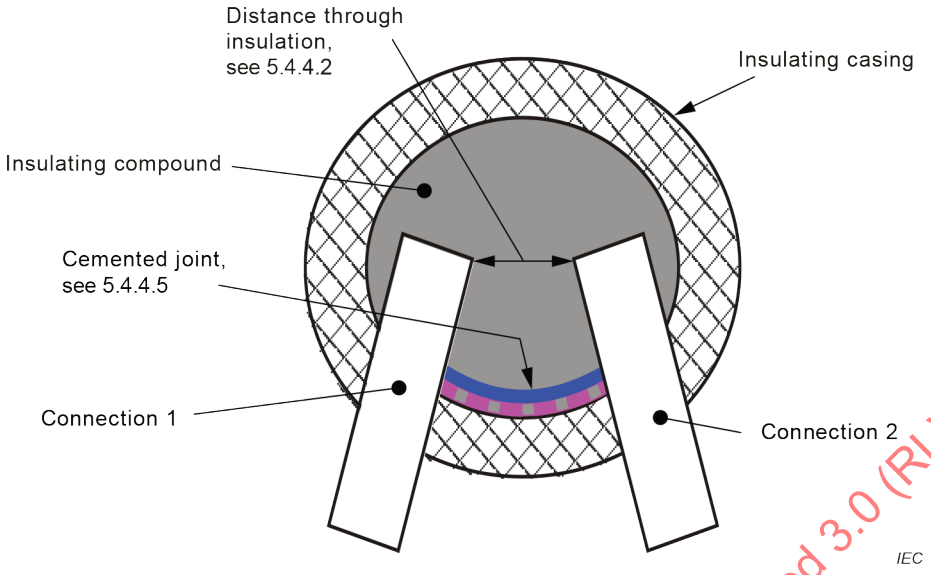


Figure O.15 – Device filled with insulating compound

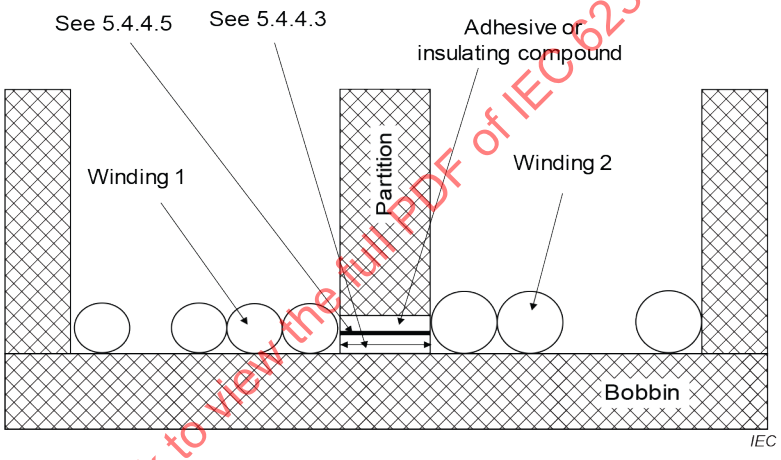
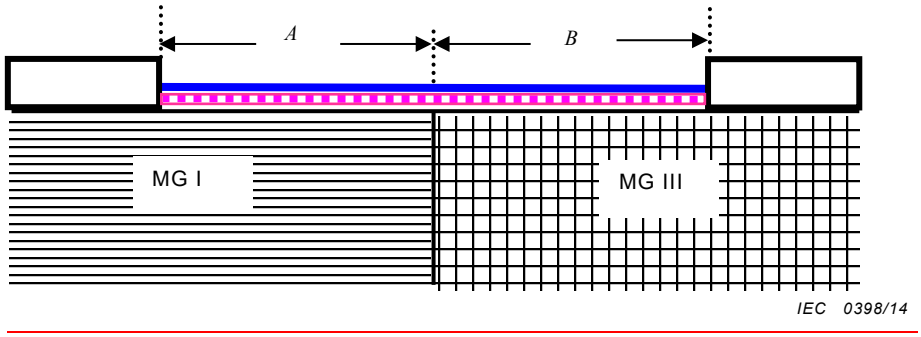


Figure O.16 – Partitioned bobbin

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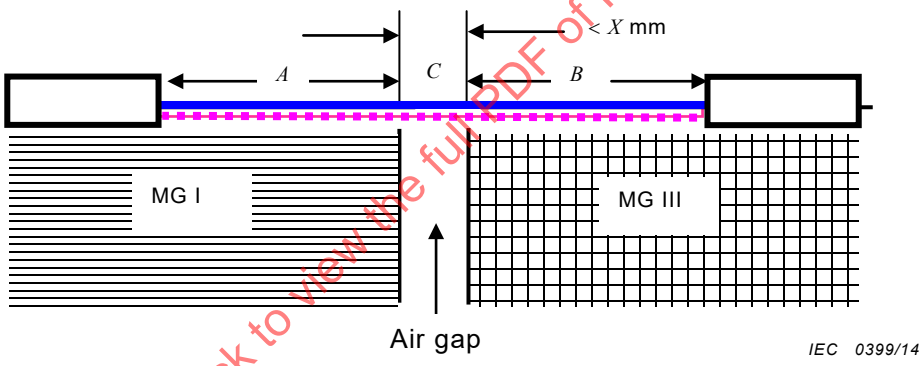
Condition: Path under consideration is along two materials having different CTI values.

Condition: Path under consideration is along two materials having different CTI values.

Rule: **Creepage distance** is calculated as follows:

$$\frac{A}{\text{Required creepage for MG I}} + \frac{B}{\text{Required creepage for MG III}} \geq 1$$

Figure O.17 – Materials with different CTI values



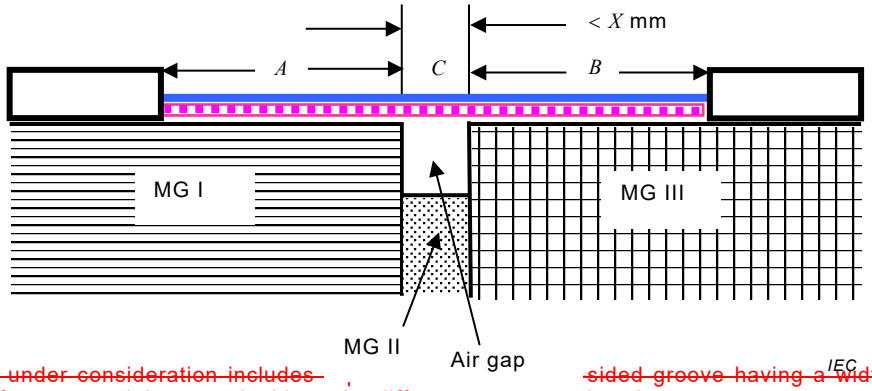
Condition: Path under consideration includes a parallel or converging sided air gap having a width of less than X mm and two different materials on each side.

Rule: **Creepage distance** is calculated as follows:

$$\frac{A}{\text{Required creepage for MG I}} + \frac{B + C}{\text{Required creepage for MG III}} \geq 1$$

Figure O.18 – Materials with different CTI values having an air gap of less than X mm

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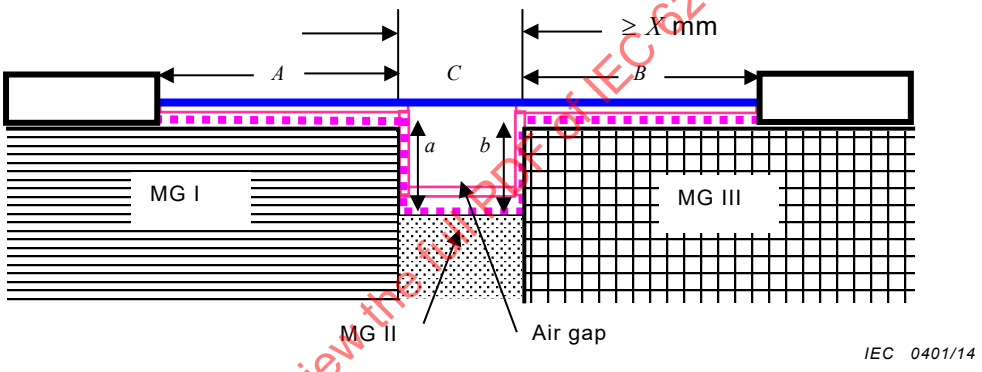


Condition: Path under consideration includes a sided groove having a width of less than *X* mm and two different materials on each side and a different material below the groove.

Rule: **Creepage distance** is calculated as follows:

$$\frac{A}{\text{Required creepage for MG I}} + \frac{B + C}{\text{Required creepage for MG III}} \geq 1$$

Figure O.19 – Materials with different CTI values having an air groove of less than *X* mm



Condition: Path under consideration includes a parallel or converging sided groove having a width greater than or equal to *X* mm and two different materials on each side and a different material below the groove.

Rule: **Creepage distance** is calculated as follows:

$$\frac{A + a}{\text{Required creepage for MG I}} + \frac{C}{\text{Required creepage for MG II}} + \frac{B + b}{\text{Required creepage for MG III}} \geq 1$$

Figure O.20 – Materials with different CTI values having an air groove not smaller than *X* mm

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Annex P
(normative)

Safeguards against conductive objects

P.1 General

This annex specifies **safeguards** to reduce the likelihood of fire, electric shock and adverse chemical reaction due to the entry of objects through top or side openings in the equipment, or due to spillage of internal liquids, or the failure of metallized coatings and adhesives securing conductive parts inside the equipment.

The **basic safeguard** against entry of a foreign object is that persons are not expected to insert a foreign object into the equipment. The **safeguards** specified in this annex are **supplementary safeguards**.

This annex does not apply to openings that are parts of connectors.

For equipment intended, according to the manufacturer's instructions, to be used in more than one orientation, the **safeguards** shall be effective for each such orientation.

For **transportable equipment**, the **safeguards** shall be effective for all orientations.

NOTE The examples of Figure P.1, Figure P.2 and Figure P.3 are not intended to be used as engineering drawings but are only shown to illustrate the intent of these requirements.

P.2 Safeguards against entry or consequences of entry of a foreign object

P.2.1 General

Equipment shall comply with the requirements of P.2.2 or with the requirements of P.2.3.

P.2.2 Safeguards against entry of a foreign object

Openings in the top and sides of an **accessible enclosure** shall be so located or constructed to reduce the likelihood that a foreign object will enter the openings.

Equipment openings shall comply with the requirements specified below when the doors, panels, and covers, etc., are closed or in place. These requirements do not apply to openings located behind doors, panels, covers, etc., even if they can be opened or removed by an **ordinary person**.

Any one of the following constructions are considered to comply:

– openings that do not exceed 5 mm in any dimension;
– openings that do not exceed 1 mm in width regardless of length;
– openings that meet the requirements of IP3X ~~or IP4X~~;
– top openings in which vertical entry is prevented (see Figure P.1 for examples);
– side openings provided with louvres that are shaped to deflect outwards an external vertically falling object (see Figure P.2 for examples);
– side openings without louvres where the **enclosure** thickness at the opening is not less than the vertical dimension of the opening.

Compliance is checked by inspection or measurement.

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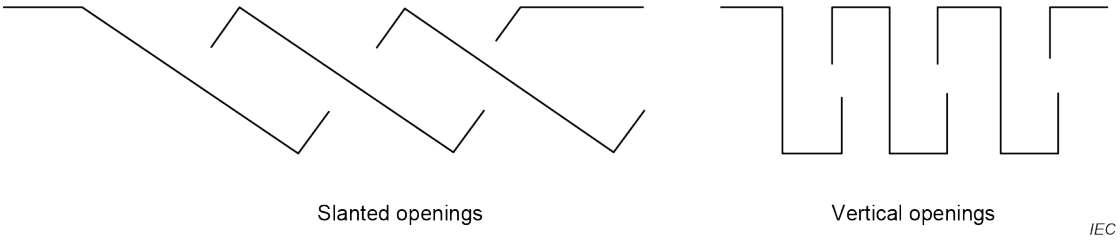


Figure P.1 – Examples of cross-sections of designs of top openings which prevent vertical entry

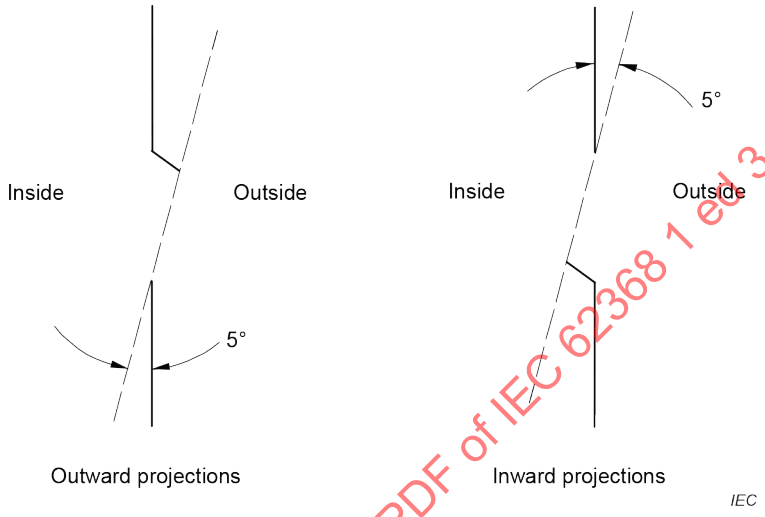


Figure P.2 – Examples of cross-sections of designs of side opening louvres which prevent vertical entry

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P.2.3 Safeguards against the consequences of entry of a foreign object

P.2.3.1 Safeguard requirements

The entry of a foreign object shall not defeat an **equipment supplementary safeguard** or an **equipment reinforced safeguard**. Furthermore, the object shall not create a **PIS**.

Safeguards against the consequences of entry of foreign objects include the following:

– an internal barrier that prevents a foreign object from defeating an **equipment safeguard** or creating a **PIS**;

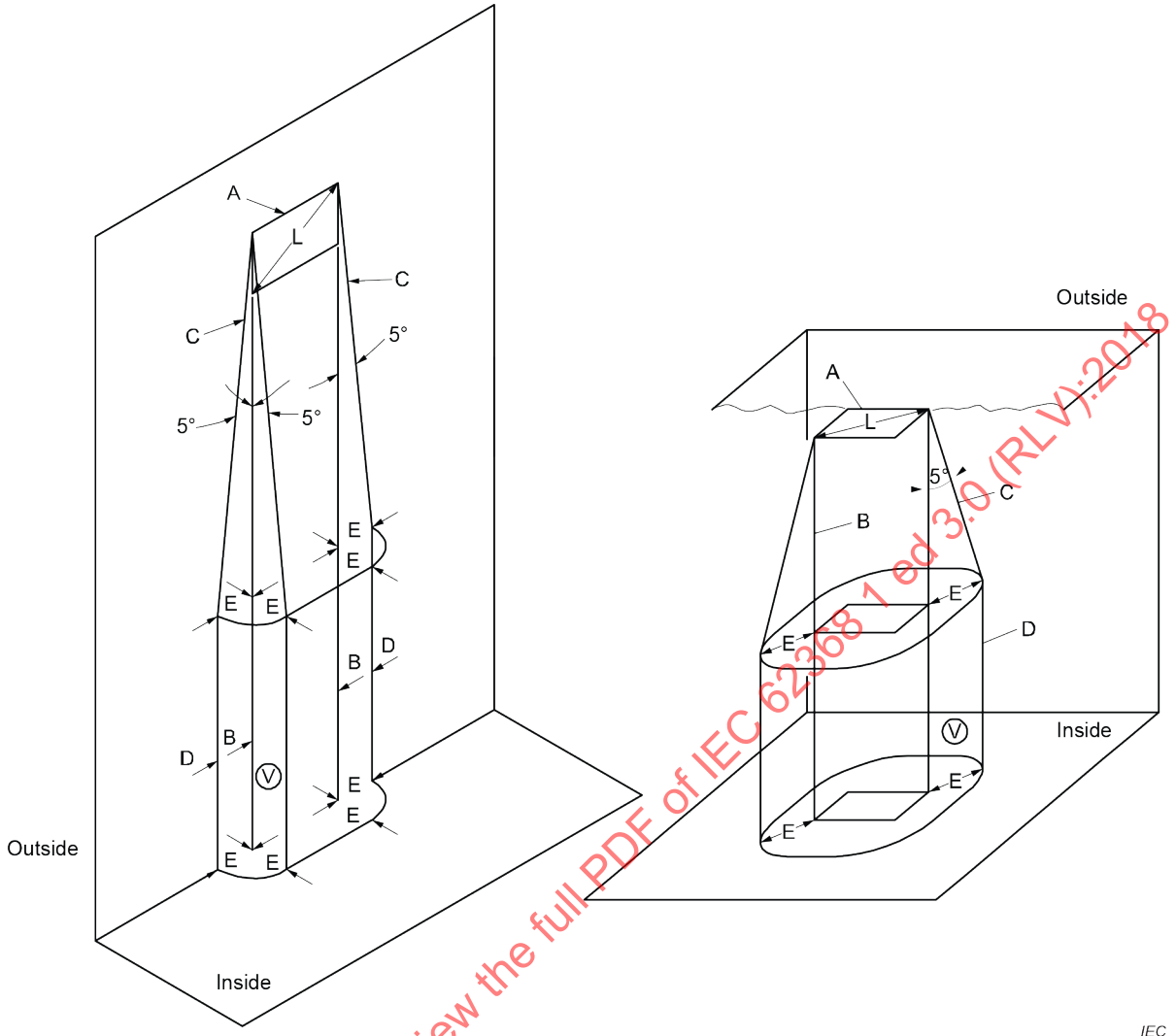
– within the projected volume as depicted in Figure P.3 there are

- no bare conductive parts of a **safeguard**, or
- no **PIS**, or
- no bare conductive parts of ES3 or PS3 circuits, or
- only conductive parts covered with conformal or other similar coatings;

NOTE 1 Conductive parts covered with conformal or other similar coatings are not considered to be bare conductive parts. A conformal coating is a dielectric material deposited on a printed circuit board and components in order to protect them against moisture, dust, corrosion and other environmental stresses.

– within the projected volume as depicted in Figure P.3, bare conductive parts at ES3 or PS3 subjected to the tests of P.2.3.2.

Other constructions shall be subject to the test of P.2.3.2.



Key

A **enclosure** opening

B vertical projection of the outer edges of the opening

C inclined lines that project at a 5° angle from the edges of the opening to points located E distance from B

D line that is projected straight downward in the same plane as the **enclosure** side wall

E projection of the outer edge of the opening (B) and the inclined line (C) (not to be greater than L)

L maximum dimension of the **enclosure** opening

V projected (keep-out) volume for **supplementary** **safeguards** or **reinforced safeguards**

Figure P.3 – Internal volume locus for foreign object entry

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For **transportable equipment**, if the design does not prevent the entry of a foreign object, the object is considered to move to any place within the equipment. The ES3 and PS3 keep-out volume in Figure P.3 is not applicable to **transportable equipment**.

For **transportable equipment** with metallized plastic parts and the like, if the design does not prevent the entry of a foreign object, the distance between the metallized parts and all bare conductive parts of ES3 or PS3 shall be at least 13 mm. Alternatively, the metallized parts and the bare conductive parts shall be tested by shorting.

NOTE 2 Examples of metallized barriers or metallized **enclosures** include those made of conductive composite materials or materials that are electroplated, vacuum-deposited, foil lined or painted with metallic paint.

Compliance is checked by inspection, measurement, and where necessary by the test of P.2.3.2.

P.2.3.2 Consequence of entry test

An attempt shall be made to short all bare conductive parts of ES3 or PS3 within volume V, Figure P.3, along a direct straight path to all other bare conductive parts and to all metallized parts within a 13 mm radius. The attempt of shorting is made by means of a straight metal object, 1 mm in diameter and having any length up to 13 mm, applied without appreciable force.

*For **transportable equipment**, the attempt of shorting shall be at all places where the foreign object could lodge.*

*During and after the tests, all **supplementary safeguards** and **reinforced safeguards** shall be effective, and no part shall become a **PIS**.*

P.3 Safeguards against spillage of internal liquids

P.3.1 General

The requirements specified below apply to equipment with internal liquids where that liquid may defeat any **equipment safeguard**.

These requirements do not apply to:

– liquids that are non-conductive, non-flammable, non-toxic, and non-corrosive, and are not in a pressurized container;

– electrolytic capacitors;

– liquids with viscosity of 1 Pa s or more; and

– **batteries** (see Annex M).

NOTE Viscosity of 1 Pa s is approximately equivalent to 60 weight motor oil.

P.3.2 Determination of spillage consequences

If the equipment is not **transportable equipment**, the equipment shall be energized, and the liquid shall be allowed to leak from piping connectors and similar joints in the liquid system.

If the equipment is **transportable equipment**, then, following introduction of the leak, the equipment shall be moved to all possible positions and then energized.

P.3.3 Spillage safeguards

If the spillage may result in a **single fault condition** not covered by Clause B.4, then:

– the vessel serving as a **basic safeguard** shall allow no spillage under **normal operating conditions**, and the **supplementary safeguard** (for example, a barrier or drip pan or supplementary containment vessel, etc.) shall effectively limit the spread of the spillage; or

– the liquid shall be contained in a vessel comprising a **reinforced safeguard**; or

– the containment vessel **safeguard** shall comprise a **double safeguard** or a **reinforced safeguard**.

If the liquid is conductive, flammable, toxic, or corrosive, then:

– the liquid shall be contained in a **double safeguard** or a **reinforced safeguard**; or

– following the spillage:

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- a toxic liquid shall not be **accessible** to **ordinary persons** or **instructed persons**, and
- a conductive liquid shall not bridge a **basic insulation**, a **supplementary insulation** or a **reinforced insulation**, and
- a flammable liquid (or its vapour) shall not contact any **PIS** or parts at a temperature that may ignite the liquid, and
- a corrosive liquid shall not contact any connection of a **protective conductor**.

A vessel that meets the relevant test requirements of Clause G.15 is considered to comprise a **reinforced safeguard**.

NOTE The following liquids are generally considered non-flammable:

– Oil or equivalent liquids used for lubrication or in a hydraulic system having a flash point of 149 °C or higher; or

– Replenishable liquids such as printing inks having a flash point of 60 °C or higher.

P.3.4 Compliance criteria

Compliance is checked by inspection or available data, and where necessary, by the relevant tests.

*During and after the tests, all **supplementary safeguards** and **reinforced safeguards** shall be effective, and no part shall become a **PIS**.*

P.4 Metallized coatings and adhesives securing parts

P.4.1 General

The metallized coating and adhesive shall have adequate bonding properties throughout the life of the equipment.

Compliance is checked by examination of the construction and of the available data. If such data is not available, compliance is checked by the tests of P.4.2.

*For metallized coatings, **clearances** and **creepage distances** for **pollution degree** 3 shall be maintained instead of the tests of P.4.2.*

P.4.2 Tests

A sample of the equipment or a subassembly of the equipment containing parts having metallized coating and the parts joined by adhesive is evaluated with the sample placed with the part secured by adhesive on the underside.

Condition the sample in an oven at a temperature T_C for the specified duration (eight weeks, three weeks or one week) as follows:

$$T_C = T_R + (T_A + 10 - T_S)$$

In case the value for $T_A + 10 - T_S$ is negative, the value will be replaced by zero.

where:

T_C *is the conditioning temperature;*

T_R *is the rated conditioning temperature value of (82 ± 2) °C for eight weeks; (90 ± 2) °C for three weeks; or (100 ± 2) °C (for one week) as applicable;*

T_A *is the temperature of the coating or the part under **normal operating conditions** (see B.2.6.1);*

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T_S = 82.

NOTE 1 For example for eight week conditioning, if the actual temperature is 70 °C, then the $T_A + 10 - T_S = 70 + 10 - 82 = -2$, then this -2 is ignored. The minimum conditioning temperature remains 82 °C. Also, for three week conditioning, if the actual temperature is 70 °C, then the $T_A + 10 - T_S = 70 + 10 - 82 = -2$, then this -2 is ignored. The minimum conditioning temperature remains 90 °C. Also, for one week conditioning, if the actual temperature is 70 °C, then the $T_A + 10 - T_S = 70 + 10 - 82 = -2$, then this -2 is ignored. The minimum conditioning temperature remains 100 °C.

NOTE 2 For example for eight week conditioning, if the actual temperature is 75 °C, then the $T_A + 10 - T_S = 75 + 10 - 82 = +3$, the minimum conditioning temperature becomes 82 + 3 = 85 °C. Also, for three week conditioning, if the actual temperature is 75 °C, then the $T_A + 10 - T_S = 75 + 10 - 82 = +3$, then the minimum conditioning temperature remains 90 + 3 = 93 °C. Also, for one week conditioning, if the actual temperature is 75 °C, then the $T_A + 10 - T_S = 75 + 10 - 82 = +3$, then the minimum conditioning temperature remains 100 + 3 = 103 °C.

NOTE 3 The table below gives the summary of the results in NOTE 1 and NOTE 2:

T_A	T_R	T_S	$T_A + 10 - T_S$	$T_C = T_R + T_A + 10 - T_S$
70	82 (8 weeks)	82	70 + 10 − 82 = −2	82 + 0 = 82
70	90 (3 weeks)	82	70 + 10 − 82 = −2	90 + 0 = 90
70	100 (1 week)	82	70 + 10 − 82 = −2	100 + 0 = 100
75	82 (8 weeks)	82	75 + 10 − 82 = +3	82 + 3 = 85
75	90 (3 weeks)	82	75 + 10 − 82 = +3	90 + 3 = 93
75	100 (1 week)	82	75 + 10 − 82 = +3	100 + 3 = 103

Upon completion of the temperature conditioning, subject the sample to the following:

- *remove the sample from oven and leave it at any convenient temperature between 20 °C and 30 °C for a minimum of 1 h;*
- *place the sample in a freezer at –40 °C ± 2 °C for a minimum of 4 h;*
- *remove and allow the sample to come to any convenient temperature between 20 °C and 30 °C for a minimum of 8 h;*
- *place the sample in a cabinet at 91 % to 95 % relative humidity for 72 h at any convenient temperature between 20 °C and 30 °C;*
- *remove the sample and leave it at any convenient temperature between 20 °C and 30 °C for a minimum of 1 h;*
- *place the sample in an oven at the temperature used for the temperature conditioning (T_C) for a minimum of 4 h; and*
- *remove the sample and allow it to reach any convenient temperature between 20 °C; and 30 °C for a minimum of 8 h.*

The sample is then immediately subjected to the tests of Annex T according to 4.4.3.

With the concurrence of the manufacturer, the above time durations may be extended.

After the above tests:

- *a metallized coating or a part secured by adhesive shall not fall off or partly dislodge;*
- *a metallized coating shall be subjected to the abrasion resistance test of G.13.6.2. After the abrasion resistance test, the coating shall have not loosened and no particles shall become loose from the coating; and*
- ***enclosure** parts serving as **safeguards** shall comply with all the applicable requirements for **enclosures**.*

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Annex Q
(normative)

Circuits intended for interconnection with building wiring

Q.1 Limited power source

Q.1.1 Requirements

A limited power source shall comply with one of the following:

a) the output is inherently limited in compliance with Table Q.1; or

b) linear or non-linear impedance limits the output in compliance with Table Q.1. If a PTC device is used, it shall:

   1) pass the tests specified in Clauses 15, 17, J.15 and J.17 of IEC 60730-1:~~2010~~ 2013; or

   2) meet the requirements of IEC 60730-1:2013 for a device providing Type 2.AL action;

c) a regulating network limits the output in compliance with Table Q.1, both with and without a simulated single fault (see Clause B.4), in the regulating network (open circuit or short-circuit); or

d) an overcurrent protective device is used and the output is limited in compliance with Table Q.2; or

e) an IC current limiter complying with Clause G.9~~ that limits the output current in accordance with Table Q.1~~.

Where an overcurrent protective device is used, it shall be a fuse or a non-adjustable, non-autoreset, electromechanical device.

Q.1.2 Test method and compliance criteria

Compliance is checked by inspection and measurement and, where appropriate, by examination of the manufacturer's data for ***batteries****.* ***Batteries*** *shall be fully charged when conducting the measurements for* U_{oc} *and* I_{sc} *according to Table Q.1 and Table Q.2. The maximum power shall be considered, such as from a* ***battery*** *and from a* ***mains*** *circuit.*

The non-capacitive load referenced in footnotes [b] *and* [c] *of Table Q.1 and Table Q.2 is adjusted to develop maximum current and maximum power transfer ~~respectively~~ in turn.* ***Single fault conditions*** *are applied in a regulating network according to Clause Q.1.1, item c) while under these maximum current and power conditions.*

Table Q.1 – Limits for inherently limited power sources

Output voltage [a] U_{oc}		Output current [b d] I_{sc}	Apparent power [c d] S
V AC	V DC	A	VA
$U_{oc} \leq 30$	$U_{oc} \leq 30$	≤ 8,0	≤ 100
–	$30 < U_{oc} \leq 60$	$\leq 150/U_{oc}$	≤ 100

[a] U_{oc}: Output voltage measured in accordance with B.2.3 with all load circuits disconnected. Voltages are for substantially sinusoidal AC and ripple free DC For non-sinusoidal AC and DC with ripple greater than 10 % of the peak, the peak voltage shall not exceed 42,4 V.

[b] I_{sc}: Maximum output current with any non-capacitive load, including a short-circuit.

[c] S (VA): Maximum output VA with any non-capacitive load.

[d] Measurement of I_{sc} and S are made 5 s after application of the load if protection is by an electronic circuit and 60 s in case of a PTC device or in other cases.

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Table Q.2 – Limits for power sources not inherently limited (overcurrent protective device required)

Output voltage [a] U_{oc}		Output current [b d] I_{sc}	Apparent power [c d] S	Current rating of overcurrent protective device [e]
V AC	V DC	A	VA	A
≤ 20	≤ 20	≤ 1 000/U_{oc}	≤ 250	≤ 5,0
20 < U_{oc} ≤ 30	20 < U_{oc} ≤ 30			≤ 100/U_{oc}
–	30 < U_{oc} ≤ 60			≤ 100/U_{oc}

[a] U_{oc}: Output voltage measured in accordance with B.2.3 with all load circuits disconnected. Voltages are for substantially sinusoidal AC and ripple free DC For non-sinusoidal AC and for DC with ripple greater than 10 % of the peak, the peak voltage shall not exceed 42,4 V.

[b] I_{sc}: Maximum output current with any non-capacitive load, including a short-circuit, measured 60 s after application of the load.

[c] S (VA): Maximum output VA with any non-capacitive load measured 60 s after application of the load.

[d] Current limiting impedances in the equipment remain in the circuit during measurement, but overcurrent protective devices are bypassed.

The reason for making measurements with overcurrent protective devices bypassed is to determine the amount of energy that is available to cause possible overheating during the operating time of the overcurrent protective devices.

[e] The current ratings of overcurrent protective devices are based on fuses and circuit breakers that break the circuit within 120 s with a current equal to 210 % of the current rating specified in the table.

Q.2 Test for external circuits – paired conductor cable

*Equipment supplying power to an **external circuit** paired conductor cable intended to be connected to the building wire shall be checked as follows.*

If current limiting is due to the inherent impedance of the power source, the output current into any resistive load, including a short-circuit, is measured. The current limit shall not be exceeded after 60 s of test.

If current limiting is provided by an overcurrent protective device having a specified time/current characteristic:

– *the time/current characteristic shall show that a current equal to 110 % of the current limit will be interrupted within 60 min; and*

– *the output current into any resistive load, including a short-circuit, with the overcurrent protective device bypassed, measured after 60 s of test, shall not exceed 1 000/U where U is the output voltage measured in accordance with B.2.3 with all load circuits disconnected.*

If current limiting is provided by an overcurrent protective device that does not have a specified time/current characteristic:

– *the output current into any resistive load, including a short-circuit, shall not exceed the current limit after 60 s of test; and*

– *the output current into any resistive load, including a short-circuit, with the overcurrent protective device bypassed, measured after 60 s of test, shall not exceed 1 000/U, where U is the output voltage measured in accordance with B.2.3 with all load circuits disconnected.*

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Annex R
(normative)

Limited short-circuit test

R.1 General

This annex documents the test procedure and compliance criteria for the limited short-circuit test. This test demonstrates that a **protective bonding conductor**, used in circuits protected by a device having a rating not exceeding 25 A, is suitable for the fault current permitted by the overcurrent protective device, and in doing so, tests the integrity of a **supplementary safeguard**.

R.2 Test setup

*The source used to conduct the limited short-circuit test shall be short-circuited at its output terminals and the current measured to ensure that it can supply at least 1 500 A. This can be an AC wall socket, generator, power supply or **battery**.*

If the overcurrent protective device is provided in the equipment, then this is used for the test.

For AC sources where only one overcurrent protective device is provided in the equipment and the plug is non-polarised, the protective device in the building installation is used for the test and the internal overcurrent protective device is by-passed. The manufacturer shall specify the device used for the test in the equipment safety instructions.

Where there is no protective device present in the equipment, a suitable overcurrent protective device shall be chosen. This overcurrent protective device shall be such that it does not interrupt the fault current before half a cycle has passed. The overcurrent protective device in the building installation for AC sources, or that specified to be provided externally to the equipment for DC sources, is used for the test. The manufacturer shall then specify the device used to conduct the test in the equipment safety instructions.

R.3 Test method

*The source shall be applied to the EUT via the **mains** cord supplied or specified by the equipment manufacturer. Where there is no **mains** cord supplied or specified, a 1 m length of 2,5 mm^2 or 12 AWG shall be used. For DC sources, the cable shall be sized for the maximum **rated** ~~input~~ **current** of the equipment.*

To conduct this test a short-circuit in the equipment to the earth connection of the equipment shall be introduced. The point at which this is done is depending on the equipment. After consideration of the equipment construction and circuit diagrams, the short-circuit shall be introduced between the phase conductor, at the point nearest to the input (the point of lowest impedance), and the protective bonding path under consideration. There may be more than one point at which this short-circuit may be applied to determine the worst case.

*The **protective bonding conductor** is connected to a source capable of supplying an AC or DC current, as appropriate to the EUT, of 1 500 A under short-circuit conditions, and using a source voltage equal to the **rated voltage** or any voltage within the **rated voltage range** of the equipment. In cases where the prospective short-circuit current seen by the equipment is known, then the source used for test shall be able to supply that current under short-circuit conditions. The manufacturer shall state the prospective short-circuit current that has been used in the evaluation in the safety instructions. The overcurrent protective device protecting the circuit under consideration (in accordance with Clause R.2) is kept in series with the*

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***protective bonding conductor**. The power supply cord, if provided or specified, shall remain connected when conducting the test.*

*The limited short-circuit test for **protective bonding conductors** in a potted or conformally coated assembly is conducted on a potted or coated sample.*

The test is conducted two more times (for a total of three times, on a different sample unless the manufacturer agrees to conduct the test on the same sample). The test is continued until the overcurrent protective device operates.

R.4 Compliance criteria

At the conclusion of the test, compliance is checked by inspection as follows.

There shall be

- *no damage to the **protective bonding conductor**;*
- *no damage to any **basic insulation**, **supplementary insulation**, or **reinforced insulation**;*
- *no reduction of **clearances**, **creepage distances** and distances through insulation; and*
- *no delamination of the printed board.*

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Annex S
(normative)

Tests for resistance to heat and fire

NOTE Toxic fumes are given off during the tests. The tests are usually carried out either under a ventilated hood or in a well-ventilated room, but free from draughts that could invalidate the tests.

S.1 Flammability test for fire enclosure and fire barrier materials of equipment where the steady state power does not exceed 4 000 W

Fire enclosure *and fire barrier materials are tested according to IEC 60695-11-5. The test is performed on three test specimens.*

The following additional requirements apply to the specified clauses of IEC 60695-11-5:~~2004~~ 2016.

Clause 6 of IEC 60695-11-5:~~2004~~ 2016 – Test specimen

For ***fire enclosures*** *and fire barriers, each test specimen consists of either a complete* ***fire enclosure*** *or fire barrier or a section of the* ***fire enclosure*** *or fire barrier representing the thinnest significant wall thickness and including any ventilation opening.*

Clause 7 of IEC 60695-11-5:~~2004~~ 2016 – ~~Severities~~ Flame application times

The values of duration of application of the test flame are as follows:

– *the test flame is applied for 10 s;*
– *if flaming does not exceed 30 s, the test flame is immediately reapplied for 1 min at the same point;*
– *if again flaming does not exceed 30 s, the test flame is immediately reapplied for 2 min at the same point.*

Clause 8 of IEC 60695-11-5:~~2004~~ 2016 – Conditioning ~~of test specimen~~ and test conditions

Prior to being tested, the ~~samples~~ specimens are conditioned in a circulating air oven for a period of 7 days (168 h), at a temperature 10 K higher than the maximum temperature of the part measured during the test of 5.4.1.4 or 70 °C, whichever is the higher, and then cooled to room temperature.

For printed boards, a preconditioning of 24 h at a temperature of 125 °C ± 2 °C in an air circulating oven and a subsequent cooling period of 4 h at room temperature in a desiccator over anhydrous calcium chloride is to be applied.

Subclause 9.~~2~~3 of IEC 60695-11-5:~~2004~~ 2016 – Application of needle flame

The test flame is applied to an inside surface of the test specimen at a point judged to be likely to become ignited because of its proximity to a source of ignition.

If a vertical part is involved, the flame is applied at an angle of approximately 45° from the vertical.

If ventilation openings are involved, the flame is applied to an edge of an opening, otherwise to a solid surface. In all cases, the tip of the flame is to be in contact with the test specimen.

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The test is repeated on the remaining two test specimens. If any part being tested is near a source of ignition at more than one point, each test specimen is tested with the flame applied to a different point that is near a source of ignition.

Clause 11 of IEC 60695-11-5:~~2004~~ 2016 – Evaluation of test results

The existing text is replaced by the following.

The test specimens shall comply with all of the following:

– *after every application of the test flame, the test specimen shall not be consumed completely; and*

– *after any application of the test flame, any self-sustaining flame shall extinguish within 30 s; and*

– *no burning of the specified layer or **wrapping tissue** shall occur.*

S.2 Flammability test for fire enclosure and fire barrier integrity

*Compliance of **fire enclosure** and fire barrier integrity is checked according to IEC 60695-11-5. The test is performed on three test specimens.*

For the purpose of this document, the following additional requirements apply to the stated clauses of IEC 60695-11-5:~~2004~~ 2016.

Clause 6 of IEC 60695-11-5:~~2004~~ 2016 – Test specimen

*For **fire enclosures** and fire barriers, each test specimen consists of either a complete **fire enclosure** and fire barrier or a section of the **fire enclosure** and fire barrier representing the thinnest significant wall thickness and including any ventilation opening.*

Clause 7 of IEC 60695-11-5:~~2004~~ 2016 – ~~Severities~~ Flame application times

The value of duration of application of the test flame is as follows:

– *the test flame is applied for 60 s. Top openings are covered with single layer of* **cheese cloth.**

Clause 8 of IEC 60695-11-5:~~2004~~ 2016 – Conditioning ~~of test specimen~~ and test conditions

Prior to being tested, the ~~samples~~ specimens are conditioned in a circulating air oven for a period of 7 days (168 h), at a temperature 10 K higher than the maximum temperature of the part measured during the test of 5.4.1.4 or 70 °C, whichever is the higher, and then cooled to room temperature.

For printed boards, a preconditioning of 24 h at a temperature of 125 °C ± 2 °C in an air circulating oven and a subsequent cooling period of 4 h at room temperature in a desiccator over anhydrous calcium chloride is to be applied.

Subclause 9.~~2~~3 of IEC 60695-11-5:~~2004~~ 2016 – Application of needle flame

~~*The test flame is applied to an inside surface of the test specimen at a point judged to be likely to become ignited because of its proximity to a source of ignition.*~~

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*The test flame is applied at a distance measured from the closest point of a **PIS** to the closest surface point of the test specimen. The application of the flame is measured from the top of the needle flame burner to the closest surface point, see Figure S.1.*

If a vertical part is involved or if the test specimen drips molten or flaming material during the application of the flame, the flame is applied at an angle of approximately 45° from the vertical.

~~*If ventilation openings are involved, the flame is applied to an edge of an opening, otherwise to a solid surface. In all cases, the tip of the flame is to be in contact with the test specimen.*~~

The test is repeated on the remaining two test specimens. If any part being tested is near a source of ignition at more than one point, each test specimen is tested with the flame applied to a different point that is near a source of ignition. In case of openings having different dimensions, the test shall be conducted on one opening of each group of openings with the same dimensions.

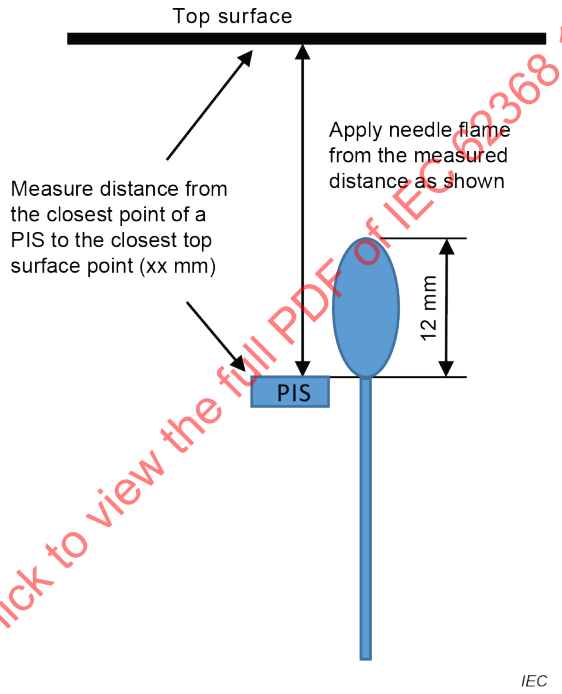


Figure S.1 – Top openings / surface of fire enclosure or fire barrier

Clause 11 of IEC 60695-11-5:~~2004~~ 2016 – Evaluation of test results

The existing text is replaced by the following.

~~*The test specimens shall comply with the following:*~~

~~*After application of the test flame, the test specimen shall not show any additional holes.*~~

*The **cheesecloth*** shall not ignite.

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S.3 Flammability tests for the bottom of a fire enclosure

S.3.1 Mounting of samples

*A sample of the complete finished bottom of the **fire enclosure** is securely supported in a horizontal position. A **cheesecloth** is placed in one layer over a shallow, flat-bottomed pan approximately 50 mm below the sample, and is of sufficient size to cover completely the pattern of openings in the sample, but not large enough to catch any of the oil that runs over the edge of the sample or otherwise does not pass through the openings.*

*Use of a metal screen or a wired-glass **enclosure** surrounding the test area is recommended.*

S.3.2 Test method and compliance criteria

A small metal ladle (preferably no more than 65 mm in diameter), with a pouring lip and a long handle whose longitudinal axis remains horizontal during pouring, is partially filled with 10 ml of diesel fuel oil. The ladle containing the oil is heated and the oil ignited and allowed to burn for 1 min, at which time all of the hot flaming oil is poured at the rate of approximately 1 ml/s in a steady stream onto the centre of the pattern of openings, from a position approximately 100 mm above the openings.

NOTE "Diesel fuel oil" is regarded to be similar to a medium volatile distillate fuel oil having a mass per unit volume between 0,845 g/ml and 0,865 g/ml, a flash point between 43,5 °C and 93,5 °C and an average calorific value of 38 MJ/l.

*The test is repeated twice at 5 min intervals, using clean **cheesecloth**.*

*During these tests the **cheesecloth** shall not ignite.*

S.4 Flammability classification of materials

Materials are classified according to the burning behaviour and their ability to extinguish, if ignited. Tests are made with the material in the thinnest significant thickness used.

The hierarchies of the **material flammability classes** are given in Table S.1, Table S.2 and Table S.3.

Table S.1 – Foamed materials

Material flammability class	ISO standard
HF-1 regarded better than **HF-2**	ISO 9772
HF-2 regarded better than **HBF**	ISO 9772
HBF	ISO 9772

Table S.2 – Rigid materials

Material flammability class	IEC standard
5VA regarded better than **5VB**	IEC 60695-11-20
5VB regarded better than **V-0**	IEC 60695-11-20
V-0 regarded better than **V-1**	IEC 60695-11-10
V-1 regarded better than **V-2**	IEC 60695-11-10
V-2 regarded better than **HB40**	IEC 60695-11-10
HB40 regarded better than **HB75**	IEC 60695-11-10
HB75	IEC 60695-11-10

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Table S.3 – Very thin materials

Material flammability class	ISO standard
VTM-0 regarded better than **VTM-1**	ISO 9773
VTM-1 regarded better than **VTM-2**	ISO 9773
VTM-2	ISO 9773

When VTM materials are used, relevant electrical and mechanical requirements should also be considered.

Wood and wood-based material with a thickness of at least 6 mm is considered to fulfil the **V-1** requirement. Wood-based material is material in which the main ingredient is machined natural wood, coupled with a binder.

EXAMPLE Wood-based materials are materials incorporating ground or chipped wood, such as hard fibre board or chip board.

S.5 Flammability test for fire enclosure materials of equipment with a steady state power exceeding 4 000 W

Fire enclosure *materials are tested according to IEC 60695-11-20:~~1999~~ 2015, using the plate procedure of IEC 60695-11-20:~~1999~~ 2015, 8.3.*

For the purpose of this document, the following additional requirements apply to the specified clauses of IEC 60695-11-20:~~1999~~ 2015.

Clause 7 of IEC 60695-11-20:~~1999~~ 2015 – Test Specimen~~, end product testing~~

*For **fire enclosures**, each test specimen consists of either a complete **fire enclosure** or a section of the **fire enclosure** representing the thinnest significant wall thickness and including any ventilation opening (plate procedure).*

Subclause 8.1 of IEC 60695-11-20:~~1999~~ 2015 – Conditioning

Prior to being tested, the samples are conditioned in a circulating air oven for a period of 7 days (168 h), at a temperature 10 K higher than the maximum temperature of the part measured during the test of 5.4.1.4 or 70 °C, whichever is the higher, and then cooled to room temperature.

Subclause 8.3 of IEC 60695-11-20:~~1999~~ 2015 – Plate ~~procedure~~ shaped test specimens

The test flame is applied to an inside surface of the test specimen at a point judged to be likely to become ignited because of its proximity to a source of ignition.

If a vertical part is involved, the flame is applied at an angle of approximately 20° from the vertical.

If ventilation openings are involved, the flame is applied to an edge of an opening, otherwise to a solid surface. In all cases, the tip of the flame is to be in contact with the test specimen.

The values of duration of application of the test flame are as follows:

– *the test flame is applied for 5 s and removed for 5 s;*

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– *the test flame application and removal is repeated four more times at the same location (total of five flame applications).*

Subclause 8.4 of IEC 60695-11-20:~~1999~~ 2015 – Classification

The existing text is replaced by the following.

The test specimens shall comply with all of the following:

– *after every application of the test flame, the test specimen shall not be consumed completely; and*

– *after the fifth application of the test flame, any flame shall extinguish within 1 min.*

*No burning of the specified cotton indicator ~~or **wrapping tissue** should~~ shall occur.*

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Annex T
(normative)

Mechanical strength tests

T.1 General

In general, this annex describes a number of tests that are invoked by this document. Compliance criteria are specified in the clause that invokes a particular test.

No tests are applied to handles, levers, knobs, the face of CRTs or to transparent or translucent covers of indicating or measuring devices, unless parts at ES3 are **accessible** when the handle, lever, knob or cover is removed.

T.2 Steady force test, 10 N

A steady force of 10 N ± 1 N is applied to the component or part under consideration for a short time duration of approximately 5 s.

T.3 Steady force test, 30 N

The test is conducted by means of the straight unjointed version of the applicable test probe of Figure V.1 or Figure V.2, applied with a force of 30 N ± 3 N for a short time duration of approximately 5 s.

T.4 Steady force test, 100 N

*The test is conducted by subjecting the external **enclosure** to a steady force of 100 N ± 10 N over a circular plane surface 30 mm in diameter for a short time duration of approximately 5 s, applied in turn to the top, bottom, and sides.*

T.5 Steady force test, 250 N

*The test is conducted by subjecting the external **enclosures** to a steady force of 250 N ± 10 N over a circular plane surface 30 mm in diameter for a short time period of approximately 5 s, applied in turn to the top, bottom and sides.*

T.6 Enclosure impact test

*A sample consisting of the complete **enclosure** or a portion thereof, representing the largest unreinforced area is supported in its normal position. A solid, smooth, steel sphere of 50 mm ± 1 mm in diameter and with a mass of 500 g ± 25 g, is used to perform the following tests:*

- *on horizontal surfaces, the sphere is to fall freely from rest through a vertical distance of 1 300 mm ± 10 mm onto the sample (see Figure T.1); and*
- *on vertical surfaces, the sphere is suspended by a cord and swung as a pendulum in order to apply a horizontal impact, dropping through a vertical distance of 1 300 mm ± 10 mm onto the sample (see Figure T.1).*

*For evaluating a part that acts as a **fire enclosure** only, the test is done as above, but the vertical distance is 410 mm ± 10 mm.*

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Alternatively horizontal impacts may be simulated on vertical or sloping surfaces by mounting the sample at 90° to its normal position and applying the vertical impact test instead of the pendulum test.

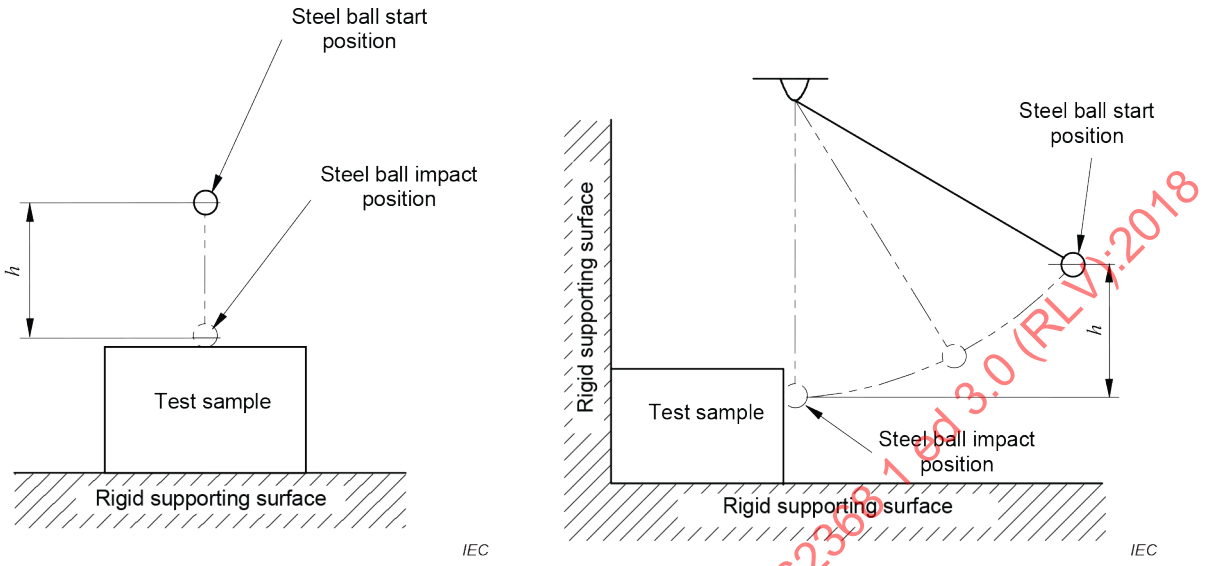


Figure T.1 – Impact test using sphere

T.7 Drop test

A sample of the complete equipment is subjected to three impacts that result from being dropped onto a horizontal surface in positions likely to produce the most adverse results.

The height of the drop shall be:

- *750 mm ± 10 mm for desk-top ~~or table-top~~ equipment and **movable equipment**;*
- *1 000 mm ± 10 mm for **hand-held equipment**, **direct plug-in equipment** and **transportable equipment**;*
- *~~500~~ 350 mm ± 10 mm for a part acting as a **fire enclosure** only of desk-top equipment and **movable equipment**;*
- *~~350~~ 500 mm ± 10 mm for a part acting as a **fire enclosure** only of **hand-held equipment**, **direct plug-in equipment** and **transportable equipment**.*

The horizontal surface consists of hardwood at least 13 mm thick, mounted on two layers of plywood each 18 mm ± 2 mm thick, all supported on a concrete or equivalent non-resilient floor.

T.8 Stress relief test

Stress relief is checked by the mould stress relief test of IEC 60695-10-3 or by the test procedure described below or by the inspection of the construction and the available data where appropriate.

*One sample consisting of the complete equipment, or of the complete **enclosure** together with any supporting framework, is placed in a circulating air oven at a temperature 10 K higher than the maximum temperature observed on the sample during the heating test of 5.4.1.4.2, but not less than 70 °C, for a period of 7 h, then cooled to room temperature.*

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*For large equipment where it is impractical to condition a complete **enclosure**, a portion of the **enclosure** representative of the complete assembly with regard to thickness and shape, including any mechanical support members, may be used.*

NOTE Relative humidity need not be maintained at a specific value during this test.

T.9 Glass impact test

The test sample is supported over its whole area and shall be subjected to a single impact, specified in Table T.1. ~~If the sample is made of glass,~~ The impact shall be applied in a location representing the centre of the glass.

The impact specified shall be caused by allowing a solid, smooth, steel ball of 50 mm ± 1 mm in diameter and with the mass of 500 g ± 25 g to fall freely from rest through a vertical distance not less than specified in Table T.1, as shown in Figure T.1, and strike the sample with the specified impact in a direction perpendicular to the surface of the sample.

Table T.1 – Impact force

Part	~~Result~~ Safeguards against	Impact J	Height mm
Unless otherwise specified below, any glass used as a **safeguard** against class 3 energy sources except PS3	Exposure to class 3 energy sources	3,5	714
Glass on floor standing equipment	Skin-lacerations	3,5	714
Glass on ~~portable equipment, table top equipment and on fixed mounted equipment~~ all other equipment	Skin-lacerations	2	408
~~Glass serving only as a **fire enclosure**~~ Laminated glass used as a **safeguard** against class 3 energy sources except PS 3	~~PS~~ Exposure to class 3 energy sources	1	204
Glass lenses that are provided for the attenuation of UV radiation	Exposure to UV radiation	0,5	102
To apply the required impact, the height is calculated by $H = E / (g \times m)$ where: H is the vertical distance in metres with a tolerance of ±10 mm; E is the impact energy in joules; g is the gravitational acceleration of 9,81 m/s^2; m is the mass of the steel ball in kilograms.			

T.10 Glass fragmentation test

The test sample is supported over its whole area and precautions shall be taken to ensure that particles will not be scattered upon fragmentation. Then the test sample is shattered with a centre punch placed approximately 15 mm in from the midpoint of one of the longer edges of the test sample. After a maximum of 5 min of fracture, and without using any aid to vision, except spectacles if normally worn, the particles are counted in a square of 50 mm side located approximately at the centre of the area of coarsest fracture and excluding any area within 15 mm of any edge or hole.

The test sample shall fragment in such a way that the number of particles counted in a square with sides of 50 mm shall not be less than 45.

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T.11 Test for telescoping or rod antennas

The end piece of telescoping or rod antennas shall be subjected to a 20 N force along the major axis of the antenna for a period of 1 min. In addition, if the end piece is attached by screw threads, a loosening torque is to be applied to the end pieces of five additional samples. The torque is to be gradually applied with the rod fixed. When the specific torque is reached, it is to be maintained for no more than 15 s. The holding time for any one sample shall be not less than 5 s and the average holding time of the five samples shall be not less than 8 s.

The value of torque is given in Table T.2.

Table T.2 – Torque values for end-piece test

End-piece diameter mm	Torque Nm
< 8,0	0,3
≥ 8,0	0,6

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Annex U
(normative)

Mechanical strength of CRTs and protection against the effects of implosion

U.1 General

This annex specifies mechanical strength of CRTs, how to protect against the effects of implosion and how a protective screen can withstand mechanical forces.

CRTs with a maximum face dimension exceeding 160 mm shall be either intrinsically protected with respect to effects of implosion and to mechanical impact, or the **enclosure** of the equipment shall provide adequate protection against the effects of an implosion of the CRT.

The face of a non-intrinsically protected CRT shall be provided with an effective screen that cannot be removed by hand. If a separate screen of glass is used, it shall not contact the surface of the CRT.

The CRT, other than the face of an intrinsically protected CRT, shall not be **accessible** to an **ordinary person**.

A protective film attached to the faceplate of the picture tube as part of the implosion protection system shall be covered on all edges by the **enclosure** of the equipment.

If the equipment is provided with a CRT with protective film attached to the faceplate as part of the safety implosion system, an **instructional safeguard** shall be provided in accordance with Clause F.5:

– element 1a: not available
– element 2: “Warning” or equivalent word or text
– element 3: “Risk of injury” or equivalent text
– element 4: “The CRT in this equipment uses a protective film on the face. This film shall not be removed as it serves a safety function and removal will increase the risk of injury” or equivalent text

The **instructional safeguard** shall be provided in the instructions.

Compliance is checked by inspection, by measurement, and by the tests of:

– *IEC 61965 for intrinsically protected CRTs, including those having integral protective screens;*
– *Clauses U.2 and U.3 for equipment having non-intrinsically protected CRTs; and*
– *Annex V for application of probes for the **enclosure**.*

NOTE 1 A picture tube CRT is considered to be intrinsically protected with respect to the effects of implosion if, when it is correctly mounted, no additional protection is necessary.

NOTE 2 To facilitate the tests, the CRT manufacturer is requested to indicate the most vulnerable area on the CRTs to be tested.

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U.2 Test method and compliance criteria for non-intrinsically protected CRTs

The equipment, with the CRT and the protective screen in position, is placed on a horizontal support at a height of (750 ± 50) mm above the floor, or directly on the floor if the equipment is obviously intended to be positioned on the floor.

The CRT is imploded inside the ***enclosure*** *of the equipment by the following method.*

Cracks are propagated in the envelope of each CRT. An area on the side or on the face of each CRT is scratched with a diamond stylus and this area is repeatedly cooled with liquid nitrogen or the like until a fracture occurs. To prevent the cooling liquid from flowing away from the test area, a dam of modelling clay or the like should be used.

NOTE Suitable scratch patterns are found in Figure 6 of IEC 61965:2003.

After this test, within 5 s of the initial fracture, no particle (a single piece of glass having a mass greater than 0,025 g) shall have passed a 250 mm high barrier, placed on the floor, 500 mm from the projection of the front of the equipment.

U.3 Protective screen

A protective screen shall be adequately secured and resistant to mechanical forces.

Compliance is checked by the tests of Clause T.3, without cracking of the protective screen or loosening of its mounting.

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Annex V
(normative)

Determination of accessible parts

V.1 Accessible parts of equipment

V.1.1 General

An **accessible** part of an equipment is a part that can be touched by a body part. For the purposes of determining an **accessible** part, a body part is represented by one or more of the specified test probes.

Accessible parts of an equipment may include parts behind a door, panel, removable cover, etc. that can be opened without the use of a **tool**.

Accessible parts do not include those that become **accessible** when floor standing equipment having a mass exceeding 40 kg is tilted.

For equipment intended for building-in or rack-mounting, or for subassemblies and the like for incorporation in larger equipment, **accessible** parts do not include those that are not **accessible** when the equipment or subassembly is installed according to the method of mounting or installation specified in the installation instructions.

A part is considered **accessible** if the instructions or markings intended to be followed require that a person physically contacts that part. This applies without test and irrespective of whether a **tool** is required to gain access.

V.1.2 Test method 1 – Surfaces and openings tested with jointed test probes

For surfaces and openings, the following jointed test probe is applied, without appreciable force and in any possible position, to the surfaces and openings of the equipment:

– *the test probe of Figure V.1 for equipment that is likely to be **accessible** to children;*

NOTE 1 Equipment intended for use in homes, schools, public and similar locations is equipment generally considered to be **accessible** to children, see also Clause F.4.

– *the test probe of Figure V.2 for equipment that is not likely to be **accessible** to children.*

*Where entry behind a door, panel, removable cover, etc. is possible without the use of a **tool**, or entry is directed by manufacturer instructions or marking, with or without the use of a **tool**, the test probe is applied to surfaces and openings in those areas.*

*Where the entire probe passes through a large opening (allowing entry of an arm but not of a shoulder), the probe shall be applied to all parts within a hemisphere with radius of 762 mm. The probe handle shall point along a path towards the large opening to simulate the hand on the end of the arm extending through the large opening. The plane of the hemisphere shall be the outside plane of the opening. Any part outside the 762 mm radius hemisphere is deemed not **accessible**.*

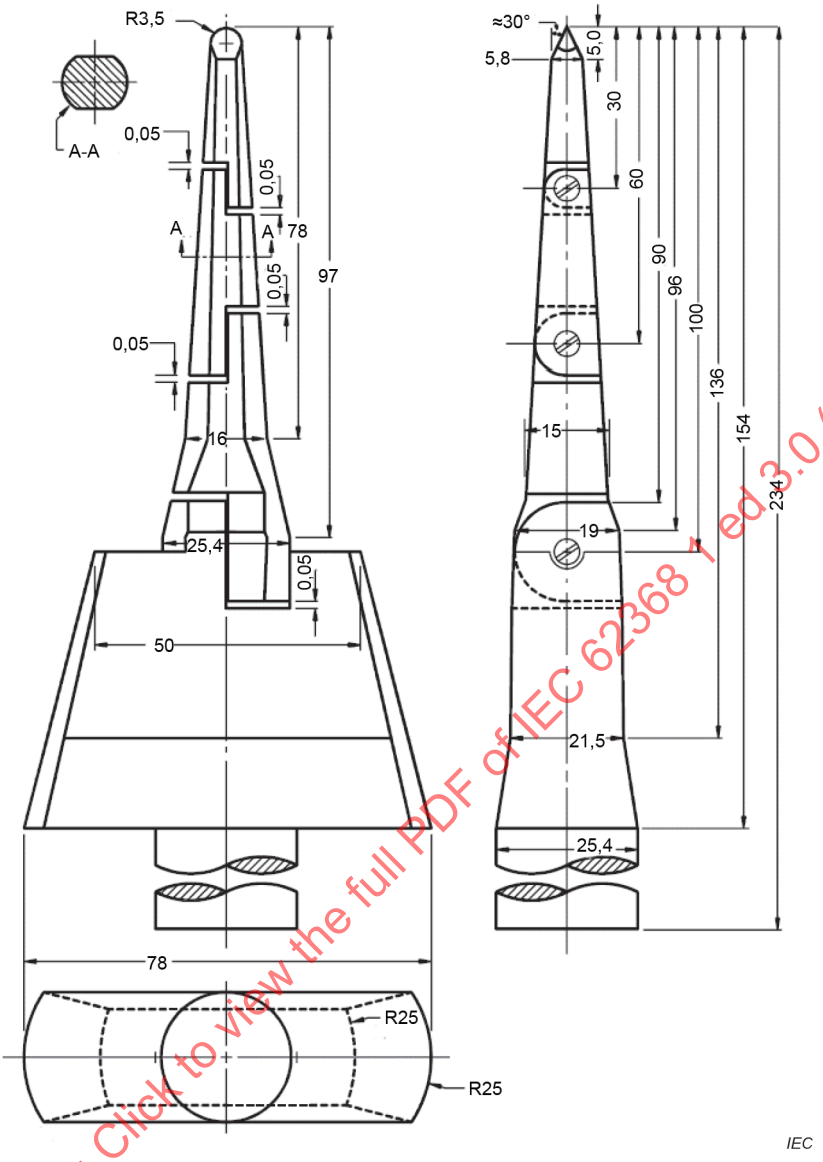
NOTE 2 The equipment can be dismantled to perform this test.

V.1.3 Test method 2 – Openings tested with straight unjointed test probes

Openings preventing access to a part by the applicable jointed test probe of Figure V.1 or Figure V.2 are further tested by means of a straight unjointed version of the respective test probe applied with a force of 30 N. If the unjointed probe enters the openings, test method 1 is repeated, except that the applicable jointed version of the test probe is pushed through the opening using any necessary force up to 30 N.

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Dimensions in millimetres



Tolerances on dimensions without specific tolerances:

angles: ± 15′

on radii: ± 0,1 mm

Tolerances on linear dimensions without specific tolerances:

≤ 15 mm: $^{0}_{-0,1}$ mm

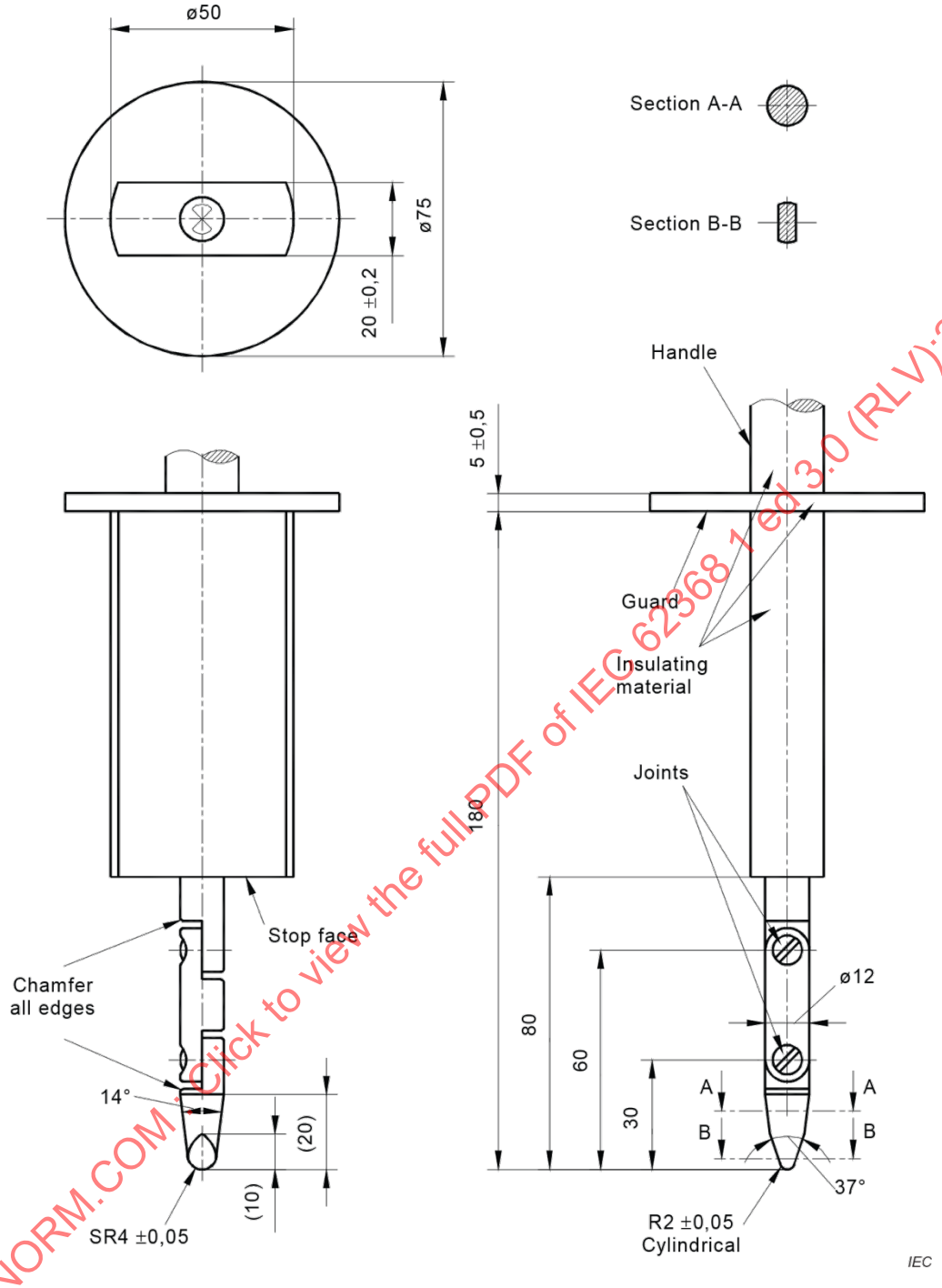
> 15 mm ≤ 25 mm: ± 0,1 mm

> 25 mm: ± 0,3 mm

Material of ~~finger~~ the test probe: heat-treated steel, for example.

Figure V.1 – Jointed test probe for equipment likely to be accessible to children

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Linear dimensions in millimetres

Tolerances on dimensions without specific tolerances:

14° and 37° angles: ± 15′

on radii: ± 0,1 mm

on linear dimensions:

≤ 15 mm: $^{0}_{-0,1}$ mm

> 15 mm ≤ 25 mm: ± 0,1 mm

> 25 mm: ± 0,3 mm

NOTE This jointed test probe is taken from Figure 2, test probe B of IEC 61032:1997.

Figure V.2 – Jointed test probe for equipment not likely to be accessible to children

V.1.4 Test method 3 – Plugs, jacks, connectors

The blunt probe of Figure V.3 is applied without appreciable force and in any possible position to specified parts.

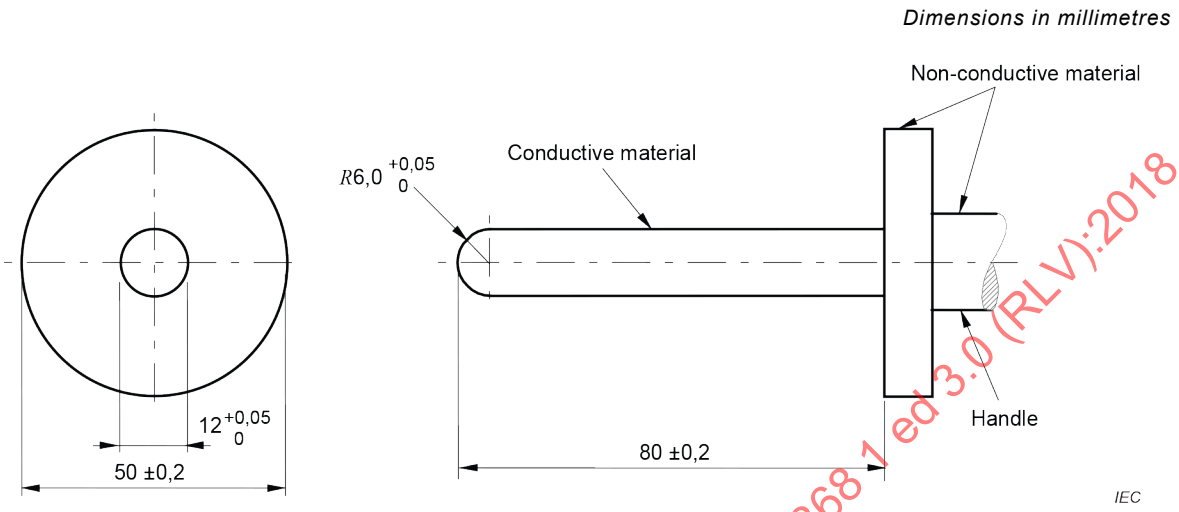


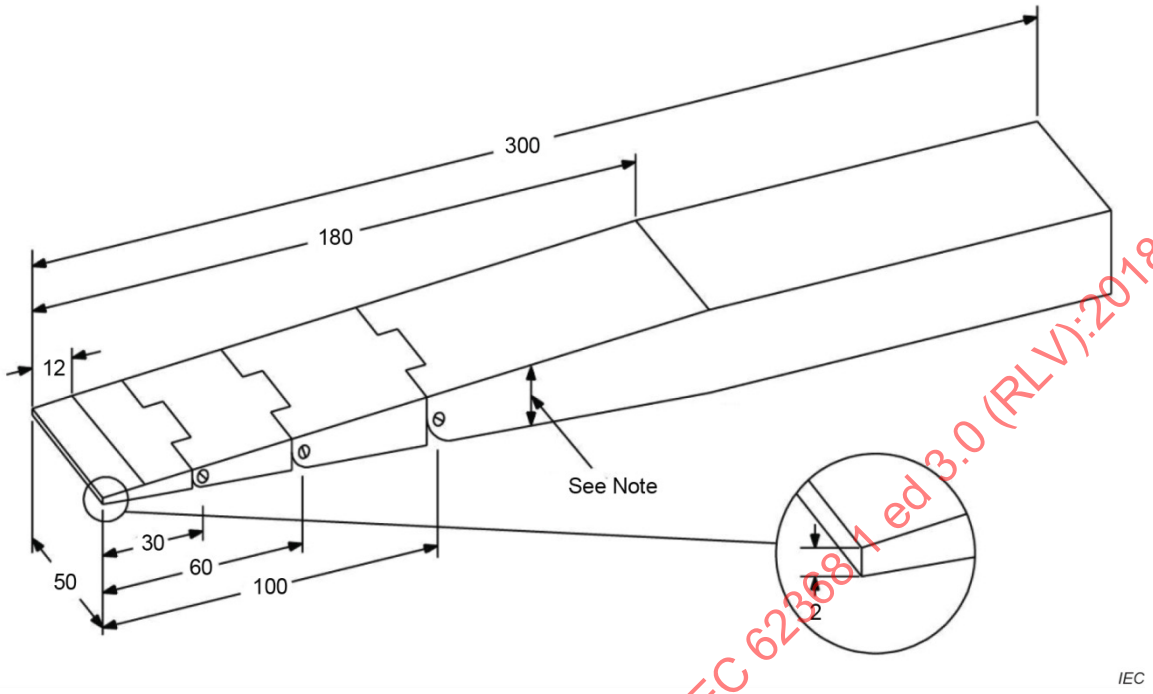
Figure V.3 – Blunt probe

V.1.5 Test method 4 – Slot openings

The wedge probe of Figure V.4 is applied as specified.

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Dimensions in millimetres



Tolerances on linear dimensions without specific tolerances:

≤ 25 mm: ± 0,13 mm

> 25 mm: ± 0,3 mm

NOTE The thickness of the probe varies linearly, with slope changes at the following points along the probe:

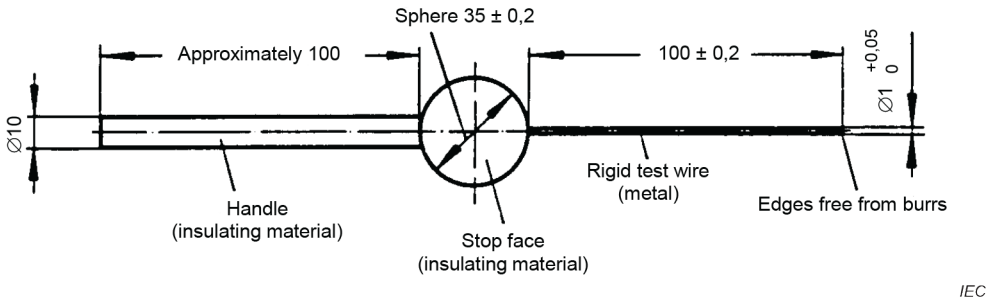
Distance from probe tip mm	Probe thickness mm
0	2
12	4
180	24

Figure V.4 – Wedge probe

V.1.6 Test method 5 – Terminals intended to be used by an ordinary person

The rigid test wire of the test probe of Figure V.5 is inserted into the applicable opening with a force up to 1 N ± 0,1 N and with the length limited to 20 mm ± 0,2 mm. While inserted, the probe is moved in any angle with minimal force.

Dimensions in millimetres



NOTE This probe is taken from Figure 4 of IEC 61032:1997.

Figure V.5 – Terminal probe

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V.2 Accessible part criterion

*If a part can be touched by the specified probe, then the part is **accessible**.*

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Annex W
(informative)

Comparison of terms introduced in this document

W.1 General

This document introduces new safety terms associated with the new safety concepts.

This annex identifies the relevant terms in this document and, where different, compare them to the equivalent IEC/TC 64 [3] basic safety publications and other relevant safety publications.

Terms not in the tables below are either the same or substantially the same as in other IEC standards.

W.2 Comparison of terms

In the Tables W.1 to W.6 below, the text quoted from an IEC standard is in normal font. Remarks about IEC 62368-1 are in italic font.

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[3] IEC/TC 64: Electrical installations and protection against electric shock. Click on the IEC website for a list of publications issued by TC 64.

Table W.1 – Comparison of terms and definitions in IEC 60664-1:2007 and IEC 62368-1

IEC 60664-1:2007	IEC 62368-1
3.2 **clearance** shortest distance in air between two conductive parts	**3.3.12.1** **clearance** shortest distance in air between two conductive parts
3.3 **creepage distance** shortest distance along the surface of a solid insulating material between two conductive parts	**3.3.12.2** **creepage distance** shortest distance along the surface of an insulating material between two conductive parts
3.4 **solid insulation** solid insulating material interposed between two conductive parts	**3.3.5.6** **solid insulation** ~~solid insulating material placed between two conductive parts or between a conductive part and a body part~~ insulation consisting entirely of solid material
3.5 **working voltage** highest RMS value of the AC or DC voltage across any particular insulation which can occur when the equipment is supplied at rated voltage	**3.3.14.8** **working voltage** highest voltage across any particular insulation that can occur when the equipment is supplied at **rated voltage** or any voltage in the **rated voltage range** under **normal operating conditions**
3.9 **rated voltage** value of voltage assigned by the manufacturer, to a component, device or equipment and to which operation and performance characteristics are referred	**3.3.10.4** **rated voltage** value of voltage assigned by the manufacturer to a component, device or equipment and to which operation and performance characteristics are referred
3.13 **pollution degree** numeral characterizing the expected pollution of the micro-environment	**3.3.6.8** **pollution degree** numeral characterising the expected pollution of the micro-environment
3.19.1 **type test** test of one or more devices made to a certain design to show that the design meets certain specifications	**3.3.6.15** **type test** test on a representative sample with the objective of determining if, as designed and manufactured, it can meet the requirements of this document
3.9.2 **rated impulse voltage** impulse withstand voltage value assigned by the manufacturer to the equipment or to a part of it, characterizing the specified withstand capability of its insulation against transient overvoltages	**3.3.14.2** **mains transient voltage** highest peak voltage expected at the ~~power~~ **mains** input to the equipment, arising from external transients ~~on the **mains**~~

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IEC 60664-1:2007	IEC 62368-1
3.17.1 **functional insulation** insulation between conductive parts which is necessary only for the proper functioning of the equipment	**3.3.5.3** **functional insulation** insulation between conductive parts which is necessary only for the proper functioning of the equipment
3.17.2 **basic insulation** insulation of hazardous-live-parts which provides basic protection	**3.3.5.1** **basic insulation** insulation to provide a **basic safeguard** against electric shock
3.17.3 **supplementary insulation** independent insulation applied in addition to basic insulation for fault protection	**3.3.5.7** **supplementary insulation** independent insulation applied in addition to **basic insulation** to provide **supplementary safeguard** for fault protection against electric shock
3.17.4 **double insulation** insulation comprising both basic insulation and supplementary insulation	**3.3.5.2** **double insulation** insulation comprising both **basic insulation** and **supplementary insulation**
3.17.5 **reinforced insulation** insulation of hazardous-live-parts which provides a degree of protection against electric shock equivalent to double insulation	**3.3.5.5** **reinforced insulation** single insulation system that provides a degree of protection against electric shock equivalent to **double insulation**
3.19.2 **routine test** test to which each individual device is subjected during or after manufacture to ascertain whether it complies with certain criteria	**3.3.6.10** **routine test** test to which each individual device is subjected during or after manufacture to ascertain whether it complies with certain criteria
3.19.3 **sampling test** test on a number of devices taken at random from a batch	**3.3.6.11** **sampling test** test on a number of devices taken at random from a batch

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Table W.2 – Comparison of terms and definitions in IEC 61140:~~2001~~ 2016 and IEC 62368-1

IEC 61140:~~2001~~ 2016 terms	IEC 62368-1 terms
	*For consistency throughout the document the term "**safeguard**" is used to describe the device or scheme that provides protection against an energy source.*
3.1.1 **basic protection** protection against electric shock under fault-free conditions	**3.3.11.2** **basic safeguard** **safeguard** that provides protection under **normal operating conditions** and under **abnormal operating conditions** whenever an energy source capable of causing pain or injury is present in the equipment
3.10.2 **supplementary insulation** Independent insulation applied in addition to basic insulation, for fault protection	**3.3.11.17** **supplementary safeguard** **safeguard** applied in addition to the **basic safeguard** that is or becomes operational in the event of failure of the **basic safeguard**
3.4 **live part** conductor or conductive part intended to be energized in normal operation, including a neutral conductor, but by convention not a PEN conductor or PEM conductor or PEL conductor Note 1 to entry: This concept does not necessarily imply a risk of electric shock. Note 2 to entry: For definitions of PEM and PEL see IEV 195-02-13 and 195-02-14.	*The term **live part** is not used.* *In accordance with the IEC 61140 definition, ES1, ES2 and ES3 are all live parts*
3.5 **hazardous-live-part** live part that, under certain conditions, can give a harmful electric shock Note 1 to entry: In case of high voltage, a hazardous voltage may be present on the surface of solid insulation. In such a case the surface is considered to be a hazardous-live-part.	*The term **hazardous-live-part** is not used.* *In accordance with the IEC 61140 definition, an ES3 source is a hazardous-live-part.*
3.26 **extra-low-voltage (ELV)** any voltage not exceeding the relevant voltage limit specified in IEC TS 61201	*No equivalent term. See ES1.*

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IEC 61140:~~2001~~ 2016 terms	IEC 62368-1 terms
3.26.1 **SELV system** an electrical system in which the voltage cannot exceed ELV: – under normal conditions; and – under single-fault conditions, including earth faults in other circuits	**ES1** ES1 is a voltage not exceeding the relevant voltage limit specified in IEC TS 61201 or a current not exceeding the relevant current limit specified in IEC TS 60479-1 – under normal conditions; and – under **single fault conditions**
3.28 **limited-current-source** device supplying electrical energy in an electric circuit – with protective-separation from hazardous-live-parts, and – that ensures that the steady state touch current and charge are limited to non-hazardous levels, under normal and fault conditions	**ES1** ES1 is a voltage not exceeding the relevant voltage limit specified in IEC TS 61201 or a current not exceeding the relevant current limit specified in IEC TS 60479-1 – under normal conditions; and – under **single fault conditions**.
5.1.6 **Limitation of steady state touch current and charge** Limitation of steady state touch current and charge shall prevent persons or animals from being subjected to values of steady state touch current and charge liable to be hazardous or perceptible. Note 1 to entry: For persons, the following values (AC values for frequencies up to 100 Hz) are given as guidance: – A steady state current flowing between simultaneously accessible conductive parts through a pure resistance of 2 000 Ω not exceeding the threshold of perception, AC 0,5 mA or DC 2 mA are recommended. – Values not exceeding the threshold of pain AC 3,5 mA or DC 10 mA may be specified.	*ES1 current limit is 0,5 mA AC and 2 mA DC* *ES2 current limit is 5 mA AC, 25 mA DC (these values are taken from IEC TS 60479-1)*
No equivalent term	**3.3.11.12** **safeguard** physical part or system or instruction specifically provided to reduce the likelihood of injury, or, for fire, to reduce the likelihood of ignition or spread of fire
No equivalent term. Based on double insulation	**3.3.11.2** **double safeguard** **safeguard** comprising both a **basic safeguard** and a **supplementary safeguard**

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IEC 61140:~~2001~~ 2016 terms	IEC 62368-1 terms
No equivalent term. Based on reinforced insulation	**3.3.11.12** **reinforced safeguard** single **safeguard** that is~~ operational~~ provides protection under – **normal operating conditions**, – **abnormal operating conditions**, and – **single fault conditions**.
No equivalent term. Roughly equivalent to a warning	**3.3.11.5** **instructional safeguard** an instruction invoking specified behaviour ~~to avoid contact with or exposure to a class 2 or class 3 energy source~~
No equivalent term	**3.3.11.7** **precautionary safeguard** **instructed person** behaviour to avoid contact with or exposure to a class 2 energy source based on supervision or instructions given by a **skilled person**
No equivalent term	**3.3.11.14** **skill safeguard** **skilled person** behaviour to avoid contact with or exposure to a class 2 or class 3 energy source based on education and experience
The term normal condition is used in IEC 61140, but not defined	**3.3.7.4** **normal operating condition** mode of operation that represents as closely as possible the~~ most severe conditions~~ range of normal use that can reasonably be expected
No equivalent term	**3.3.7.1** **abnormal operating condition** temporary operating condition that is not a **normal operating condition** and is not a **single fault condition** of the equipment itself
The term single fault is used in IEC 61140, but not defined	**3.3.7.9** **single fault condition** fault under **normal operating condition** of a single **safeguard** (but not a **reinforced safeguard**) or of a single component or a device

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Table W.3 – Comparison of terms and definitions in IEC 60950-1:2005 and IEC 62368-1

IEC 60950-1:2005 terms	IEC 62368-1 terms
1.2.8.8 **SELV circuit** secondary circuit that is so designed and protected that under normal operating conditions and single fault conditions, its voltages do not exceed a safe value	**5.2.1.1** **ES1** ~~ES1 is a class 1 electrical energy source with levels not exceeding ES1 limits under **normal operating conditions** and **abnormal operating conditions** that do not lead to a **single fault conditions** and not exceeding ES2 limits under **single fault conditions**.~~ ~~NOTE ES1 may be **accessible** to an **ordinary person**.~~ ES1 is a class 1 electrical energy source with **touch current** or **prospective touch voltage** levels – not exceeding ES1 limits under • **normal operating conditions**, and • **abnormal operating conditions**, and • **single fault conditions** of a component, device or insulation not serving as a **safeguard**; and **not exceeding ES2 limits under** single fault conditions **of a** basic safeguard **or of a** supplementary safeguard**.**
1.2.8.11 **TNV circuit** circuit that is in the equipment and to which the accessible area of contact is limited and that is so designed and protected that, under normal operating conditions and single fault conditions (see 1.4.14 of IEC 60950-1:2005), the voltages do not exceed specified limit values A TNV circuit is considered to be a secondary circuit in the meaning of this document.	~~**5.2.1.2**~~ ~~**ES2**~~ ~~ES2 is a class 2 electrical energy source with levels not exceeding ES2 limits under **normal operating conditions**, **abnormal operating conditions**, and **single fault conditions**, but is not ES1.~~ ~~NOTE ES2 may be **accessible** to an **instructed person**.~~ *See detailed TNV classes for comparison.*
1.2.8.12 **TNV-1 circuit** TNV circuit – whose normal operating voltages do not exceed the limits for an SELV circuit under normal operating conditions and – On which overvoltages from telecommunication networks and cable distribution systems are possible	ES 1 on which transients according to Table 13, ID numbers 1, 2 and 3 are possible NOTE The electrical characteristics are not identical to TNV circuits but will give equivalent level of safety.

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IEC 60950-1:2005 terms	IEC 62368-1 terms
1.2.8.13 **TNV-2 circuit** TNV circuit – whose normal operating voltages exceed the limits for an SELV circuit under normal operating conditions and – which is not subject to overvoltages from telecommunication networks	ES2 ES2 is a class 2 electrical energy source where – both the **prospective touch voltage** and the **touch current** exceed the limits for ES1; and – under • **normal operating conditions**, and • **abnormal operating conditions**, and • **single fault conditions**, either the **prospective touch voltage** or the **touch current** does not exceed the limit for ES2. NOTE The electrical characteristics are not identical to TNV circuits but will give equivalent level of safety.
1.2.8.14 **TNV-3 circuit** TNV circuit – whose normal operating voltages exceed the limits for an SELV circuit under normal operating conditions and – on which overvoltages from telecommunication networks and cable distribution systems are possible	ES 2 on which transients according to Table 13, ID numbers 1, 2 and 3 are possible NOTE The electrical characteristics are not identical to TNV circuits but will give equivalent level of safety.
1.2.13.6 **USER** any person, other than a service person *The term user in this document is the same as the term operator and the two terms can be interchanged*	**3.3.8.2** **ordinary person** person who is neither a **skilled person** nor an **instructed person**
1.2.13.7 **operator** see **user** (1.2.13.6 of IEC 60950-1:2005)	**See 3.3.8.2**

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IEC 60950-1:2005 terms	IEC 62368-1 terms
1.2.13.8 **telecommunication network** metallically terminated transmission medium intended for communication between equipment that may be located in separate buildings, excluding: – the mains system for supply, transmission and distribution of electrical power, if used as a telecommunication transmission medium; – cable distribution systems; – SELV circuits connecting units of information technology equipment Note 1 to entry: The term telecommunication network is defined in terms of its functionality, not its electrical characteristics. a telecommunication network is not itself defined as being either an SELV circuit or a TNV circuit. Only the circuits in the equipment are so classified. Note 2 to entry: A telecommunication network may be: – publicly or privately owned: – subject to transient overvoltages due to atmospheric discharges and faults in power distribution systems: – subject to longitudinal (common mode) voltages induced from nearby power lines or electric traction lines. Note 3 to entry: Examples of telecommunication networks are: – a public switched telephone network: – a public data network: – an integrated Services Digital Network (ISDN); – a private network with electrical interface characteristics similar to the above.	**3.3.1.1** **external circuit** electrical circuit that is external to the equipment and is not **mains** ~~NOTE The relevant **external circuits** are identified in Table 14~~ Note 1 to entry: An **external circuit** is classified as ES1, ES2 or ES3, and PS1, PS2, or PS3.
None	**3.3.8.1** **instructed person** person instructed or supervised by a **skilled person** as to energy sources and who can responsibly use equipment **safeguards** and **precautionary safeguards** with respect to those energy sources

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IEC 60950-1:2005 terms	IEC 62368-1 terms
1.2.13.5 **service person** person having appropriate technical training and experience necessary to be aware of hazards to which that person may be exposed in performing a task and of measures to minimize the risks to that person or other persons	**3.3.8.3** **skilled person** person with relevant education or experience to enable him or her to ~~avoid dangers~~ identify hazards and to take appropriate actions to reduce the likelihood of risks ~~that may be created by the equipment~~ of injury to themselves and others
1.2.13.14 **cable distribution system** metallically terminated transmission medium using coaxial cable, mainly intended for transmission of video and/or audio signals between separate buildings or between outdoor antennas and buildings, excluding: – the mains system for supply, transmission and distribution of electric power, if used as a communication transmission medium; – telecommunication networks; – SELV circuits connecting units of information technology equipment Note 1 to entry: Examples Of cable distribution systems are: – local area cable networks, community antenna television systems and master antenna television systems providing video and audio signal distribution; – outdoor antennas including satellite dishes, receiving antennas, and other similar devices. Note 2 to entry: Cable distribution systems may be subjected to greater transients than telecommunication networks.	**3.3.1.1** **external circuit** electrical circuit that is external to the equipment and is not **mains** Note 1 to entry: The relevant **external circuits** are identified in Table 13.

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Table W.4 – Comparison of terms and definitions in IEC 60728-11:2016 and IEC 62368-1

IEC 60728-11:2016 terms	IEC 62368-1 terms
3.1.4 **cable networks <for television signals, sound signals and interactive services>** ~~general overall term used to define CATV-networks, MATV-networks, SMATV-networks and individual receiving networks~~ regional and local broadband cable networks, extended satellite and terrestrial television distribution networks or systems and individual satellite and terrestrial television receiving systems Note 1 to entry: These networks and systems can be used in downstream and upstream directions. **3.1.5** **CATV network or community antenna television network** regional and local broadband cable networks designed to provide sound and television signals as well as signals for interactive services to ~~communities~~ a regional or local area Note 1 to entry: Originally defined as Community Antenna Television network. **3.1.31** **MATV network or master antenna television network** extended terrestrial television distribution networks or systems designed to provide sound and television signals ~~as well as signals for interactive services~~ received by terrestrial receiving antenna to households in one or more buildings **3.1.44** **SMATV network or satellite master antenna television network** extended distribution networks or systems designed to provide sound and television signals ~~as well as signals for interactive services,~~ received by satellite receiving antenna ~~eventually combined with terrestrial TV and/or radio signals,~~ to households in one or more buildings Note 1 to entry: Originally defined as satellite master antenna television network Note 2 to entry: This kind of network or system can possibly be combined with terrestrial antennas for the additional reception of TV and/or radio signals via terrestrial networks. Note 3 to entry: This kind of network or system can also carry control signals for satellite switched	**3.3.1.1** **external circuit** electrical circuit that is external to the equipment and is not **mains** Note 1 to entry: The relevant **external circuits** are identified in Table 13.

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IEC 60728-11:2016 terms	IEC 62368-1 terms
systems or other signals for special transmission systems (e.g. MoCA or WiFi) in the return path direction.	

Table W.5 – Comparison of terms and definitions in IEC 62151:2000 and IEC 62368-1

IEC 62151:2000 terms	IEC 62368-1 terms
3.1.3 **telecommunication network** a metallically terminated transmission medium intended for communication between equipments that may be located in separate buildings, excluding: – the mains systems for supply, transmission and distribution of electrical power, if used as a telecommunication transmission medium; – television distribution systems using cable Note 1 to entry: The term telecommunication network is defined in terms of its functionality, not its electrical characteristics. a telecommunication networK is not itself defined as being a TNV circuit. Only the circuits in equipment are so classified. Note 2 to entry: A telecommunication network may be – publicly or privately owned; – subject to transient overvoltages due to atmospheric discharges and faults in power distribution systems; – subject to permanent longitudinal (common mode) voltages induced from nearby power lines or electric traction lines. Note 3 to entry: Examples of telecommunication networks are – a public switched telephone network; – a public data network; – an ISDN network; – a private network with electrical interface characteristics similar to the above.	**3.3.1.1** **external circuit** electrical circuit that is external to the equipment and is not **mains** Note 1 to entry: The relevant **external circuits** are identified in Table 13.

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IEC 62151:2000 terms	IEC 62368-1 terms
3.5.4 **TNV-0 circuit** a TNV circuit: – whose normal operating voltages do not exceed a safe value under normal operating conditions and under single fault conditions; – which is not subject to overvoltages from telecommunication networks Note 1 to entry: The limiting values of voltage under normal operating and single fault conditions are specified in 4.1.	**5.2.1.1** **ES1** ~~ES1 is a class 1 electrical energy source with levels not exceeding ES1 limits under **normal operating conditions** and **abnormal operating conditions** and not exceeding ES2 limits under **single fault conditions**.~~ ~~NOTE 1 ES1 may be **accessible** to an **ordinary person**.~~ ~~NOTE 2 The electrical characteristics are not identical but will give equivalent level of safety~~ ES1 is a class 1 electrical energy source with **touch current** or **prospective touch voltage** levels – not exceeding ES1 limits under • **normal operating conditions**, and • **abnormal operating conditions**, and • **single fault conditions** of a component, device or insulation not serving as a **safeguard**; and not exceeding ES2 limits under **single fault conditions** of a **basic safeguard** or of a **supplementary safeguard**.

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IEC 62151:2000 terms	IEC 62368-1 terms
3.5.3 **TNV circuit** a circuit which is in the equipment and to which the accessible area of contact is limited (except for a TNV-0 circuit) and that is so designed and protected that, under normal operating and single fault conditions, the voltages do not exceed specified limiting values A TNV circuit is considered to be a secondary circuit in the meaning of this document. Note 1 to entry: The voltage relationships between TNV CIRCUITS are shown in table 1.	**5.2.1.2** **ES2** ~~ES2 is a class 2 electrical energy source with levels not exceeding ES2 limits under **normal operating conditions**, **abnormal operating conditions**, or **single fault conditions**, but is not ES1.~~ ~~NOTE 1 ES2 may be **accessible** to an **instructed person**.~~ ~~NOTE 2 The electrical characteristics are not identical to TNV circuits but will give an equivalent level of safety.~~ ES2 is a class 2 electrical energy source where – both the **prospective touch voltage** and the **touch current** exceed the limits for ES1; and – under • **normal operating conditions**, and • **abnormal operating conditions**, and • **single fault conditions**. either the **prospective touch voltage** or the **touch current** does not exceed the limit for ES2.

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Table W.6 – Comparison of terms and definitions in IEC 60065:2014 and IEC 62368-1

IEC 60065:2014 terms	IEC 62368-1 terms
2.2.12 **professional apparatus** apparatus for use in trades, professions or industries and which is not intended for sale to the general public Note 1 to entry: The designation should be specified by the manufacturer.	~~**No equivalent term**~~ **3.3.3.8** **professional equipment** equipment for use in trades, professions or industries and which is not intended for sale to the general public
2.4.3 **directly connected to the mains** electrical connection with the mains in such a way that a connection to either pole of the mains causes in that connection a permanent current equal to or greater than 9 A, protective devices in the apparatus being not short-circuited Note 1 to entry: A current of 9 A is chosen as the minimum breaking current of a 6 A fuse.	*No equivalent term.* *In accordance with the IEC 60065 definition, an ES3 source would be considered directly connected to the **mains**.*
2.4.4 **conductively connected to the mains** electrical connection with the mains in such a way that a connection through a resistance of 2 000 Ω to either pole of the mains causes in that resistance a permanent current greater than 0,7 mA (peak), the apparatus not being connected to earth	*No equivalent term.* *In accordance with the IEC 60065 definition, an ES3 or ES2 source could be considered conductively connected to the **mains**.*

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IEC 60065:2014 terms	IEC 62368-1 terms
2.4.7 **telecommunication network** metallically-terminated transmission medium intended for communication between apparatus that may be located in separate buildings, excluding: – the mains systems for supply, transmission and distribution of electrical power, if used as a telecommunication transmission medium; – television – distribution systems using cable Note 1 to entry: The term telecommunication network is defined in terms of its functionality, not its electrical characteristics. a telecommunication network is not itself defined as being either a TNV circuit. Only the circuits in the apparatus are so classified. Note 2 to entry: A telecommunication network may be: – publicly or privately owned: – subject to transient overvoltages due to atmospheric discharges and faults in power distribution systems: – subject to longitudinal (common mode) voltages induced from nearby power lines or electric traction lines. Note 3 to entry: Examples of telecommunication networks are: – a public switched telephone network; – a public data network; – an ISDN network; – a private network with electrical interface characteristics similar to the above.	**3.3.1.1** **external circuit** electrical circuit that is external to the equipment and is not **mains** Note 1 to entry: The relevant **external circuits** are identified in Table 13.
2.6.10 **hazardous live** electrical condition of an object from which a hazardous touch current (electric shock) could be drawn (see 9.1.1)	*The term hazardous-live is not used.* *In accordance with the IEC 60065 definition, an ES3 source is hazardous live.*
2.8.6 **instructed person** person adequately advised or supervised by skilled persons to enable him or her to avoid dangers and to prevent risks which electricity may create	**3.3.8.1** **instructed person** person instructed or supervised by a skilled person as to energy sources and who can responsibly uses **equipment safeguards** and **precautionary safeguards** with respect to those energy sources Note 1 to entry: Supervised, as used in the definition, means having the direction and oversight of the performance of others. [SOURCE: IEV 826-18-02, modified]

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IEC 60065:2014 terms	IEC 62368-1 terms
2.8.11 **potential ignition source** possible fault which can start a fire if the open-circuit voltage measured across an interruption or faulty contact exceeds a value of 50 V (peak) AC or DC and the product of the peak value of this voltage and the measured RMS current under normal operating conditions exceeds 15 VA. Such a faulty contact or interruption in an electrical connection includes those which may occur in conductive patterns on printed boards. Note 1 to entry: An electronic protection circuit may be used to prevent such a fault from becoming a potential ignition source.	**3.3.9.2** **arcing PIS** ~~location~~ **PIS** where an arc may occur due to the opening of a conductor or contact Note 1 to entry: An electronic protection circuit or additional constructional measures may be used to prevent a location from becoming an **arcing PIS**. Note 2 to entry: A faulty contact or interruption in an electric connection that may occur in conductive patterns on printed boards is considered to be within the scope of this definition.

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Annex X
(normative)

Alternative method for determining clearances for insulation in circuits connected to an AC mains not exceeding 420 V peak (300 V RMS)

For an AC **mains** not exceeding 420 V peak (300 V RMS):

– if the peak of the **working voltage** does not exceed the peak value of the AC **mains** supply voltage, the alternate minimum **clearance** is determined from Table X.1;

– if the peak of the **working voltage** exceeds the peak value of the AC **mains** supply voltage, the alternate minimum **clearance** is the sum of the following two values:

- the **clearance** from Table X.1, and
- the appropriate additional **clearance** from Table X.2.

NOTE A **clearance** obtained by the use of Table X.1 lies between the values required for homogeneous and inhomogeneous fields. As a result, it may not pass the appropriate electric strength test if the field is substantially inhomogeneous.

Table X.1 – Alternative minimum clearances for insulation in circuits connected to ac mains not exceeding 420 V peak (300 V RMS)

Clearances in mm

Voltage up to and including V	Mains transient voltage							
	1 500 V [a]				2 500 V [a]			
	Pollution degree							
	1 and 2		3		1 and 2		3	
	B/S	R	B/S	R	B/S	R	B/S	R
71	1,0	2,0	1,3	2,6	2,0	4,0	2,0	4,0
210	1,0	2,0	1,3	2,6	2,0	4,0	2,0	4,0
420	B/S 2,0 R 4,0							
If the peak of the **working voltage** exceeds the peak value of the AC **mains** supply voltage, linear interpolation is permitted between the nearest two points, the calculated minimum **clearance** being rounded up to the next higher 0,1 mm increment.								
[a] The relationship between **mains transient voltage** and AC **mains** supply voltage is given in Table 12.								

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Table X.2 – Additional clearances for insulation in circuits connected to ac mains not exceeding 420 V peak (300 V RMS)

Clearances in mm

Mains transient voltage						
1 500 V [a]				2 500 V [a]		
Voltage up to and including V		Basic or supplementary insulation	Reinforced insulation	Voltage up to and including V	Basic or supplementary insulation	Reinforced insulation
Pollution degrees 1 and 2	Pollution degree 3			Pollution degrees 1, 2 and 3		
210	210	0,0	0,0	420	0,0	0,0
298	294	0,1	0,2	493	0,1	0,2
386	379	0,2	0,4	567	0,2	0,4
474	463	0,3	0,6	640	0,3	0,6
562	547	0,4	0,8	713	0,4	0,8
650	632	0,5	1,0	787	0,5	1,0
738	715	0,6	1,2	860	0,6	1,2
826	800	0,7	1,4	933	0,7	1,4
914	885	0,8	1,6	1 006	0,8	1,6
1 002	970	0,9	1,8	1 080	0,9	1,8
1 090	1 055	1,0	2,0	1 153	1,0	2,0
1 178	1 140	1,1	2,2	1 226	1,1	2,2
1 266	1 225	1,2	2,4	1 300	1,2	2,4
1 354	1 310	1,3	2,6	1 374	1,3	2,6

For voltages above the peak value of the **working voltage** given in the table, linear extrapolation is permitted.

For voltages within the peak value of the **working voltage** given in the table, linear interpolation is permitted between the nearest two points, the calculated minimum additional **clearance** being rounded up to the next higher 0,1 mm increment.

[a] The relationship between **mains transient voltage** and AC **mains** supply voltage is given in Table 12.

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Annex Y
(normative)

Construction requirements for outdoor enclosures

Y.1 General

Protection against corrosion shall be provided by the use of suitable materials or by the application of a protective coating applied to the exposed surface, taking into account the intended conditions of use.

Parts, such as dials or connectors, that serve as a functional part of an **outdoor enclosure** shall comply with the same environmental protection requirements as for the **outdoor enclosure**.

NOTE 1 Aspects affecting safety that influence the integrity of the **outdoor enclosure** through the life of the product include:

– continued protection against access to class 2 and class 3 energy sources, including after mechanical strength tests;

– continued protection against ingress of dust and water; and

– continued provision of earth continuity.

An **outdoor enclosure** shall not be used to carry current during normal operation if this could cause corrosion that would impair safety. This does not preclude connection of a conductive part of an **outdoor enclosure** to **protective earthing** for the purpose of carrying fault currents.

NOTE 2 The action of a current flowing through a joint can increase corrosion under wet conditions.

Where a conductive part of an **outdoor enclosure** is connected to **protective earthing** for the purpose of carrying fault currents, the resulting connection shall meet the requirements of 5.6, after the appropriate weather conditioning tests, see Clause Y.3.

Compliance is checked by inspection and, if necessary, by the tests of 5.6 after the tests of Clause Y.3.

Y.2 Resistance to UV radiation

Non-metallic parts of an **outdoor enclosure** required for compliance with this document shall be sufficiently resistant to degradation by UV radiation.

*Compliance is checked by examination of the construction and of available data regarding the UV resistance characteristics of the **outdoor enclosure** material and any associated protective coating. If such data is not available, Annex C applies.*

Y.3 Resistance to corrosion

Y.3.1 General

Metallic parts of **outdoor enclosures**, with or without protective coatings, shall be resistant to the effects of water-borne contaminants.

Compliance is checked by either:

– *inspection and by evaluation of data provided by the manufacturer; or*

– *the tests and criteria as specified in Y.3.2 through Y.3.5; or*

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– *the applicable performance level (A1, A2 or A3) of IEC 61587-1.*

Y.3.2 Test apparatus

The apparatus for the salt spray test shall consist of a test chamber and spraying devices as described in IEC 60068-2-11.

The apparatus for the test in a water-saturated sulphur dioxide atmosphere shall consist of an inert, hermetically sealed, chamber containing a water-saturated sulphur dioxide atmosphere in which the test specimens and their supports are held. The chamber shall be as described in ISO 3231.

Y.3.3 Water – saturated sulphur dioxide atmosphere

If the test chamber has an internal volume of 300 l ± 30 l the water-saturated sulphur dioxide atmosphere is created by the introduction of 0,2 l of sulphur dioxide with a concentration of 0,067 % by volume into the closed test chamber. The sulphur dioxide can either be introduced from a gas cylinder or by creating a specific reaction within the chamber. For test chambers having a different internal volume the quantity of sulphur dioxide is varied accordingly.

Sulphur dioxide can be formed inside the test apparatus by treating sodium pyrosulphite ($Na_2S_2O_5$) with a relatively strong acid, sulphamic acid (HSO_3NH_2).

NOTE 1 The method consists of dissolving excess sodium pyrosulphite in water, giving the reaction:

$$Na_2S_2O_5 + H_2O \rightarrow 2\ NaHSO_3$$

A stoichiometric quantity of sulphamic acid is then added giving the reaction:

$$NaHSO_3 + HSO_3NH_2 \rightarrow NaSO_3NH_2 + H_2O + SO_2$$

The resulting overall reaction is:

$$Na_2S_2O_5 + 2\ HSO_3NH_2 \rightarrow 2\ NaSO_3NH_2 + H_2O + 2\ SO_2$$

To obtain 1 l of SO_2 under normal conditions of 0 °C temperature and 1,013 3 × 105 Pa, air pressure, 4,24 g sodium pyrosulphite and 4,33 g sulphamic acid are needed.

NOTE 2 Sulphamic acid is the only solid mineral acid that is easy to conserve.

NOTE 3 The above description is taken from 8.2.11.3.1 and 8.2.11.3.2 of IEC 61439-5:2014.

Y.3.4 Test procedure

The test shall consist of two identical and successive 12 day periods.

Each 12 day period consists of test a) followed by test b):

test a) 168 h of exposure to the salt spray atmosphere. The concentration of the saline solution forming the salt spray atmosphere is 5 % ± 1 % by weight and the temperature of the test chamber is maintained at 35 °C ± 2 °C.

test b) 5 exposure cycles each consisting of an 8 h exposure to a water-saturated sulphur dioxide-rich atmosphere (see Y.3.3), during which the temperature of the test chamber is maintained at 40 °C ± 3 °C , followed by 16 h at rest with the test chamber door open.

After each 12 day period, the test specimens are washed with demineralized water.

Alternatively, the test procedures as described in the following standards may be used to show compliance:

– *ISO 21207 Method B; or*

– *ISO 14993; or*

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– *any other equivalent standard.*

Y.3.5 Compliance criteria

*Compliance is checked by visual inspection. The **outdoor enclosure** shall not show rust or oxidation of the protective coating, cracking or other deterioration that will jeopardize the safety aspects as follows:*

– *continued protection against access to class 2 and class 3 energy sources, including after mechanical strength tests; and*

– *continued protection against ingress of dust and water; and*

– *continued provision of earth continuity.*

However, surface corrosion of the protective coating is disregarded.

Y.4 Gaskets

Y.4.1 General

When gaskets are used as the method providing protection against the ingress of potential contaminants, Y.4.2 through Y.4.6 shall apply as appropriate.

NOTE In Canada and the United States, **enclosure** types are specified in the Canadian Electrical Code and the U.S. National Electrical Code.

Joints for all devices closing openings into the equipment cavity of an **outdoor enclosure** subjected to splashing or seepage of oil, as well as any door or cover for such an **outdoor enclosure**, shall include a gasket in the full length of the joint.

A gasket of elastomeric or thermoplastic material, or a composition gasket utilizing an elastomeric material that is provided on an **outdoor enclosure** subjected to water or dust, shall meet requirements of this document.

Compliance is checked by inspection and by applying the relevant tests of Y.4.2 through Y.4.6.

Y.4.2 Gasket tests

The relevant tests specified in Y.4.3 or Y.4.4, depending on the type of gasket material used, are applicable to gaskets employed on an **outdoor enclosure** subjected to water or dust. The additional test of Y.4.5 is applicable to gaskets employed on an **outdoor enclosure** subjected to oil or coolant. A set of three specimens of the gasket material shall be subjected to the relevant tests.

Y.4.3 Tensile strength and elongation tests

This test is applicable to gaskets, which can stretch (such as O-rings). Gasket material shall be of such quality that samples subjected to a temperature of 69 °C to 70 °C in circulating air for 168 h have a tensile strength of not less than 75 % and an elongation of not less than 60 % of values determined for unaged samples. At the conclusion of the temperature conditioning, there shall be no visible deterioration, deformation, melting, or cracking of the material and the material shall not harden as determined by normal hand flexing.

As an alternative, the tensile strength and elongation tests as given in ISO 37, ISO 1798, ASTM D412 or ASTM D3574 may be used.

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Y.4.4 Compression test

This test is applicable to gaskets with closed cell construction. The set of specimens of gasket material shall be tested to the requirements of a), b) and c) (see Figure Y.1). On completion of each test, the specimens shall not show signs of deterioration or cracks that can be seen with normal or corrected vision.

a) A cylindrical weight sufficient to apply 69 kPa shall be placed on the middle portion of each specimen for a period of 2 h. At the end of that time the weight shall be removed and the specimen allowed to rest at a room temperature of 25 °C ± 3 °C for 30 min. The thickness of the gasket shall then be determined and compared with a measurement obtained before the application of the weight. The compression set shall not exceed 50 % of the initial thickness of the specimen.

b) Following the test specified in a), the same specimens shall be suspended in an air oven at a temperature of 70° C for a period of 5 days. The specimens shall then be tested for compliance with a), approximately 24 h after removal from the oven.

c) Following the test specified in b), the same specimens shall be cooled for a period of 24 h to the minimum temperature specified by the manufacturer or -33 °C if no minimum ambient temperature is specified and then subjected to an impact from a hammer of 1,35 kg mass falling from a height of 150 mm upon removal from the cold chamber. The hammer head shall be steel, 28,6 mm in diameter and have a flat striking surface, 25,4 mm in diameter with slightly rounded edges. The specimens being tested shall be placed on short lengths of 50 mm by 100 mm minimum wooden pieces (clear spruce) when being impacted. Following the impact the specimens shall be examined for evidence of cracking or other adverse effects. The test shall be continued and the specimens impacted every 24 h for two more days. The specimens shall then be removed from the cold chamber, allowed to rest at a room temperature of 25 °C ± 3 °C for approximately 24 h, and then again tested for compliance with a).

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Dimensions in millimetres

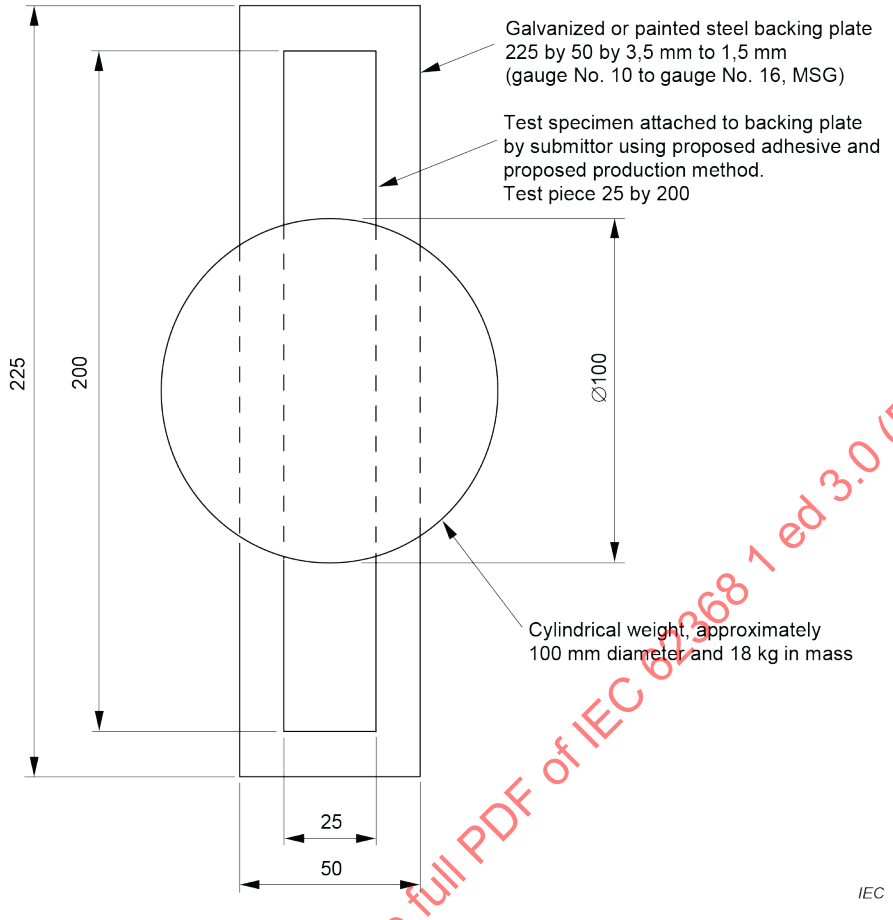


Figure Y.1 – Gasket test

Y.4.5 Oil resistance

A gasket provided on an **outdoor enclosure** subjected to oil or coolant shall be oil resistant.

Compliance is checked by inspection and by the following oil immersion test.

Gasket material shall not swell more than 25 % or shrink more than 1 % as a result of immersion in oil for 70 h at a room temperature of 25 °C ± 3 °C. Specifications are provided in ISO 1817:2015 or ASTM D471-98.

NOTE In Canada and United States, IRM Immersion Oil No. 903 is accepted.

Y.4.6 Securing means

A gasket shall be secured with adhesive or by mechanical means. The gasket and its securing means shall not be damaged when the joint is opened.

Where a gasket is secured by adhesive alone without mechanical securement, and the specific part(s) associated with the gasket may be subjected to opening or similar movement on a periodic basis, the gasket and adhesive shall be subjected to the testing in Clause P.4.Compliance is checked by inspection and available manufacturer's data. If data is not available, then the tests according to Clause P.4 are conducted, as applicable.

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Y.5 Protection of equipment within an outdoor enclosure

Y.5.1 General

Equipment within an **outdoor enclosure** shall have adequate protection from the effects of moisture and excessive dust.

See Table Y.1 for examples for provisions of **pollution degree** environments. To establish a **pollution degree**, both considerations shall be met.

Table Y.1 – Examples of the provision of pollution degree environments

Pollution degree	Method of achievement Dust (Y.5.5)	Method of achievement Moisture (Y.5.1 to Y.5.3)
Pollution degree 3	Default	The use of an **enclosure** meeting IPX4 or the requirements of Y.5.3 relating to the ingress of water is considered to provide a **pollution degree** 3 environment within the **outdoor enclosure**.
Reduction of **pollution degree** 3 to **pollution degree** 2	Reduction of **pollution degree** 3 to **pollution degree** 2 can be accomplished by either: – providing continuous energization of the enclosed equipment; or – providing separate climate conditioning which prevents condensation within the **outdoor equipment** or **outdoor enclosure**; or – IP5X – IP6X – Y.5.5.2 – Y.5.5.3 equivalent (for, example NEMA).	Reduction of the **pollution degree** 3 environment to **pollution degree** 2 can be accomplished by either: – providing continuous energization of the enclosed equipment; or – providing separate climate conditioning which prevents condensation within the **outdoor equipment** or **outdoor enclosure**; or – the use of an **enclosure** meeting IPX4.
Reduction to **pollution degree** 1	See 5.4.1.5.2, Test for **pollution degree** 1 environment and for an insulating compound.	Control of the environment at the insulation surface to **pollution degree** 1 can be accomplished for example by, encapsulation, potting or coating.

Compliance is checked by inspection of the construction, available data and, if necessary, by the tests in Y.5.2 to Y.5.5.

Y.5.2 Protection from moisture

The **outdoor enclosure** shall provide adequate protection from the effect of moisture on the enclosed equipment.

NOTE 1 This does not preclude **outdoor enclosure** or **outdoor equipment** being constructed with segmented volumes, each providing a different **pollution degree**.

NOTE 2 For consideration of the effects of the presence of conductive pollution, as opposed to non-conductive pollution which can become conductive only due to the presence of moisture, see the relevant requirements in IEC 60529.

Where necessary, the **outdoor enclosure** shall be provided with drain holes to control the accumulation of moisture due to:

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– entrance of water through openings; and

– condensation, when this is likely to occur (for example, keeping the equipment energized or separately heating the equipment is considered to keep it free of condensation).

The provision of drain holes and their location shall be taken into consideration when determining the IP rating.

Compliance is checked by inspection and, if necessary, by the relevant tests of IEC 60529 or Y.5.3.

Prior to testing, the equipment shall be mounted, so far as is reasonably practicable, according to the manufacturer's installation instructions. If fans or other means for ventilation are provided, which could affect the ingress of water, the test shall be conducted with the ventilation means both on and off unless it is evident that one of the modes of operation will produce the more onerous result.

At the conclusion of the test the following conditions shall exist:

– For **outdoor enclosures**, no water shall have entered the **outdoor enclosure**.

– For **outdoor equipment**, water is permitted to enter the **outdoor enclosure** provided it does not:

  - deposit on insulation where it could lead to tracking along the **creepage distance**,
  - deposit on bare live parts or bare wiring, or on windings not designed to operate when wet, or
  - enter any supply wiring space, see G.7.6.

Y.5.3 Water spray test

*The water-spray test apparatus, using fresh water, is to consist of three spray heads mounted in a water supply pipe rack as shown in Figure Y.2. Spray heads are to be constructed in accordance with the details shown in Figure Y.3. The **outdoor enclosure** is to be positioned in the focal area of the spray heads so that the greatest quantity of water is likely to enter the **outdoor enclosure**. The water pressure is to be maintained at 34,5 kPa at each spray head. The **outdoor enclosure** is to be exposed to the water spray for 1 h.*

*Unless the construction is such that a test on one side of the **outdoor enclosure** is representative of a test on another side, the test is to be repeated on other sides of the **outdoor enclosure** as necessary.*

*The water spray is to produce a uniform spray over the surface or surfaces under test. The various vertical surfaces of an **outdoor enclosure** may be tested separately or collectively, provided that a uniform spray is applied.*

*The top surface of the **outdoor enclosure** shall be tested by applying a uniform spray from nozzles located at proper heights (see the focal point in Figure Y.2), if*

– *there are openings in the top surface; or*

– *from an examination of the construction, it is determined that run-off from the top surface could cause water ingress at a vertical surface which would not be detected by the test of the vertical surface.*

*If there are openings in a vertical surface, located less than 250 mm above ground level, such that water ingress from rain bouncing upwards from the ground surface might occur, a test shall be performed, spraying water on the ground surface in front of such openings, over such distance necessary to cause the deflected spray to reach the **outdoor enclosure**. This test is not carried out if, from an examination of the construction, it is determined that the test of the vertical surface adequately assures compliance.*

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Dimensions in millimetres, unless indicated otherwise

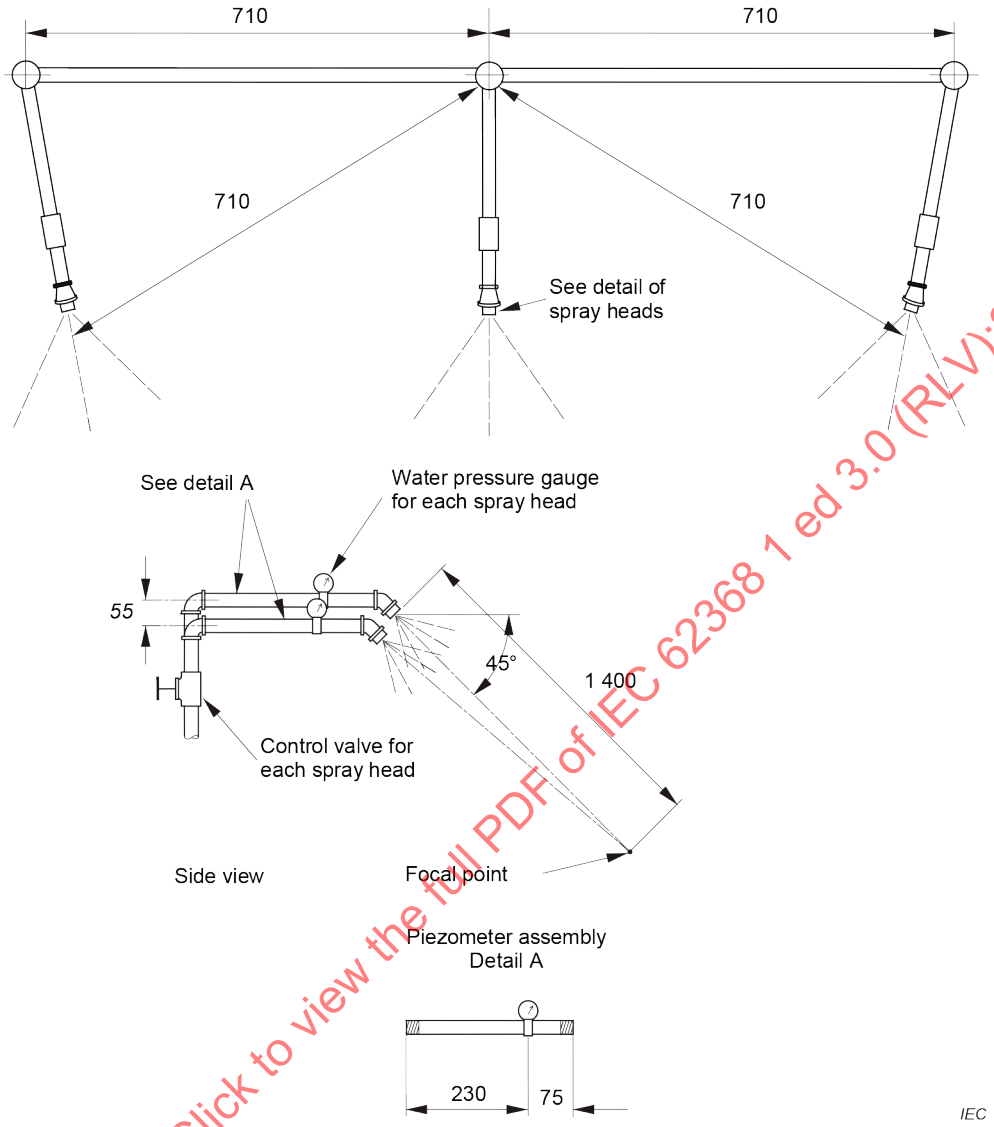


Figure Y.2 – Water-spray test spray-head piping

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Dimensions in millimetres, unless indicated otherwise

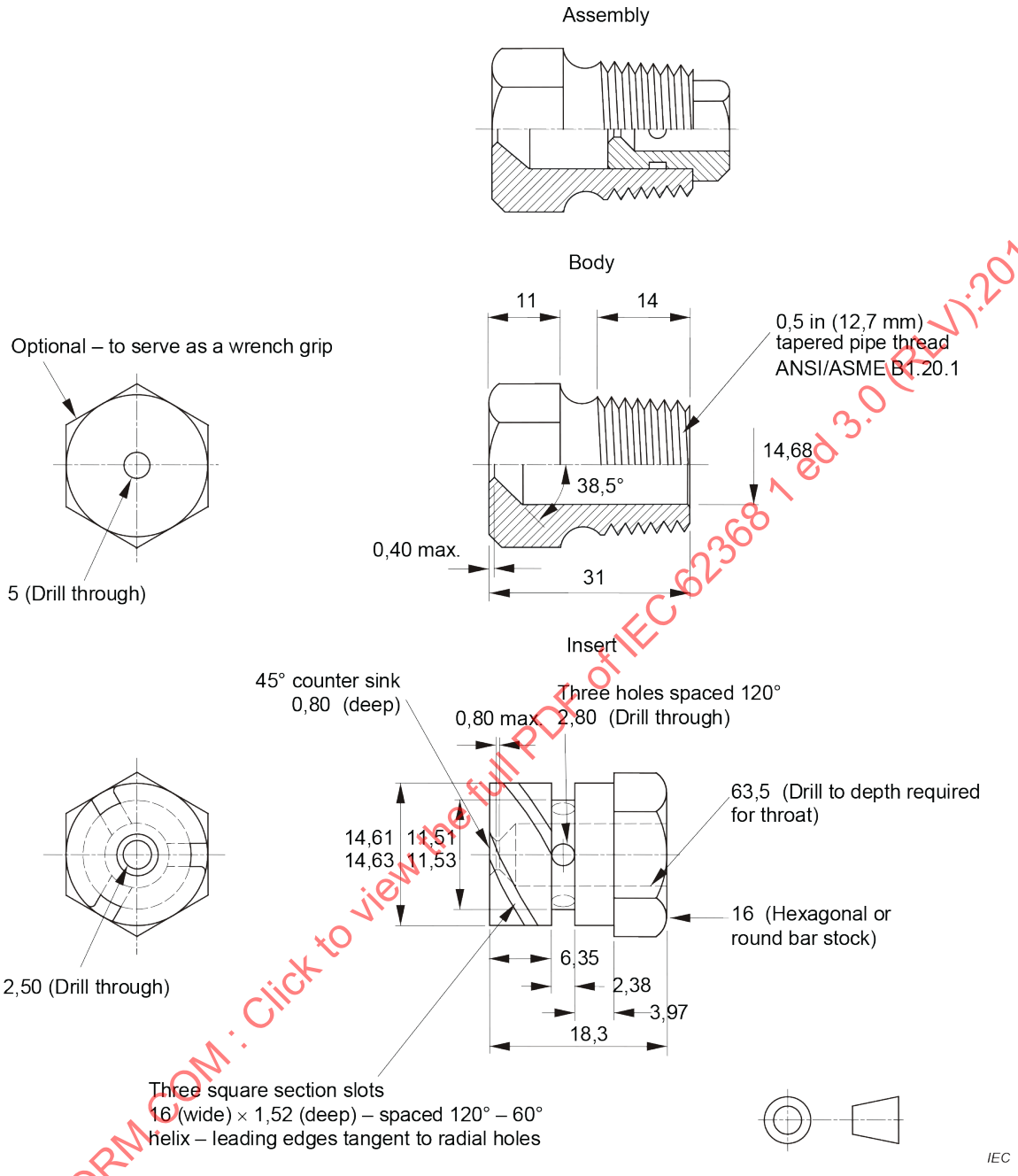


Figure Y.3 – Water-spray test spray head

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Y.5.4 Protection from plants and vermin

If entry by plants and vermin is a consideration, **outdoor equipment** shall have adequate protection.

NOTE For protection against plants and vermin, see IEC 61969-3.

Compliance is checked by inspection.

Y.5.5 Protection from excessive dust

Y.5.5.1 General

Unless the **clearances** and **creepage distances** comply with the requirements as given in 5.4 for **pollution degree** 3, **outdoor equipment** shall have adequate protection against the ingress of the dust through the use of an appropriately rated IP5X or IP6X **enclosure**, or equivalent (for example, an equivalent NEMA rated **enclosure**).

NOTE Dust from road vehicles is not considered to be conductive.

Compliance is checked by inspection and, if necessary, by the relevant tests of IEC 60529 or alternatively, by the tests of Y.5.5.2 or Y.5.5.3 using the acceptance conditions of IEC 60529:1989, Clause 5, 13.5.2 and 13.6.2.

*If the **enclosure** complies with the dust chamber test for IP5X or IP6X, the examination for spherical objects mentioned in the note of 13.3 of IEC 60529:1989 can be considered done and complied with.*

Y.5.5.2 IP5X equipment

Dust-proof equipment (first characteristic IP numeral 5) shall be tested in a dust chamber similar to that shown in Figure 2 of IEC 60529:1989, in which talcum powder is maintained in suspension by an air current. The chamber shall contain 2 kg of powder for every cubic meter of its volume. The talcum powder used shall be able to pass through a square-meshed sieve whose nominal wire diameter is 50 μm and whose nominal free distance between wires is 75 μm. It shall not have been used for more than 20 tests.

The test shall proceed as follows:

*a) The equipment is suspended outside the dust chamber and operated at **rated voltage** until operating temperature is achieved.*

b) The equipment, whilst still operating, is placed with the minimum disturbance in the dust chamber.

c) The door of the dust chamber is closed.

d) The fan/blower causing the talcum powder to be in suspension is switched on.

e) After 1 min, the equipment is disconnected and allowed to cool for 3 h whilst the talcum powder remains in suspension.

NOTE The 1 min interval between switching on the fan/blower and switching off the equipment is to ensure that the talcum powder is properly in suspension around the equipment during initial cooling, which is most important with smaller equipment. The equipment is operated initially as in item a) to ensure the test chamber is not overheated.

Y.5.5.3 IP6X equipment

Dust-tight equipment (first characteristic IP numeral 6) shall be tested in accordance with Y.5.5.2.

Y.6 Mechanical strength of enclosures

Y.6.1 General

Outdoor enclosures and **outdoor equipment** shall have adequate mechanical strength and shall provide protection against access to class 3 energy sources within the equipment throughout the intended ambient operating range.

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Compliance is checked by the inspection of the construction and available data and, if necessary, by the test of Y.6.2. After the test, the level of protection shall remain in accordance with Y.5.5.1,

Y.6.2 Impact test

*For equipment with an **outdoor enclosure** made of polymeric material, the **outdoor enclosure** of the equipment should be subjected to the low temperature conditioning before the impact test. Subsequently **outdoor enclosures** and **outdoor equipment** are to be subjected to the impact test of Clause T.6. Where the **outdoor enclosure** is made of polymeric material, the test is carried out at an ambient temperature equal to the minimum ambient temperature specified by the manufacturer or –33 °C if no minimum ambient temperature is specified, for 24 h. The test can be applied to a portion of the **enclosure** representing the largest unreinforced area, supported in its normal position.*

The impacts are applied to doors, covers, seams and the like which could affect the ingress of dust and moisture. The test is performed whether or not failure would give direct access to class 3 energy sources. The impacts are applied within 2 min of removal from the climatic chamber.

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IEC 62368-1

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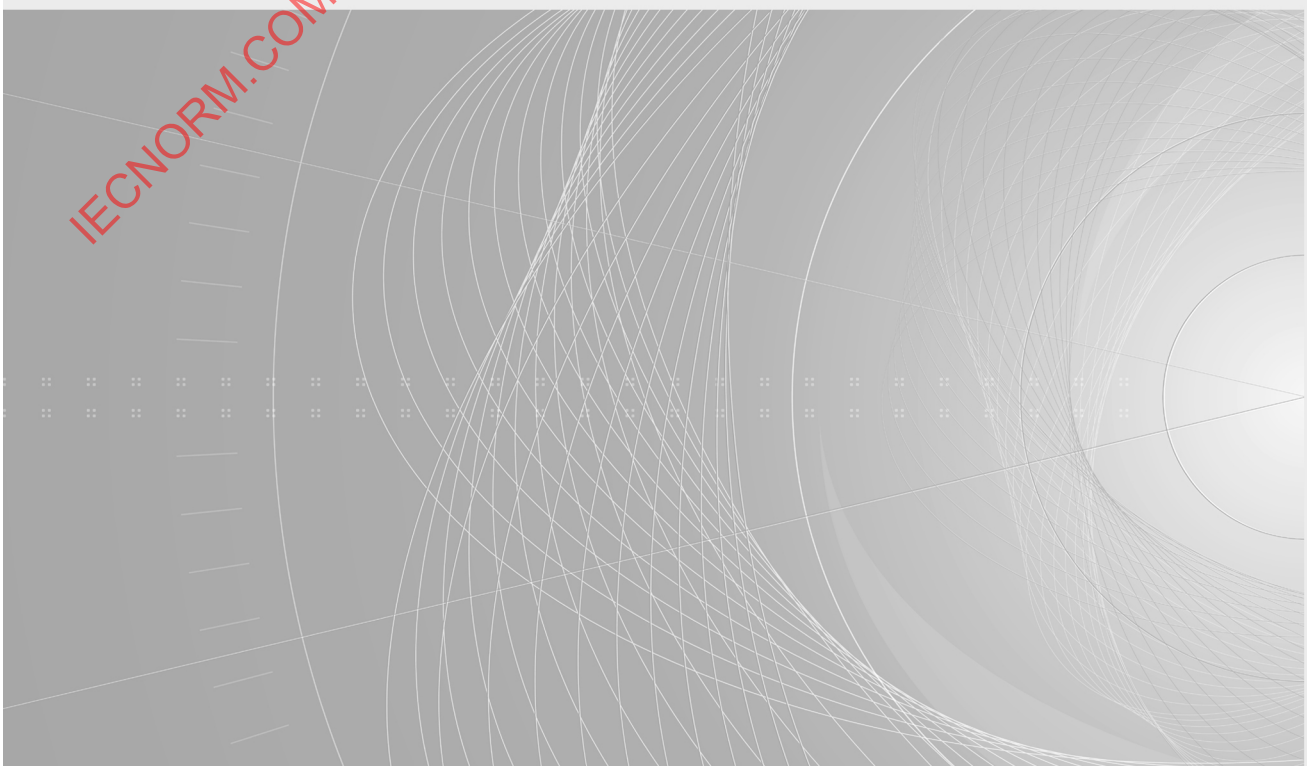
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Audio/video, information and communication technology equipment – Part 1: Safety requirements

Équipements des technologies de l'audio/vidéo, de l'information et de la communication – Partie 1: Exigences de sécurité



IEC 62368-1:2018-10(en-fr)

CONTENTS

FOREWORD 20
INTRODUCTION 23
0 Principles of this product safety standard 23
0.1 Objective 23
0.2 Persons 23
0.2.1 General 23
0.2.2 Ordinary person 23
0.2.3 Instructed person 23
0.2.4 Skilled person 23
0.3 Model for pain and injury 24
0.4 Energy sources 24
0.5 Safeguards 25
0.5.1 General 25
0.5.2 Equipment safeguard 26
0.5.3 Installation safeguard 26
0.5.4 Personal safeguard 26
0.5.5 Behavioural safeguards 27
0.5.6 Safeguards during ordinary or instructed person service conditions 28
0.5.7 Equipment safeguards during skilled person service conditions 28
0.5.8 Examples of safeguard characteristics 28
0.6 Electrically-caused pain or injury (electric shock) 29
0.6.1 Models for electrically-caused pain or injury 29
0.6.2 Models for protection against electrically-caused pain or injury 30
0.7 Electrically-caused fire 31
0.7.1 Models for electrically-caused fire 31
0.7.2 Models for protection against electrically-caused fire 31
0.8 Injury caused by hazardous substances 32
0.9 Mechanically-caused injury 32
0.10 Thermally-caused injury (skin burn) 33
0.10.1 Models for thermally-caused injury 33
0.10.2 Models for protection against thermally-caused pain or injury 34
0.11 Radiation-caused injury 35
1 Scope 36
2 Normative references 37
3 Terms, definitions and abbreviated terms 44
3.1 Energy source abbreviations 44
3.2 Other abbreviations 45
3.3 Terms and definitions 46
3.3.1 Circuit terms 49
3.3.2 Enclosure terms 49
3.3.3 Equipment terms 50
3.3.4 Flammability terms 51
3.3.5 Electrical insulation 53
3.3.6 Miscellaneous 53
3.3.7 Operating and fault conditions 55
3.3.8 Persons 56

IECNORM.COM : Click to view the full PDF of IEC 62368-1:2018 (RLV)

3.3.9 Potential ignition sources 57
3.3.10 Ratings 57
3.3.11 Safeguards 58
3.3.12 Spacings 60
3.3.13 Temperature controls 60
3.3.14 Voltages and currents 60
3.3.15 Classes of equipment with respect to protection from electric shock 61
3.3.16 Chemical terms 62
3.3.17 Batteries 62
3.3.18 FIW terms 63
3.3.19 Sound exposure 63
4 General requirements 64
4.1 General 64
4.1.1 Application of requirements and acceptance of materials, components and subassemblies 64
4.1.2 Use of components 65
4.1.3 Equipment design and construction 65
4.1.4 Equipment installation 65
4.1.5 Constructions and components not specifically covered 66
4.1.6 Orientation during transport and use 66
4.1.7 Choice of criteria 66
4.1.8 Liquids and liquid filled components (LFC) 66
4.1.9 Electrical measuring instruments 67
4.1.10 Temperature measurements 67
4.1.11 Steady state conditions 67
4.1.12 Hierarchy of safeguards 67
4.1.13 Examples mentioned in this document 67
4.1.14 Tests on parts or samples separate from the end-product 67
4.1.15 Markings and instructions 67
4.2 Energy source classifications 68
4.2.1 Class 1 energy source 68
4.2.2 Class 2 energy source 68
4.2.3 Class 3 energy source 68
4.2.4 Energy source classification by declaration 68
4.3 Protection against energy sources 68
4.3.1 General 68
4.3.2 Safeguards for protection of an ordinary person 68
4.3.3 Safeguards for protection of an instructed person 70
4.3.4 Safeguards for protection of a skilled person 71
4.3.5 Safeguards in a restricted access area 72
4.4 Safeguards 72
4.4.1 Equivalent materials or components 72
4.4.2 Composition of a safeguard 72
4.4.3 Safeguard robustness 72
4.4.4 Displacement of a safeguard by an insulating liquid 74
4.4.5 Safety interlocks 75
4.5 Explosion 75
4.5.1 General 75
4.5.2 Requirements 75

IECNORM.COM : Click to view the full PDF of IEC 62368-1:ed 3.0 (RLV):2018

4.6 Fixing of conductors 76
4.6.1 Requirements 76
4.6.2 Compliance criteria 76
4.7 Equipment for direct insertion into mains socket-outlets 76
4.7.1 General 76
4.7.2 Requirements 76
4.7.3 Compliance criteria 76
4.8 Equipment containing coin / button cell batteries 77
4.8.1 General 77
4.8.2 Instructional safeguard 77
4.8.3 Construction 77
4.8.4 Tests 77
4.8.5 Compliance criteria 78
4.9 Likelihood of fire or shock due to entry of conductive objects 79
4.10 Components requirements 79
4.10.1 Disconnect device 79
4.10.2 Switches and relays 79
5 Electrically-caused injury 79
5.1 General 79
5.2 Classification and limits of electrical energy sources 80
5.2.1 Electrical energy source classifications 80
5.2.2 Electrical energy source ES1 and ES2 limits 80
5.3 Protection against electrical energy sources 86
5.3.1 General 86
5.3.2 Accessibility to electrical energy sources and safeguards 86
5.4 Insulation materials and requirements 89
5.4.1 General 89
5.4.2 Clearances 94
5.4.3 Creepage distances 104
5.4.4 Solid insulation 108
5.4.5 Antenna terminal insulation 117
5.4.6 Insulation of internal wire as a part of a supplementary safeguard 117
5.4.7 Tests for semiconductor components and for cemented joints 118
5.4.8 Humidity conditioning 118
5.4.9 Electric strength test 119
5.4.10 Safeguards against transient voltages from external circuits 122
5.4.11 Separation between external circuits and earth 124
5.4.12 Insulating liquid 125
5.5 Components as safeguards 126
5.5.1 General 126
5.5.2 Capacitors and RC units 126
5.5.3 Transformers 127
5.5.4 Optocouplers 127
5.5.5 Relays 127
5.5.6 Resistors 128
5.5.7 SPDs 128
5.5.8 Insulation between the mains and an external circuit consisting of a coaxial cable 129
5.5.9 Safeguards for socket-outlets in outdoor equipment 129

IECNORM.COM : Click to view the full PDF of IEC 62368-1:2018 ed 3.0 (RLV):2018

5.6 Protective conductor 130
5.6.1 General 130
5.6.2 Requirements for protective conductors 130
5.6.3 Requirements for protective earthing conductors 131
5.6.4 Requirements for protective bonding conductors 131
5.6.5 Terminals for protective conductors 134
5.6.6 Resistance of the protective bonding system 135
5.6.7 Reliable connection of a protective earthing conductor 137
5.6.8 Functional earthing 137
5.7 Prospective touch voltage, touch current and protective conductor current 137
5.7.1 General 137
5.7.2 Measuring devices and networks 138
5.7.3 Equipment set-up, supply connections and earth connections 138
5.7.4 Unearthed accessible parts 138
5.7.5 Earthed accessible conductive parts 139
5.7.6 Requirements when touch current exceeds ES2 limits 139
5.7.7 Prospective touch voltage and touch current associated with external circuits 139
5.7.8 Summation of touch currents from external circuits 141
5.8 Backfeed safeguard in battery backed up supplies 143
6 Electrically-caused fire 143
6.1 General 143
6.2 Classification of power sources (PS) and potential ignition sources (PIS) 143
6.2.1 General 143
6.2.2 Power source circuit classifications 144
6.2.3 Classification of potential ignition sources 147
6.3 Safeguards against fire under normal operating conditions and abnormal operating conditions 148
6.3.1 Requirements 148
6.3.2 Compliance criteria 149
6.4 Safeguards against fire under single fault conditions 149
6.4.1 General 149
6.4.2 Reduction of the likelihood of ignition under single fault conditions in PS1 circuits 149
6.4.3 Reduction of the likelihood of ignition under single fault conditions in PS2 circuits and PS3 circuits 149
6.4.4 Control of fire spread in PS1 circuits 151
6.4.5 Control of fire spread in PS2 circuits 151
6.4.6 Control of fire spread in a PS3 circuit 152
6.4.7 Separation of combustible materials from a PIS 152
6.4.8 Fire enclosures and fire barriers 155
6.4.9 Flammability of an insulating liquid 160
6.5 Internal and external wiring 161
6.5.1 General requirements 161
6.5.2 Requirements for interconnection to building wiring. 161
6.5.3 Internal wiring for socket-outlets 161
6.6 Safeguards against fire due to the connection of additional equipment 162
7 Injury caused by hazardous substances 162
7.1 General 162
7.2 Reduction of exposure to hazardous substances 162

IECNORM.COM : Click to view the full PDF of IEC 62368-1 ed 3.0 (RLV):2018

7.3 Ozone exposure 162
7.4 Use of personal safeguards or personal protective equipment (PPE) 162
7.5 Use of instructional safeguards and instructions 163
7.6 Batteries and their protection circuits 163
8 Mechanically-caused injury 163
8.1 General 163
8.2 Mechanical energy source classifications 163
8.2.1 General classification 163
8.2.2 MS1 165
8.2.3 MS2 166
8.2.4 MS3 166
8.3 Safeguards against mechanical energy sources 166
8.4 Safeguards against parts with sharp edges and corners 166
8.4.1 Requirements 166
8.4.2 Compliance criteria 166
8.5 Safeguards against moving parts 167
8.5.1 Requirements 167
8.5.2 Instructional safeguard requirements 168
8.5.3 Compliance criteria 168
8.5.4 Special categories of equipment containing moving parts 168
8.5.5 High pressure lamps 173
8.6 Stability of equipment 174
8.6.1 Requirements 174
8.6.2 Static stability 176
8.6.3 Relocation stability 177
8.6.4 Glass slide test 178
8.6.5 Horizontal force test and compliance criteria 178
8.7 Equipment mounted to a wall, ceiling or other structure 178
8.7.1 Requirements 178
8.7.2 Test methods 178
8.7.3 Compliance criteria 180
8.8 Handle strength 180
8.8.1 General 180
8.8.2 Test method 180
8.9 Wheels or casters attachment requirements 181
8.9.1 General 181
8.9.2 Test method 181
8.10 Carts, stands, and similar carriers 181
8.10.1 General 181
8.10.2 Marking and instructions 181
8.10.3 Cart, stand or carrier loading test and compliance criteria 182
8.10.4 Cart, stand or carrier impact test 183
8.10.5 Mechanical stability 183
8.10.6 Thermoplastic temperature stability 183
8.11 Mounting means for slide-rail mounted equipment (SRME) 183
8.11.1 General 183
8.11.2 Requirements 184
8.11.3 Mechanical strength test 184
8.11.4 Compliance criteria 185

IECNORM.COM : Click to view the full PDF of IEC 62368-1:2018 Ed 3.0 (RLV)

8.12 Telescoping or rod antennas 185
9 Thermal burn injury 185
9.1 General 185
9.2 Thermal energy source classifications 186
9.2.1 TS1 186
9.2.2 TS2 186
9.2.3 TS3 186
9.3 Touch temperature limits 186
9.3.1 Requirements 186
9.3.2 Test method and compliance criteria 186
9.4 Safeguards against thermal energy sources 187
9.5 Requirements for safeguards 188
9.5.1 Equipment safeguard 188
9.5.2 Instructional safeguard 188
9.6 Requirements for wireless power transmitters 188
9.6.1 General 188
9.6.2 Specification of the foreign objects 189
9.6.3 Test method and compliance criteria 191
10 Radiation 192
10.1 General 192
10.2 Radiation energy source classifications 192
10.2.1 General classification 192
10.2.2 RS1 193
10.2.3 RS2 194
10.2.4 RS3 194
10.3 Safeguards against laser radiation 194
10.4 Safeguards against optical radiation from lamps and lamp systems (including LED types) 194
10.4.1 General requirements 194
10.4.2 Requirements for enclosures 196
10.4.3 Instructional safeguard 196
10.4.4 Compliance criteria 198
10.5 Safeguards against X-radiation 198
10.5.1 Requirements 198
10.5.2 Compliance criteria 198
10.5.3 Test method 198
10.6 Safeguards against acoustic energy sources 199
10.6.1 General 199
10.6.2 Classification 200
10.6.3 Requirements for dose-based systems 201
10.6.4 Measurement methods 201
10.6.5 Protection of persons 202
10.6.6 Requirements for listening devices (headphones, earphones, etc.) 202
Annex A (informative) Examples of equipment within the scope of this document 204
Annex B (normative) Normal operating condition tests, abnormal operating condition tests and single fault condition tests 205
B.1 General 205
B.1.1 Test applicability 205
B.1.2 Type of test 205

IECNORM.COM : Click to view the full PDF of IEC 62368-1:2018 Ed 3.0 (RLV)

B.1.3 Test samples 205
B.1.4 Compliance by inspection of relevant data 205
B.1.5 Temperature measurement conditions 205
B.2 Normal operating conditions 206
B.2.1 General 206
B.2.2 Supply frequency 206
B.2.3 Supply voltage 206
B.2.4 Normal operating voltages 206
B.2.5 Input test 207
B.2.6 Operating temperature measurement conditions 208
B.2.7 Battery charging and discharging under normal operating conditions 208
B.3 Simulated abnormal operating conditions 208
B.3.1 General 208
B.3.2 Covering of ventilation openings 209
B.3.3 DC mains polarity test 210
B.3.4 Setting of voltage selector 210
B.3.5 Maximum load at output terminals 210
B.3.6 Reverse battery polarity 210
B.3.7 Audio amplifier abnormal operating conditions 210
B.3.8 Compliance criteria during and after abnormal operating conditions 210
B.4 Simulated single fault conditions 210
B.4.1 General 210
B.4.2 Temperature controlling device 211
B.4.3 Motor tests 211
B.4.4 Functional insulation 211
B.4.5 Short-circuit and interruption of electrodes in tubes and semiconductors 212
B.4.6 Short-circuit or disconnection of passive components 212
B.4.7 Continuous operation of components 212
B.4.8 Compliance criteria during and after single fault conditions 213
B.4.9 Battery charging and discharging under single fault conditions 213
Annex C (normative) UV radiation 214
C.1 Protection of materials in equipment from UV radiation 214
C.1.1 General 214
C.1.2 Requirements 214
C.1.3 Test method and compliance criteria 214
C.2 UV light conditioning test 215
C.2.1 Test apparatus 215
C.2.2 Mounting of test samples 215
C.2.3 Carbon-arc light-exposure test 215
C.2.4 Xenon-arc light-exposure test 215
Annex D (normative) Test generators 216
D.1 Impulse test generators 216
D.2 Antenna interface test generator 216
D.3 Electronic pulse generator 217
Annex E (normative) Test conditions for equipment containing audio amplifiers 218
E.1 Electrical energy source classification for audio signals 218
E.2 Audio amplifier normal operating conditions 218
E.3 Audio amplifier abnormal operating conditions 219
Annex F (normative) Equipment markings, instructions, and instructional safeguards 220

IECNORM.COM : Click to view the full PDF of IEC 62368-1:2018 ed 3.0 (RLV):2018

F.1 General 220
F.2 Letter symbols and graphical symbols 220
F.2.1 Letter symbols 220
F.2.2 Graphical symbols 220
F.2.3 Compliance criteria 220
F.3 Equipment markings 220
F.3.1 Equipment marking locations 220
F.3.2 Equipment identification markings 221
F.3.3 Equipment rating markings 221
F.3.4 Voltage setting device 223
F.3.5 Markings on terminals and operating devices 223
F.3.6 Equipment markings related to equipment classification 225
F.3.7 Equipment IP rating marking 225
F.3.8 External power supply output marking 226
F.3.9 Durability, legibility and permanence of markings 226
F.3.10 Test for the permanence of markings 226
F.4 Instructions 226
F.5 Instructional safeguards 227
Annex G (normative) Components 230
G.1 Switches 230
G.1.1 General 230
G.1.2 Requirements 230
G.1.3 Test method and compliance criteria 231
G.2 Relays 231
G.2.1 Requirements 231
G.2.2 Overload test 232
G.2.3 Relay controlling connectors supplying power to other equipment 232
G.2.4 Test method and compliance criteria 232
G.3 Protective devices 232
G.3.1 Thermal cut-offs 232
G.3.2 Thermal links 233
G.3.3 PTC thermistors 234
G.3.4 Overcurrent protective devices 235
G.3.5 Safeguard components not mentioned in G.3.1 to G.3.4 235
G.4 Connectors 235
G.4.1 Clearance and creepage distance requirements 235
G.4.2 Mains connectors 235
G.4.3 Connectors other than mains connectors 236
G.5 Wound components 236
G.5.1 Wire insulation in wound components 236
G.5.2 Endurance test 236
G.5.3 Transformers 238
G.5.4 Motors 246
G.6 Wire insulation 250
G.6.1 General 250
G.6.2 Enamelled winding wire insulation 251
G.7 Mains supply cords 251
G.7.1 General 251
G.7.2 Cross sectional area 252

IECNORM.COM : Click to view the full PDF of IEC 62368-1:2018 ed 3.0 (RLV)

G.7.3 Cord anchorages and strain relief for non-detachable power supply cords 254
G.7.4 Cord entry 255
G.7.5 Non-detachable cord bend protection 255
G.7.6 Supply wiring space 256
G.8 Varistors 257
G.8.1 General 257
G.8.2 Safeguards against fire 258
G.9 Integrated circuit (IC) current limiters 260
G.9.1 Requirements 260
G.9.2 Test program 260
G.9.3 Compliance criteria 261
G.10 Resistors 261
G.10.1 General 261
G.10.2 Conditioning 261
G.10.3 Resistor test 262
G.10.4 Voltage surge test 262
G.10.5 Impulse test 262
G.10.6 Overload test 262
G.11 Capacitors and RC units 262
G.11.1 General 262
G.11.2 Conditioning of capacitors and RC units 262
G.11.3 Rules for selecting capacitors 263
G.12 Optocouplers 263
G.13 Printed boards 264
G.13.1 General 264
G.13.2 Uncoated printed boards 264
G.13.3 Coated printed boards 264
G.13.4 Insulation between conductors on the same inner surface 265
G.13.5 Insulation between conductors on different surfaces 266
G.13.6 Tests on coated printed boards 266
G.14 Coatings on component terminals 268
G.14.1 Requirements 268
G.14.2 Test method and compliance criteria 268
G.15 Pressurized liquid filled components 269
G.15.1 Requirements 269
G.15.2 Test methods and compliance criteria 269
G.15.3 Compliance criteria 270
G.16 IC that includes a capacitor discharge function (ICX) 270
G.16.1 Requirements 270
G.16.2 Tests 270
G.16.3 Compliance criteria 271
Annex H (normative) Criteria for telephone ringing signals 272
H.1 General 272
H.2 Method A 272
H.3 Method B 275
H.3.1 Ringing signal 275
H.3.2 Tripping device and monitoring voltage 275

IECNORM.COM : Click to view the full PDF of IEC 62368-1:2018 (RLV)

Annex I (informative) Overvoltage categories (see IEC 60364-4-44) 277
Annex J (normative) Insulated winding wires for use without interleaved insulation 278
J.1 General 278
J.2 Type tests 278
J.2.1 General 278
J.2.2 Electric strength 278
J.2.3 Flexibility and adherence 279
J.2.4 Heat shock 279
J.2.5 Retention of electric strength after bending 280
J.3 Testing during manufacturing 280
J.3.1 General 280
J.3.2 Spark test 280
J.3.3 Sampling test 280
Annex K (normative) Safety interlocks 281
K.1 General 281
K.1.1 General requirements 281
K.1.2 Test method and compliance criteria 281
K.2 Components of the safety interlock safeguard mechanism 281
K.3 Inadvertent change of operating mode 282
K.4 Interlock safeguard override 282
K.5 Fail-safe 282
K.5.1 Requirement 282
K.5.2 Test method and compliance criteria 282
K.6 Mechanically operated safety interlocks 283
K.6.1 Endurance requirement 283
K.6.2 Test method and compliance criteria 283
K.7 Interlock circuit isolation 283
K.7.1 Separation distances for contact gaps and interlock circuit elements 283
K.7.2 Overload test 284
K.7.3 Endurance test 284
K.7.4 Electric strength test 284
Annex L (normative) Disconnect devices 285
L.1 General requirements 285
L.2 Permanently connected equipment 285
L.3 Parts that remain energized 285
L.4 Single-phase equipment 285
L.5 Three-phase equipment 286
L.6 Switches as disconnect devices 286
L.7 Plugs as disconnect devices 286
L.8 Multiple power sources 286
L.9 Compliance criteria 287
Annex M (normative) Equipment containing batteries and their protection circuits 288
M.1 General requirements 288
M.2 Safety of batteries and their cells 288
M.2.1 Requirements 288
M.2.2 Compliance criteria 288
M.3 Protection circuits for batteries provided within the equipment 288
M.3.1 Requirements 288

IECNORM.COM : Click to view the full PDF of IEC 62368-1 ed 3.0 (RLV):2018

M.3.2 Test method 289
M.3.3 Compliance criteria 290
M.4 Additional safeguards for equipment containing a portable secondary lithium battery 290
M.4.1 General 290
M.4.2 Charging safeguards 290
M.4.3 Fire enclosure 291
M.4.4 Drop test of equipment containing a secondary lithium battery 291
M.5 Risk of burn due to short-circuit during carrying 292
M.5.1 Requirements 292
M.5.2 Test method and compliance criteria 293
M.6 Safeguards against short-circuits 293
M.6.1 Requirements 293
M.6.2 Compliance criteria 293
M.7 Risk of explosion from lead acid and NiCd batteries 293
M.7.1 Ventilation preventing an explosive gas concentration 293
M.7.2 Test method and compliance criteria 294
M.7.3 Ventilation tests 297
M.7.4 Marking requirement 298
M.8 Protection against internal ignition from external spark sources of batteries with aqueous electrolyte 298
M.8.1 General 298
M.8.2 Test method 298
M.9 Preventing electrolyte spillage 301
M.9.1 Protection from electrolyte spillage 301
M.9.2 Tray for preventing electrolyte spillage 301
M.10 Instructions to prevent reasonably foreseeable misuse 301
Annex N (normative) Electrochemical potentials (V) 303
Annex O (normative) Measurement of creepage distances and clearances 304
Annex P (normative) Safeguards against conductive objects 311
P.1 General 311
P.2 Safeguards against entry or consequences of entry of a foreign object 311
P.2.1 General 311
P.2.2 Safeguards against entry of a foreign object 311
P.2.3 Safeguards against the consequences of entry of a foreign object 312
P.3 Safeguards against spillage of internal liquids 314
P.3.1 General 314
P.3.2 Determination of spillage consequences 314
P.3.3 Spillage safeguards 314
P.3.4 Compliance criteria 315
P.4 Metallized coatings and adhesives securing parts 315
P.4.1 General 315
P.4.2 Tests 315
Annex Q (normative) Circuits intended for interconnection with building wiring 317
Q.1 Limited power source 317
Q.1.1 Requirements 317
Q.1.2 Test method and compliance criteria 317
Q.2 Test for external circuits – paired conductor cable 318
Annex R (normative) Limited short-circuit test 319

IECNORM.COM : Click to view the full PDF of IEC 62368-1:2018 (RLV)

R.1 General 319
R.2 Test setup 319
R.3 Test method 319
R.4 Compliance criteria 320
Annex S (normative) Tests for resistance to heat and fire 321
S.1 Flammability test for fire enclosure and fire barrier materials of equipment where the steady state power does not exceed 4 000 W 321
S.2 Flammability test for fire enclosure and fire barrier integrity 322
S.3 Flammability tests for the bottom of a fire enclosure 323
S.3.1 Mounting of samples 323
S.3.2 Test method and compliance criteria 323
S.4 Flammability classification of materials 324
S.5 Flammability test for fire enclosure materials of equipment with a steady state power exceeding 4 000 W 325
Annex T (normative) Mechanical strength tests 327
T.1 General 327
T.2 Steady force test, 10 N 327
T.3 Steady force test, 30 N 327
T.4 Steady force test, 100 N 327
T.5 Steady force test, 250 N 327
T.6 Enclosure impact test 327
T.7 Drop test 328
T.8 Stress relief test 328
T.9 Glass impact test 329
T.10 Glass fragmentation test 329
T.11 Test for telescoping or rod antennas 330
Annex U (normative) Mechanical strength of CRTs and protection against the effects of implosion 331
U.1 General 331
U.2 Test method and compliance criteria for non-intrinsically protected CRTs 332
U.3 Protective screen 332
Annex V (normative) Determination of accessible parts 333
V.1 Accessible parts of equipment 333
V.1.1 General 333
V.1.2 Test method 1 – Surfaces and openings tested with jointed test probes 333
V.1.3 Test method 2 – Openings tested with straight unjointed test probes 333
V.1.4 Test method 3 – Plugs, jacks, connectors 336
V.1.5 Test method 4 – Slot openings 336
V.1.6 Test method 5 – Terminals intended to be used by an ordinary person 337
V.2 Accessible part criterion 338
Annex W (informative) Comparison of terms introduced in this document 339
W.1 General 339
W.2 Comparison of terms 339
Annex X (normative) Alternative method for determining clearances for insulation in circuits connected to an AC mains not exceeding 420 V peak (300 V RMS) 356
Annex Y (normative) Construction requirements for outdoor enclosures 358
Y.1 General 358
Y.2 Resistance to UV radiation 358
Y.3 Resistance to corrosion 358

IECNORM.COM : Click to view the full PDF of IEC 62368-1:2018 Ed. 3.0 (RLV):2018

Y.3.1 General 358
Y.3.2 Test apparatus 359
Y.3.3 Water – saturated sulphur dioxide atmosphere 359
Y.3.4 Test procedure 359
Y.3.5 Compliance criteria 360
Y.4 Gaskets 360
Y.4.1 General 360
Y.4.2 Gasket tests 360
Y.4.3 Tensile strength and elongation tests 360
Y.4.4 Compression test 361
Y.4.5 Oil resistance 362
Y.4.6 Securing means 362
Y.5 Protection of equipment within an outdoor enclosure 363
Y.5.1 General 363
Y.5.2 Protection from moisture 363
Y.5.3 Water spray test 364
Y.5.4 Protection from plants and vermin 366
Y.5.5 Protection from excessive dust 367
Y.6 Mechanical strength of enclosures 367
Y.6.1 General 367
Y.6.2 Impact test 368
Bibliography 369

Figure 1 – Three block model for pain and injury 24
Figure 2 – Three block model for safety 25
Figure 3 – Schematic and model for electrically-caused pain or injury 30
Figure 4 – Model for protection against electrically-caused pain or injury 30
Figure 5 – Model for electrically-caused fire 31
Figure 6 – Models for protection against fire 32
Figure 7 – Schematic and model for thermally-caused injury 34
Figure 8 – Model for protection against thermally-caused injury 34
Figure 9 – Model for protection of an ordinary person against a class 1 energy source 69
Figure 10 – Model for protection of an ordinary person against a class 2 energy source 69
Figure 11 – Model for protection of an ordinary person against a class 2 energy source during ordinary person servicing conditions 69
Figure 12 – Model for protection of an ordinary person against a class 3 energy source 70
Figure 13 – Model for protection of an instructed person against a class 1 energy source 70
Figure 14 – Model for protection of an instructed person against a class 2 energy source 70
Figure 15 – Model for protection of an instructed person against a class 3 energy source 71
Figure 16 – Model for protection of a skilled person against a class 1 energy source 71
Figure 17 – Model for protection of a skilled person against a class 2 energy source 71
Figure 18 – Model for protection of a skilled person against a class 3 energy source 71

IECNORM.COM : Click to view the full PDF of IEC 62368-1:2018 ed 3.0 (RLV):2018

Figure 19 – Model for protection of a skilled person against class 3 energy sources during equipment servicing conditions 72
Figure 20 – Test hook 79
Figure 21 – Illustration showing ES limits for voltage and current 81
Figure 22 – Maximum values for combined AC current and DC current 83
Figure 23 – Maximum values for combined AC voltage and DC voltage 83
Figure 24 – Contact requirements to bare internal conductive parts 87
Figure 25 – Mandrel 112
Figure 26 – Initial position of mandrel 113
Figure 27 – Final position of mandrel 113
Figure 28 – Position of metal foil on insulating material 113
Figure 29 – Example of electric strength test instrument for solid insulation 121
Figure 30 – Application points of test voltage 122
Figure 31 – Test for separation between an external circuit and earth 125
Figure 32 – Test circuit for touch current of single-phase equipment 141
Figure 33 – Test circuit for touch current of three-phase equipment 141
Figure 34 – Power measurement for worst-case fault 145
Figure 35 – Power measurement for worst-case power source fault 146
Figure 36 – Illustration of power source classification 147
Figure 37 – Minimum separation requirements from a PIS 153
Figure 38 – Extended separation requirements from a PIS 153
Figure 39 – Deflected separation requirements from a PIS when a fire barrier is used 154
Figure 40 – Determination of top, bottom and side openings 156
Figure 41 – Top openings 157
Figure 42 – Bottom openings 158
Figure 43 – Baffle plate construction 158
Figure 44 – PIS trajectory downwards 159
Figure 45 – Limits for moving fan blades made of non-plastic materials 165
Figure 46 – Limits for moving fan blades made of plastic materials 165
Figure 47 – Steel disc 189
Figure 48 – Aluminium ring 190
Figure 49 – Aluminium foil 191
Figure 50 – Example of a warning label for a lamp with multiple hazard spectral regions 198
Figure D.1 – 1,2/50 μs and 10/700 μs voltage impulse generator 216
Figure D.2 – Antenna interface test generator circuit 217
Figure D.3 – Example of an electronic pulse generator 217
Figure E.1 – Band-pass filter for wide-band noise measurement 219
Figure F.1 – Example of an instructional safeguard 228
Figure G.1 – Determination of arithmetic average temperature 241
Figure G.2 – Test voltages 246
Figure G.3 – Thermal ageing time 267
Figure G.4 – Abrasion resistance test for coating layers 268
Figure H.1 – Definition of ringing period and cadence cycle 273

IECNORM.COM : Click to view the full PDF of IEC 62368-1 ed 3.0 (RLV):2018

Figure H.2 – I_{TS1} limit curve for cadenced ringing signal 274
Figure H.3 – Peak and peak-to-peak currents 274
Figure H.4 – Ringing voltage trip criteria 276
Figure M.1 – Distance d as a function of the rated capacity for various charge currents I (mA/Ah) 301
Figure O.1 – Narrow groove 304
Figure O.2 – Wide groove 305
Figure O.3 – V-shaped groove 305
Figure O.4 – Intervening unconnected conductive part 305
Figure O.5 – Rib 305
Figure O.6 – Uncemented joint with narrow groove 306
Figure O.7 – Uncemented joint with wide groove 306
Figure O.8 – Uncemented joint with narrow and wide grooves 306
Figure O.9 – Narrow recess 307
Figure O.10 – Wide recess 307
Figure O.11 – Coating around terminals 308
Figure O.12 – Coating over printed wiring 308
Figure O.13 – Example of measurements in an enclosure of insulating material 309
Figure O.14 – Cemented joints in multi-layer printed boards 309
Figure O.15 – Device filled with insulating compound 310
Figure O.16 – Partitioned bobbin 310
Figure P.1 – Examples of cross-sections of designs of top openings which prevent vertical entry 312
Figure P.2 – Examples of cross-sections of designs of side opening louvres which prevent vertical entry 312
Figure P.3 – Internal volume locus for foreign object entry 313
Figure S.1 – Top openings / surface of fire enclosure or fire barrier 323
Figure T.1 – Impact test using sphere 328
Figure V.1 – Jointed test probe for equipment likely to be accessible to children 334
Figure V.2 – Jointed test probe for equipment not likely to be accessible to children 335
Figure V.3 – Blunt probe 336
Figure V.4 – Wedge probe 337
Figure V.5 – Terminal probe 338
Figure Y.1 – Gasket test 362
Figure Y.2 – Water-spray test spray-head piping 365
Figure Y.3 – Water-spray test spray head 366

Table 1 – Response to energy class 24
Table 2 – Examples of body response or property damage related to energy sources 25
Table 3 – Examples of safeguard characteristics 29
Table 4 – Electrical energy source limits for steady state ES1 and ES2 82
Table 5 – Electrical energy source limits for a charged capacitor 84
Table 6 – Voltage limits for single pulses 85
Table 7 – Current limits for single pulses 85

IECNORM.COM : Click to view the full PDF of IEC 62368-1 ed 3.0 (RLV):2018

Table 8 – Minimum air gap distance 88
Table 9 – Temperature limits for materials, components and systems 90
Table 10 – Minimum clearances for voltages with frequencies up to 30 kHz 96
Table 11 – Minimum clearances for voltages with frequencies above 30 kHz 97
Table 12 – Mains transient voltages 98
Table 13 – External circuit transient voltages 100
Table 14 – Minimum clearances using required withstand voltage 102
Table 15 – Electric strength test voltages 103
Table 16 – Multiplication factors for clearances and test voltages 104
Table 17 – Minimum creepage distances for basic insulation and supplementary insulation in mm 107
Table 18 – Minimum values of creepage distances (in mm) for frequencies higher than 30 kHz and up to 400 kHz 108
Table 19 – Tests for insulation in non-separable layers 111
Table 20 – Electric field strength E_P for some commonly used materials 115
Table 21 – Reduction factors for the value of breakdown electric field strength E_P at higher frequencies 116
Table 22 – Reduction factors for the value of breakdown electric field strength E_P at higher frequencies for thin materials 116
Table 23 – Values for insulation resistance 117
Table 24 – Distance through insulation of internal wiring 118
Table 25 – Test voltages for electric strength tests based on transient voltages 120
Table 26 – Test voltages for electric strength tests based on the peak of the working voltages and recurring peak voltages 120
Table 27 – Test voltages for electric strength tests based on temporary overvoltages 120
Table 28 – Test values for electric strength tests 123
Table 29 – Overview of tests for resistor applications 128
Table 30 – Protective earthing conductor sizes for reinforced safeguards for permanently connected equipment 131
Table 31 – Minimum protective bonding conductor size of copper conductors 133
Table 32 – Sizes of terminals for protective conductors 135
Table 33 – Test duration, mains connected equipment 136
Table 34 – List of applicable IEC standards regarding insulating liquids 160
Table 35 – Classification for various categories of mechanical energy sources 164
Table 36 – Overview of requirements and tests 175
Table 37 – Torque to be applied to screws 180
Table 38 – Touch temperature limits for accessible parts 187
Table 39 – Radiation energy source classifications 192
Table 40 – Allowable radiation level according to IEC 62471 (all parts) for each hazard type 195
Table 41 – Hazard-related risk group marking of equipment 197
Table 42 – Explanation of marking information and guidance on control measures 197
Table C.1 – Minimum property retention limits after UV exposure 214
Table D.1 – Component values for Figure D.1 and Figure D.2 217
Table E.1 – Audio signal electrical energy source classes and safeguards 218

IECNORM.COM : Click to view the full PDF of IEC 62368-1:2018 Ed 3.0 (RLV):2018

Table F.1 – Instructional safeguard element description and examples 228
Table F.2 – Examples of markings, instructions, and instructional safeguards 229
Table G.1 – Peak surge current 231
Table G.2 – Test temperature and testing time (days) per cycle 237
Table G.3 – Temperature limits for transformer windings and for motor windings (except for the motor running overload test) 240
Table G.4 – Test voltages for electric strength tests based on the peak of the working voltages 242
Table G.5 – Values of FIW wires with maximum overall diameter and minimum test voltages according to the enamel increase 245
Table G.6 – Temperature limits for running overload tests 247
Table G.7 – Sizes of conductors 253
Table G.8 – Strain relief test force 254
Table G.9 – Range of conductor sizes to be accepted by terminals 256
Table G.10 – Varistor overload and temporary overvoltage test 259
Table G.11 – Performance test program for integrated circuit (IC) current limiters 261
Table G.12 – Capacitor ratings according to IEC 60384-14 263
Table G.13 – Minimum separation distances for coated printed boards 265
Table G.14 – Insulation in printed boards 266
Table I.1 – Overvoltage categories 277
Table J.1 – Mandrel diameter 279
Table J.2 – Oven temperature 280
Table M.1 – Values for current I_{float} and I_{boost}, factors f_g and f_s, and voltages U_{float} and U_{boost} 296
Table O.1 – Value of X 304
Table Q.1 – Limits for inherently limited power sources 317
Table Q.2 – Limits for power sources not inherently limited (overcurrent protective device required) 318
Table S.1 – Foamed materials 324
Table S.2 – Rigid materials 324
Table S.3 – Very thin materials 324
Table T.1 – Impact force 329
Table T.2 – Torque values for end-piece test 330
Table W.1 – Comparison of terms and definitions in IEC 60664-1:2007 and IEC 62368-1 340
Table W.2 – Comparison of terms and definitions in IEC 61140:2016 and IEC 62368-1 342
Table W.3 – Comparison of terms and definitions in IEC 60950-1:2005 and IEC 62368-1 345
Table W.4 – Comparison of terms and definitions in IEC 60728-11:2016 and IEC 62368-1 349
Table W.5 – Comparison of terms and definitions in IEC 62151:2000 and IEC 62368-1 351
Table W.6 – Comparison of terms and definitions in IEC 60065:2014 and IEC 62368-1 353
Table X.1 – Alternative minimum clearances for insulation in circuits connected to ac mains not exceeding 420 V peak (300 V RMS) 356
Table X.2 – Additional clearances for insulation in circuits connected to ac mains not exceeding 420 V peak (300 V RMS) 357

IECNORM.COM : Click to view the full PDF of IEC 62368-1 ed 3.0 (RLV):2018

Table Y.1 – Examples of the provision of pollution degree environments 363

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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AUDIO/VIDEO, INFORMATION AND COMMUNICATION TECHNOLOGY EQUIPMENT –

Part 1: Safety requirements

FOREWORD

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International Standard IEC 62368-1 has been prepared by TC 108: Safety of electronic equipment within the field of audio/video, information technology and communication technology.

This third edition cancels and replaces the second edition published in 2014. This edition constitutes a technical revision.

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

– addition of requirements for outdoor equipment;
– new requirements for optical radiation;
– addition of requirements for insulating liquids;
– addition of requirements for work cells;

– addition of requirements for wireless power transmitters;
– addition of requirements for fully insulated winding wire (FIW);
– alternative method for determination of top, bottom and side openings for fire enclosures;
– alternative requirements for sound pressure.

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

FDIS	Report on voting
108/701/FDIS	108/707/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

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

A list of all parts in the IEC 62368 series, published under the general title *Audio/video, information and communication technology equipment*, can be found on the IEC website.

The “in some countries” notes regarding differing national practices are contained in the following clauses, subclauses and tables:

0.2.1, Clause 1, 3.3.8.1, 3.3.8.3, 4.1.15, 4.7.3, 5.2.2.2, 5.4.2.3.2.4, 5.4.2.5, 5.4.5.1, 5.4.10.2.1, 5.4.10.2.2, 5.4.10.2.3, 5.5.2.1, 5.5.6, 5.6.4.2.1, 5.6.8, 5.7.6, 5.7.7.1, 8.5.4.2.3, 10.5.3, 10.6.1, F.3.3.6, Y.4.1, Y.4.5, Table 12, Table 13 and Table 39.

In this document, the following print types or formats are used:

– requirements proper and normative annexes: in roman type;
– compliance statements and test specifications: *in italic type*;
– notes/explanatory matter: in smaller roman type;
– normative conditions within tables: in smaller roman type;
– terms that are defined in 3.3: **bold**.

In figures and tables, if colour is available:

– green colour denotes a class 1 energy source;
– yellow colour denotes a class 2 energy source;
– red colour denotes a class 3 energy source.

A comparison of terms introduced in this document that are different from other existing IEC documents is given in Annex W.

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The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://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.

NOTE Explanatory information related to IEC 62368-1 is contained in IEC TR 62368-2. It provides rationale together with explanatory information related to this document.

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 document using a colour printer.

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INTRODUCTION

0 Principles of this product safety standard

0.1 Objective

This part of IEC 62368 is a product safety standard that classifies energy sources, prescribes **safeguards** against those energy sources, and provides guidance on the application of, and requirements for, those **safeguards**.

The prescribed **safeguards** are intended to reduce the likelihood of pain, injury and, in the case of fire, property damage.

The objective of the INTRODUCTION is to help designers to understand the underlying principles of safety in order to design safe equipment. These principles are informative and not an alternative to the detailed requirements of this document.

0.2 Persons

0.2.1 General

This document describes **safeguards** for the protection of three kinds of persons: the **ordinary person**, the **instructed person**, and the **skilled person**. Unless otherwise specified, the requirements for an **ordinary person** apply. This document assumes that a person will not intentionally create conditions or situations that could cause pain or injury.

NOTE 1 In Australia, the work conducted by an **instructed person** or **skilled person** may require formal licensing from regulatory authorities.

NOTE 2 In Germany, a person may only be regarded as an **instructed person** or a **skilled person** if certain legal requirements are fulfilled.

0.2.2 Ordinary person

Ordinary person is the term applied to all persons other than **instructed persons** and **skilled persons**. **Ordinary persons** include not only users of the equipment, but also all persons who may have access to the equipment or who may be in the vicinity of the equipment. Under **normal operating conditions** or **abnormal operating conditions**, **ordinary persons** should not be exposed to parts comprising energy sources capable of causing pain or injury. Under a **single fault condition**, **ordinary persons** should not be exposed to parts comprising energy sources capable of causing injury.

0.2.3 Instructed person

Instructed person is a term applied to persons who have been instructed and trained by a **skilled person**, or who are supervised by a **skilled person**, to identify energy sources that may cause pain (see Table 1) and to take precautions to avoid unintentional contact with or exposure to those energy sources. Under **normal operating conditions**, **abnormal operating conditions** or **single fault conditions**, **instructed persons** should not be exposed to parts comprising energy sources capable of causing injury.

0.2.4 Skilled person

Skilled person is a term applied to persons who have training or experience in the equipment technology, particularly in knowing the various energies and energy magnitudes used in the equipment. **Skilled persons** are expected to use their training and experience to recognize energy sources capable of causing pain or injury and to take action for protection from injury from those energies. **Skilled persons** should also be protected against unintentional contact or exposure to energy sources capable of causing injury.

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0.3 Model for pain and injury

An energy source that causes pain or injury does so through the transfer of some form of energy to or from a body part.

This concept is represented by a three-block model (see Figure 1).

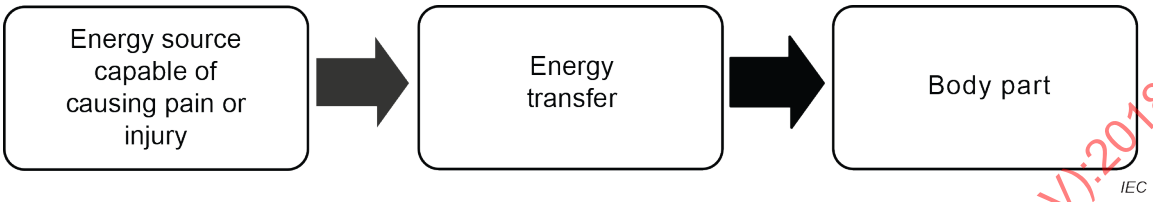


Figure 1 – Three block model for pain and injury

This safety standard specifies three classes of energy sources defined by magnitudes and durations of source parameters relative to the body responses to those electrical and thermal energy sources (see Table 1). Source parameters relative to responses to **combustible material**, mechanical energy sources and radiation energy sources are specified based on experience and basic safety standards.

Table 1 – Response to energy class

Energy source	Effect on the body	Effect on combustible materials
Class 1	Not painful, but may be detectable	Ignition not likely
Class 2	Painful, but not an injury	Ignition possible, but limited growth and spread of fire
Class 3	Injury	Ignition likely, rapid growth and spread of fire

The energy threshold for pain or injury is not constant throughout the population. For example, for some energy sources, the threshold is a function of body mass; the lower the mass, the lower the threshold, and vice-versa. Other body variables include age, state of health, state of emotions, effect of drugs, skin characteristics, etc. Furthermore, even where outward appearances otherwise appear equal, individuals differ in their thresholds of susceptibility to the same energy source.

The effect of duration of energy transfer is a function of the specific energy form. For example, pain or injury from thermal energy can be very short (1 s) for high skin temperature, or very long (several hours) for low skin temperature.

Furthermore, the pain or injury may occur some considerable time after the transfer of energy to a body part. For example, pain or injury from some chemical or physiological reaction may not be manifested for days, weeks, months, or years.

0.4 Energy sources

Energy sources are addressed by this document, together with the pain or injury that results from a transfer of that energy to the body, and the likelihood of property damage that results from fire escaping the equipment.

An electrical product is connected to an electrical energy source (for example, the **mains**), an external power supply, or a **battery**. An electrical product uses the electrical energy to perform its intended functions.

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In the process of using electrical energy, the product transforms the electrical energy into other forms of energy (for example, thermal energy, kinetic energy, optical energy, audio energy, electromagnetic energy, etc.). Some energy transformations may be a deliberate part of the product function (for example, moving parts of a printer, images on a visual display unit, sound from a speaker, etc.). Some energy transformations may be a by-product of the product function (for example, heat dissipated by functional circuits, X-radiation from a cathode-ray tube, etc.).

Some products may use energy sources that are non-electrical energy sources such as moving parts or chemicals. The energy in these other sources may be transferred to or from a body part, or may be transformed into other energy forms (for example, chemical energy may be converted to electrical energy through a **battery**, or a moving body part transfers its kinetic energy to a sharp edge).

Examples of the types of energy forms and the associated injuries and property damage addressed in this document are in Table 2.

Table 2 – Examples of body response or property damage related to energy sources

Forms of energy	Examples of body response or property damage	Clause
Electrical energy (for example, energized conductive parts)	Pain, fibrillation, cardiac arrest, respiratory arrest, skin burn, or internal organ burn	5
Thermal energy (for example, electrical ignition and spread of fire)	Electrically-caused fire leading to burn-related pain or injury, or property damage	6
Chemical reaction (for example, electrolyte, poison)	Skin damage, organ damage, or poisoning	7
Kinetic energy (for example, moving parts of equipment, or a moving body part against an equipment part)	Laceration, puncture, abrasion, contusion, crush, amputation, or loss of a limb, eye, ear, etc.	8
Thermal energy (for example, hot **accessible** parts)	Skin burn	9
Radiated energy (for example, electromagnetic energy, optical energy, acoustic energy)	Loss of sight, skin burn, or loss of hearing	10

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0.5 Safeguards

0.5.1 General

Many products necessarily use energy capable of causing pain or injury. Product design cannot eliminate such energy use. Consequently, such products should use a scheme that reduces the likelihood of such energy being transferred to a body part. The scheme that reduces the likelihood of energy transfer to a body part is a **safeguard** (see Figure 2).



Figure 2 – Three block model for safety

A **safeguard** is a device or scheme or system that:

– is interposed between an energy source capable of causing pain or injury and a body part, and

– reduces the likelihood of transfer of energy capable of causing pain or injury to a body part.

NOTE **Safeguard** mechanisms against transfer of energy capable of causing pain or injury include:

– attenuating the energy (reduces the value of the energy); or

– impeding the energy (slows the rate of energy transfer); or

– diverting the energy (changes the energy direction); or

– disconnecting, interrupting, or disabling the energy source; or

– enveloping the energy source (reduces the likelihood of the energy from escaping); or

– interposing a barrier between a body part and the energy source.

A **safeguard** can be applied to the equipment, to the local installation, to a person or can be a learned or directed behaviour (for example, resulting from an **instructional safeguard**) intended to reduce the likelihood of transfer of energy capable of causing pain or injury. A **safeguard** may be a single element or may be a set of elements.

Generally, this document uses an order of preference for providing **safeguards** based on the requirements given in ISO/IEC Guide 51 as follows:

– **equipment safeguards** are always useful, since they do not require any knowledge or actions by persons coming into contact with the equipment;

– **installation safeguards** are useful when a safety characteristic can only be provided after installation (for example, the equipment has to be bolted to the floor to provide stability);

– behavioural **safeguards** are useful when the equipment requires an energy source to be **accessible**.

In practice, **safeguard** selection accounts for the nature of the energy source, the intended user, the functional requirements of the equipment, and similar considerations.

0.5.2 Equipment safeguard

An **equipment safeguard** may be a **basic safeguard**, a **supplementary safeguard**, a **double safeguard**, or a **reinforced safeguard**.

0.5.3 Installation safeguard

Installation safeguards are not controlled by the equipment manufacturer, although in some cases, **installation safeguards** may be specified in the equipment installation instructions.

Generally, with respect to equipment, an **installation safeguard** is a **supplementary safeguard**.

NOTE For example, the **supplementary safeguard** providing **protective earthing** is located partly in the equipment and partly in the installation. The **supplementary safeguard** providing **protective earthing** is not effective until the equipment is connected to the **protective earthing** of the installation.

Requirements for **installation safeguards** are not addressed in this document. However, this document does assume some **installation safeguards**, such as **protective earthing**, are in place and are effective.

0.5.4 Personal safeguard

A **personal safeguard** may be a **basic safeguard**, a **supplementary safeguard**, or a **reinforced safeguard**.

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Requirements for **personal safeguards** are not addressed in this document. However, this document does assume that **personal safeguards** are available for use as specified by the manufacturer.

0.5.5 Behavioural safeguards

0.5.5.1 Introduction to behavioural safeguards

In the absence of an **equipment**, **installation**, or **personal safeguard**, a person may use a specific behaviour as a **safeguard** to avoid energy transfer and consequent injury. A behavioural **safeguard** is a voluntary or instructed behaviour intended to reduce the likelihood of transfer of energy to a body part.

Three kinds of behavioural **safeguards** are specified in this document. Each kind of behavioural **safeguard** is associated with a specific kind of person. An **instructional safeguard** is usually addressed to an **ordinary person**, but may also be addressed to an **instructed person** or a **skilled person**. A **precautionary safeguard** is used by an **instructed person**. A **skill safeguard** is used by a **skilled person**.

0.5.5.2 Instructional safeguard

An **instructional safeguard** is a means of providing information, describing the existence and location of an energy source capable of causing pain or injury, and is intended to invoke a specific behaviour on the part of a person to reduce the likelihood of transfer of energy to a body part (see Annex F).

An **instructional safeguard** may be a visual indicator (symbols or words or both) or an audible message, as applicable to the expected use of the product.

When accessing locations where the equipment needs to be energized to perform a service activity, an **instructional safeguard** may be considered acceptable protection to bypass an **equipment safeguard** such that the person is made aware of how to avoid contact with a class 2 or class 3 energy source.

If **equipment safeguards** would interfere with or prohibit the equipment function, an **instructional safeguard** may replace an **equipment safeguard**.

If exposure to an energy source capable of causing pain or injury is essential to the correct functioning of equipment, an **instructional safeguard** may be used to ensure protection of persons instead of another **safeguard**. Consideration should be given as to whether the **instructional safeguard** should require the use of a **personal safeguard**.

Provision of an **instructional safeguard** does not result in an **ordinary person** becoming an **instructed person** (see 0.5.5.3).

0.5.5.3 Precautionary safeguard (used by an instructed person)

A **precautionary safeguard** is the training and experience or supervision of an **instructed person** by a **skilled person** to use precautions to protect the **instructed person** against class 2 energy sources. **Precautionary safeguards** are not specifically prescribed in this document but are assumed to be effective when the term **instructed person** is used.

During equipment servicing, an **instructed person** may need to remove or defeat an **equipment safeguard**. In this case, an **instructed person** is expected to then apply precaution as a **safeguard** to avoid exposure to class 2 energy sources.

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0.5.5.4 Skill safeguard (used by a skilled person)

A **skill safeguard** is the education, training, knowledge and experience of the **skilled person** that is used to protect the **skilled person** against class 2 or class 3 energy sources. **Skill safeguards** are not specifically prescribed in this document but are assumed to be effective when the term **skilled person** is used.

During equipment servicing, a **skilled person** may need to remove or defeat an **equipment safeguard**. In this case, a **skilled person** is expected to then apply skill as a **safeguard** to avoid injury.

0.5.6 Safeguards during ordinary or instructed person service conditions

During **ordinary person** or **instructed person** service conditions, **safeguards** for such persons may be necessary. Such **safeguards** can be **equipment safeguards**, **personal safeguards**, or **instructional safeguards**.

0.5.7 Equipment safeguards during skilled person service conditions

During **skilled person** service conditions, **equipment safeguards** should be provided to protect against the effects of a body's involuntary reaction (for example, startle) that might cause unintentional contact with a class 3 energy source located outside the view of the **skilled person**.

NOTE This **safeguard** typically applies in large equipment, where the **skilled person** needs to partially or wholly enter between two or more class 3 energy source locations while servicing.

0.5.8 Examples of safeguard characteristics

Table 3 lists some examples of **safeguard** characteristics.

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Table 3 – Examples of safeguard characteristics

Safeguard	Basic safeguard	Supplementary safeguard	Reinforced safeguard
Equipment safeguard: a physical part of an equipment	Effective under **normal operating conditions**	Effective in the event of failure of the **basic safeguard**	Effective under **normal operating conditions** and in the event of a **single fault condition** elsewhere in the equipment
	Example: **basic insulation**	Example: **supplementary insulation**	Example: **reinforced insulation**
	Example: normal temperatures below ignition temperatures	Example: **fire enclosure**	Not applicable
Installation safeguard: a physical part of a man-made installation	Effective under **normal operating conditions**	Effective in the event of failure of an equipment **basic safeguard**	Effective under **normal operating conditions** and in the event of a **single fault condition** elsewhere in the equipment
	Example: wire size	Example: overcurrent protective device	Example: socket outlet
Personal safeguard: a physical device worn on the body	In the absence of any **equipment safeguard**, effective under **normal operating conditions**	Effective in the event of failure of an equipment **basic safeguard**	In the absence of any **equipment safeguard**, effective under **normal operating conditions** and in the event of a **single fault condition** elsewhere in the equipment
	Example: gloves	Example: insulating floor mat	Example: electrically-insulated glove for handling live conductors
Instructional safeguard: a voluntary or instructed behaviour intended to reduce the likelihood of transfer of energy to a body part	In the absence of any **equipment safeguard**, effective under **normal operating conditions**	Effective in the event of failure of an equipment **basic safeguard**	Only effective on an exceptional basis, when providing all appropriate **safeguards** would prevent the intended functioning of the equipment
	Example: **instructional safeguard** to disconnect telecommunication cable before opening the cover	Example: after opening a door, an **instructional safeguard** against hot parts	Example: **instructional safeguard** of hot parts in an office photocopier, or a continuous roll paper cutter on a commercial printer

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0.6 Electrically-caused pain or injury (electric shock)

0.6.1 Models for electrically-caused pain or injury

Electrically-caused pain or injury may occur when electrical energy capable of causing pain or injury is transferred to a body part (see Figure 3).

Electrical energy transfer occurs when there are two or more electrical contacts to the body:

– the first electrical contact is between a body part and a conductive part of the equipment;
– the second electrical contact is between another body part and
  - earth, or
  - another conductive part of the equipment.

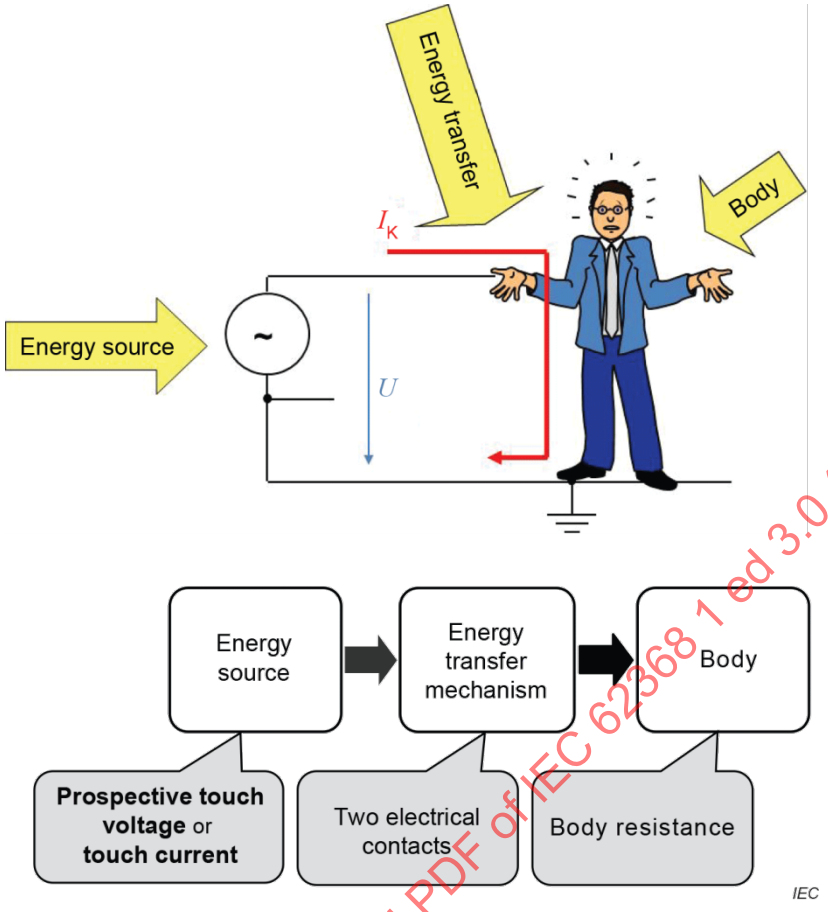


Figure 3 – Schematic and model for electrically-caused pain or injury

Depending on the magnitude, duration, wave shape, and frequency of the current, the effect on the human body varies from undetectable to detectable to painful to injurious.

0.6.2 Models for protection against electrically-caused pain or injury

One or more **safeguards** are interposed between an electrical energy source capable of causing pain or injury and a body part to protect against electrically-caused pain or injury (see Figure 4).

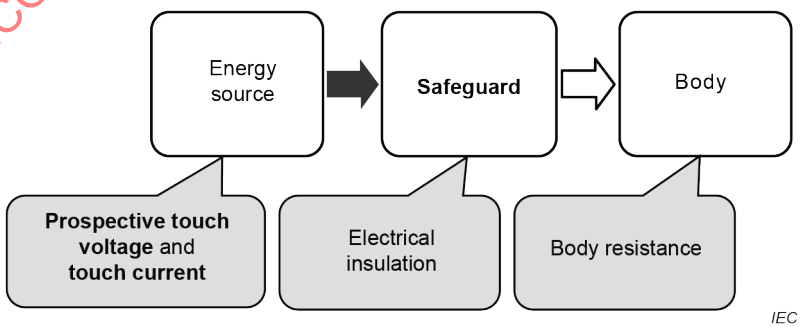


Figure 4 – Model for protection against electrically-caused pain or injury

Protection against electrically-caused pain is provided under **normal operating conditions** and **abnormal operating conditions**. For such protection, under **normal operating conditions** and **abnormal operating conditions**, a **basic safeguard** is interposed between an electrical energy source capable of causing pain and an **ordinary person**.

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The most common **basic safeguard** against an electrical energy source capable of causing pain is electrical insulation (also known as **basic insulation**) interposed between the energy source and a body part.

Protection against electrically-caused injury is provided under **normal operating conditions**, **abnormal operating conditions**, and **single fault conditions**. For such protection, under **normal operating conditions** and **abnormal operating conditions**, both a **basic safeguard** and a **supplementary safeguard** are interposed between an electrical energy source capable of causing injury and an **ordinary person** (see 4.3.2.4), or an **instructed person** (see 4.3.3.3). In the event of a failure of either **safeguard**, the other **safeguard** becomes effective. The **supplementary safeguard** against an electrical energy source capable of causing injury is placed between the **basic safeguard** and a body part. A **supplementary safeguard** may be additional electrical insulation (**supplementary insulation**) or a protectively earthed conductive barrier or other construction that performs the same function.

Another **safeguard** against an electrical energy source capable of causing injury is electrical insulation (also known as **double insulation** or **reinforced insulation**) placed between the energy source and a body part.

Likewise, a **reinforced safeguard** may be placed between an electrical energy source capable of causing injury and a body part.

0.7 Electrically-caused fire

0.7.1 Models for electrically-caused fire

Electrically-caused fire is due to conversion of electrical energy to thermal energy (see Figure 5), where the thermal energy heats a fuel material followed by ignition and combustion.

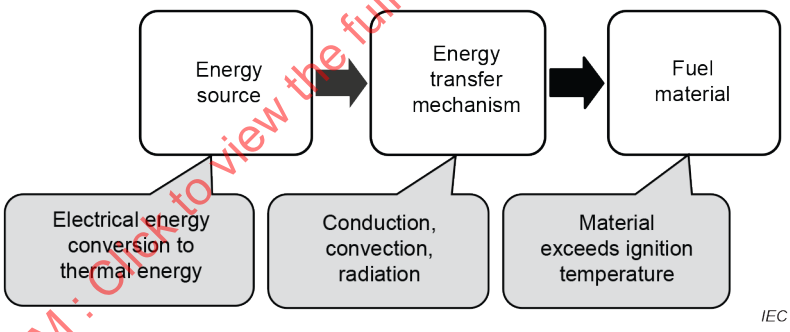


Figure 5 – Model for electrically-caused fire

Electrical energy is converted to thermal energy either in a resistance or in an arc and is transferred to a fuel material by conduction, convection, or radiation. As the fuel material heats, it chemically decomposes into gases, liquids and solids. When the gas is at its ignition temperature, the gas can be ignited by an ignition source. When the gas is at its spontaneous ignition temperature, the gas ignites by itself. Both result in fire.

0.7.2 Models for protection against electrically-caused fire

The **basic safeguard** against electrically-caused fire (see Figure 6) is that the temperature of a material, under **normal operating conditions** and **abnormal operating conditions**, does not cause the material to ignite.

The **supplementary safeguard** against electrically-caused fire reduces the likelihood of ignition or, in the case of ignition, reduces the likelihood of spread of fire.

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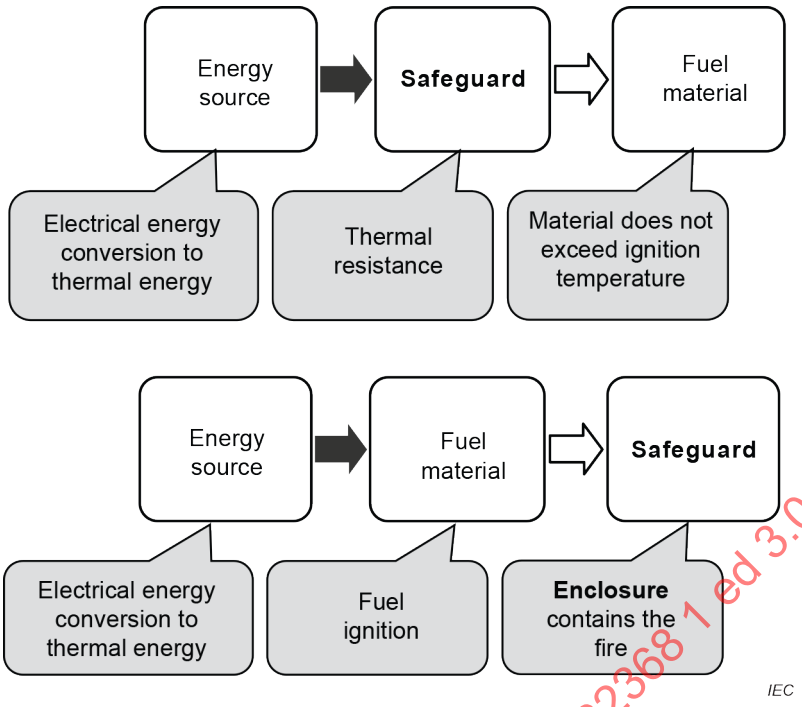


Figure 6 – Models for protection against fire

0.8 Injury caused by hazardous substances

Injury caused by **hazardous substances** is due to a chemical reaction with a body part. The extent of injury by a given substance depends on both the magnitude and duration of exposure and on the body part susceptibility to that substance.

The **basic safeguard** against injury caused by **hazardous substances** is containment of the material.

Supplementary safeguards against injury caused by **hazardous substances** may include:

– a second container or a spill-resistant container;
– containment trays;
– tamper-proof screws to prevent unauthorized access;
– **instructional safeguards**.

National and regional regulations govern the use of and exposure to **hazardous substances** used in equipment. These regulations do not enable a practical classification of **hazardous substances** in the manner in which other energy sources are classified in this document. Therefore, energy source classifications are not applied in Clause 7.

0.9 Mechanically-caused injury

Mechanically-caused injury is due to kinetic energy transfer to a body part when a collision occurs between a body part and an equipment part. The kinetic energy is a function of the relative motion between a body part and **accessible** parts of the equipment, including parts ejected from the equipment that collide with a body part.

Examples of kinetic energy sources are:

– body motion relative to sharp edges and corners;
– part motion due to rotating or other moving parts, including pinch points;
– part motion due to loosening, exploding, or imploding parts;

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– equipment motion due to instability;
– equipment motion due to wall, ceiling, or rack mounting means failure;
– equipment motion due to handle failure;
– part motion due to an exploding **battery**;
– equipment motion due to cart or stand instability or failure.

The **basic safeguard** against mechanically-caused injury is a function of the specific energy source. **Basic safeguards** may include:

– rounded edges and corners;
– an **enclosure** to prevent a moving part from being **accessible**;
– an **enclosure** to prevent expelling a moving part;
– a **safety interlock** to control access to an otherwise moving part;
– means to stop the motion of a moving part;
– means to stabilize the equipment;
– robust handles;
– robust mounting means;
– means to contain parts expelled during **explosion** or implosion.

The **supplementary safeguard** against mechanically-caused injury is a function of the specific energy source. **Supplementary safeguards** may include:

– **instructional safeguards**;
– instructions and training;
– additional **enclosures** or barriers;
– **safety interlocks**.

The **reinforced safeguard** against mechanically-caused injury is a function of the specific energy source. **Reinforced safeguards** may include:

– extra thick glass on the front of a CRT;
– rack slide-rails and means of support;
– **safety interlock**.

0.10 Thermally-caused injury (skin burn)

0.10.1 Models for thermally-caused injury

Thermally-caused injury may occur when thermal energy capable of causing injury is transferred to a body part (see Figure 7).

Thermal energy transfer occurs when a body touches a hot equipment part. The extent of injury depends on the temperature difference, the thermal mass of the object, rate of thermal energy transfer to the skin, and duration of contact.

The requirements in this document only address **safeguards** against thermal energy transfer by conduction. This document does not address **safeguards** against thermal energy transfer by convection or radiation.

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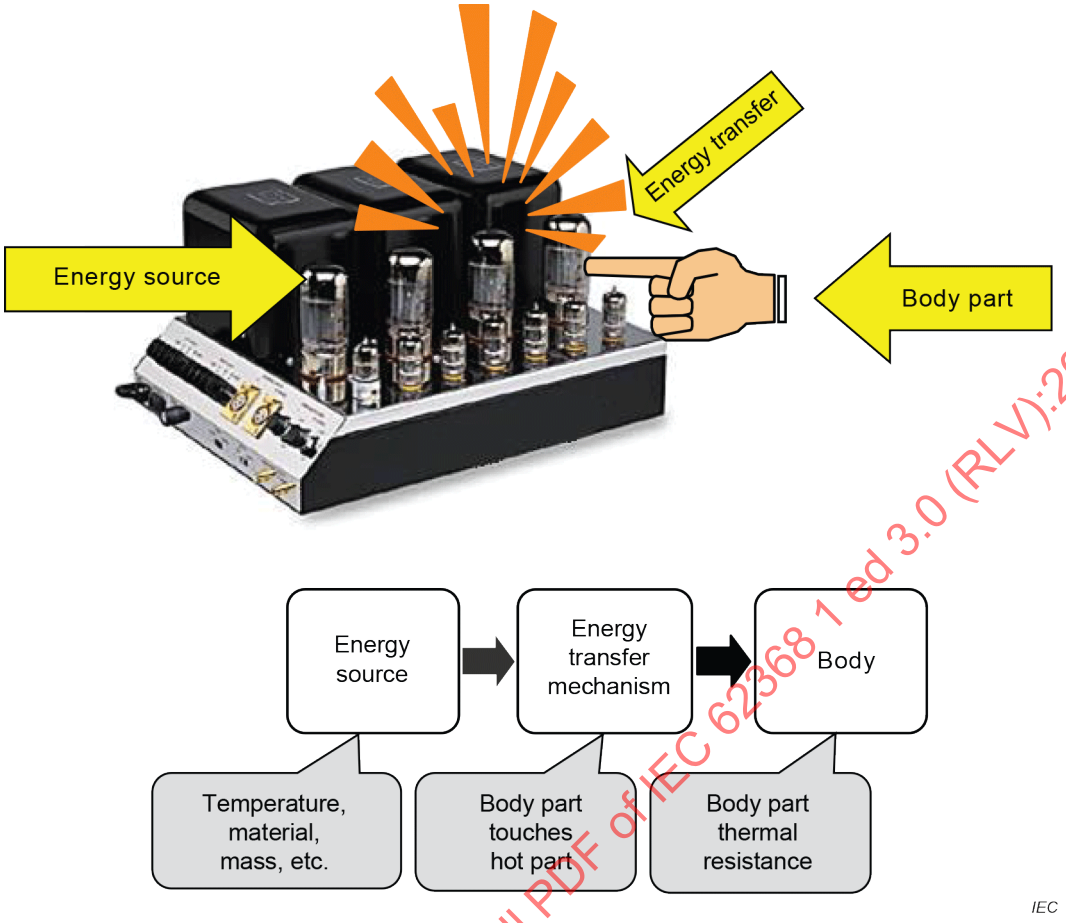


Figure 7 – Schematic and model for thermally-caused injury

Depending on the temperature, contact duration, material properties, and mass of the material, the perception of the human body varies from warmth to heat that may result in pain or injury (burn).

0.10.2 Models for protection against thermally-caused pain or injury

One or more **safeguards** are interposed between a thermal energy source capable of causing pain or injury and an **ordinary person** (see Figure 8).

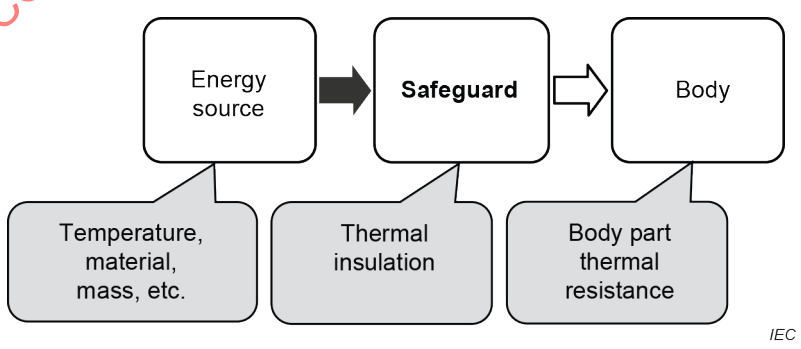


Figure 8 – Model for protection against thermally-caused injury

Under **normal operating conditions** and **abnormal operating conditions**, protection is used against thermally-cause pain. For such protection, a **basic safeguard** is interposed between a thermal energy source capable of causing pain and an **ordinary person**.

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Under **normal operating conditions**, **abnormal operating conditions** and **single fault conditions**, protection is used against thermally-caused injury. For such protection, a **basic safeguard** and a **supplementary safeguard** are interposed between a thermal energy source capable of causing injury and an **ordinary person**.

The **basic safeguard** against a thermal energy source capable of causing pain or injury is thermal insulation placed between the energy source and a body part. In some cases, a **basic safeguard** against a thermal energy source capable of causing pain or injury may be an **instructional safeguard** identifying the hot parts and how to reduce the likelihood of injury. In some cases, a **basic safeguard** reduces the likelihood of a non-injurious thermal energy source from becoming a thermal energy source capable of causing pain or injury.

Examples of such **basic safeguards** are:

– control of electrical energy being converted to thermal energy (for example, a **thermostat**);

– heat sinking, etc.

The **supplementary safeguard** against a thermal energy source capable of causing injury is thermal insulation placed between the energy source and a body part. In some cases, a **supplementary safeguard** against a thermal energy source capable of causing pain or injury may be an **instructional safeguard** identifying the hot parts and how to reduce the likelihood of injury.

0.11 Radiation-caused injury

Radiation-caused injury within the scope of this document is generally attributed to one of the following energy transfer mechanisms:

– heating of a body organ caused by exposure to non-ionising radiation, such as the highly localised energy of a laser impinging on the retina; or

– auditory injury caused by over stimulation of the ear by excessive peaks or sustained loud sound, leading to physical or nerve damage; or

– X-radiation; or

– UV radiation.

Radiated energy is transferred by impingement of wave emission upon a body part.

The **basic safeguard** against radiation-caused injury is containment of the energy within an **enclosure** that is opaque to the radiated energy.

There are several **supplementary safeguards** against radiation-caused injury. The **supplementary safeguards** may include **safety interlocks** to disconnect power to the generator, tamper-proof screws to prevent unauthorized access, etc.

The **basic safeguard** against auditory injury is to limit the acoustic output of personal music players and their associated headphones and earphones.

Examples of **supplementary safeguards** against auditory pain and injury are the provision of warnings and information advising the user how to use the equipment correctly.

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AUDIO/VIDEO, INFORMATION AND COMMUNICATION TECHNOLOGY EQUIPMENT –

Part 1: Safety requirements

1 Scope

This part of IEC 62368 is applicable to the safety of electrical and electronic equipment within the field of audio, video, information and communication technology, and business and office machines with a **rated voltage** not exceeding 600 V. This document does not include requirements for performance or functional characteristics of equipment.

NOTE 1 Examples of equipment within the scope of this document are given in Annex A.

NOTE 2 A **rated voltage** of 600 V is considered to include equipment rated 400/690 V.

This document is also applicable to:

– components and subassemblies intended for incorporation in this equipment. Such components and subassemblies need not comply with every requirement of this document, provided that the complete equipment, incorporating such components and subassemblies, does comply;

– external power supply units intended to supply other equipment within the scope of this document;

– accessories intended to be used with equipment within the scope of this document;

– large equipment installed in **restricted access areas**. For equipment having large machinery aspects, additional requirements may apply; and

– equipment to be used in tropical regions.

This document also includes requirements for audio/video, information and communication technology equipment intended to be installed in an **outdoor location**. The requirements for **outdoor equipment** also apply, where relevant, to **outdoor enclosures** suitable for direct installation in the field and supplied for housing audio/video, information and communication technology equipment to be installed in an **outdoor location**. See Annex Y for specific construction requirements not covered elsewhere in this document.

Each installation may have particular requirements. In addition, requirements for protection of the **outdoor equipment** against the effects of direct lightning strikes are not covered by this document.

NOTE 3 For information on this subject, see IEC 62305-1.

This document assumes a maximum altitude of 2 000 m unless otherwise specified by the manufacturer.

Additional requirements for equipment having the capability to supply DC power over commonly used communication cables, such as USB or Ethernet (PoE), are given in IEC 62368-3. IEC 62368-3 does not apply to:

– equipment supplying power using proprietary connectors; or

– equipment using a proprietary protocol for power selection.

This document specifies **safeguards** for **ordinary persons**, **instructed persons**, and **skilled persons**. Additional requirements may apply for equipment that is clearly designed or intended for use by children or specifically attractive to children.

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NOTE 4 In Australia, the work conducted by an **instructed person** or a **skilled person** may require formal licensing from regulatory authorities.

NOTE 5 In Germany, in many cases a person may only be regarded as an **instructed person** or a **skilled person** if certain legal requirements are fulfilled.

This document does not apply to:

– equipment with non-self-contained hazardous moving parts, such as robotic equipment; and

NOTE 6 For requirements related to robotic equipment in an industrial environment, see IEC 60204-1, IEC 60204-11, ISO 10218-1 and ISO 10218-2.

– personal care robots, including mobile servant robots, physical assistant robots, and person carrier robots; and

NOTE 7 For requirements related to personal care robots, see ISO 13482.

– power supply systems that are not an integral part of the equipment, such as motor-generator sets, **battery** backup systems and distribution transformers.

This document does not address:

– manufacturing processes except for **routine tests**;
– injurious effects of gases released by thermal decomposition or combustion;
– disposal processes;
– effects of transport (other than as specified in this document);
– effects of storage of materials, components, or the equipment itself;
– the likelihood of injury from particulate radiation such as alpha particles and beta particles;
– the likelihood of thermal injury due to radiated or convected thermal energy;
– the likelihood of injury due to flammable liquids;
– the use of the equipment in oxygen-enriched or **explosive** atmospheres;
– exposure to chemicals other than as specified in Clause 7;
– electrostatic discharge events;
– exposure to electromagnetic fields;
– environmental aspects; or
– requirements for functional safety, except for those related to **work cells**.

NOTE 8 For specific functional and software safety requirements of electronic safety-related systems (for example, protective electronic circuits), see IEC 61508-1.

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 60027-1, *Letter symbols to be used in electrical technology – Part 1: General*

IEC 60065, *Audio, video and similar electronic apparatus – Safety requirements*

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

IEC 60068-2-11, *Basic environmental testing procedures – Part 2-11: Tests – Test Ka: Salt mist*

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

IEC 60073, *Basic and safety principles for man-machine interface, marking and identification – Coding principles for indicators and actuators*

IEC 60076-14, *Power transformers – Part 14: Liquid-immersed power transformers using high-temperature insulation materials*

IEC TR 60083, *Plugs and socket-outlets for domestic and similar general use standardized in member countries of IEC*

IEC 60085, *Electrical insulation – Thermal evaluation and designation*

IEC 60086-4, *Primary batteries – Part 4: Safety of lithium batteries*

IEC 60086-5, *Primary batteries – Part 5: Safety of batteries with aqueous electrolyte*

IEC 60107-1:1997, *Methods of measurement on receivers for television broadcast transmissions – Part 1: General considerations – Measurements at radio and video frequencies*

IEC 60112, *Method for the determination of the proof and the comparative tracking indices of solid insulating materials*

IEC 60127 (all parts), *Miniature fuses*

IEC 60227-1, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 1: General requirements*

IEC 60227-2:1997, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 2: Test methods*
IEC 60227-2:1997/AMD1:2003

IEC 60245-1, *Rubber insulated cables – Rated voltages up to and including 450/750 V – Part 1: General requirements*

IEC 60296, *Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear*

IEC 60309 (all parts), *Plugs, socket-outlets and couplers for industrial purposes*

IEC 60317 (all parts), *Specifications for particular types of winding wires*

IEC 60317-0-7:2017, *Specifications for particular types of winding wires – Part 0-7: General requirements – Fully insulated (FIW) zero-defect enamelled round copper wire*

IEC 60317-43, *Specifications for particular types of winding wires – Part 43: Aromatic polyimide tape wrapped round copper wire, class 240*

IEC 60317-56, *Specifications for particular types of winding wires – Part 56: Solderable fully insulated (FIW) zero-defect polyurethane enamelled round copper wire, class 180*

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

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IEC 60320-1, *Appliance couplers for household and similar general purposes – Part 1: General requirements*

IEC 60332-1-2, *Tests on electric and optical fibre cables under fire conditions – Part 1-2: Test for vertical flame propagation for a single insulated wire or cable – Procedure for 1 kW pre-mixed flame*

IEC 60332-1-3, *Tests on electric and optical fibre cables under fire conditions – Part 1-3: Test for vertical flame propagation for a single insulated wire or cable – Procedure for determination of flaming droplets/particles*

IEC 60332-2-2, *Tests on electric and optical fibre cables under fire conditions – Part 2-2: Test for vertical flame propagation for a single small insulated wire or cable – Procedure for diffusion flame*

IEC 60384-14, *Fixed capacitors for use in electronic equipment – Part 14: Sectional specification: Fixed capacitors for electromagnetic interference suppression and connection to the supply mains*

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

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

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

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

IEC 60691:2015, *Thermal-links – Requirements and application guide*

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

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

IEC 60695-10-3, *Fire hazard testing – Part 10-3: Abnormal heat – Mould stress relief distortion test*

IEC 60695-11-5:2016, *Fire hazard testing – Part 11-5: Test flames – Needle-flame test method – Apparatus, confirmatory test arrangement and guidance*

IEC 60695-11-10, *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 methods*

IEC TS 60695-11-21, *Fire hazard testing – Part 11-21: Test flames – 500 W vertical flame test method for tubular polymeric materials*

IEC 60728-11:2016, *Cable networks for television signals, sound signals and interactive services – Part 11: Safety*

IEC 60730 (all parts), *Automatic electrical controls for household and similar use*

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

IEC 60738-1:2006, *Thermistors – Directly heated positive temperature coefficient – Part 1: Generic specification*

IEC 60747-5-5:2007, *Semiconductor devices – Discrete devices – Part 5-5: Optoelectronic devices – Photocouplers*
IEC 60747-5-5:2007/AMD1:2015

IEC 60825-1, *Safety of laser products – Part 1: Equipment classification and requirements*

IEC 60825-2, *Safety of laser products – Part 2: Safety of optical fibre communication systems (OFCS)*

IEC 60825-12, *Safety of laser products – Part 12: Safety of free space optical communication systems used for transmission of information*

IEC 60836, *Specifications for unused silicone insulating liquids for electrotechnical purposes*

IEC 60851-3:2009, *Winding wires – Test methods – Part 3: Mechanical properties*
IEC 60851-3:2009/AMD1:2013

IEC 60851-5:2008, *Winding wires – Test methods – Part 5: Electrical properties*
IEC 60851-5:2008/AMD1:2011

IEC 60884-1, *Plugs and socket-outlets for household and similar purposes – Part 1: General requirements*

IEC 60896-11, *Stationary lead-acid batteries – Part 11: Vented types – General requirements and methods of tests*

IEC 60896-21:2004, *Stationary lead-acid batteries – Part 21: Valve regulated types – Methods of test*

IEC 60896-22, *Stationary lead-acid batteries – Part 22: Valve regulated types – Requirements*

IEC 60906-1, *IEC system of plugs and socket-outlets for household and similar purposes – Part 1: Plugs and socket-outlets 16 A 250 V AC*

IEC 60906-2, *IEC system of plugs and socket-outlets for household and similar purposes – Part 2: Plugs and socket-outlets 15 A 125 V AC*

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

IEC 60947-5-5, *Low-voltage switchgear and controlgear – Part 5-5: Control circuit devices and switching elements – Electrical emergency stop device with mechanical latching function*

IEC 60950-1, *Information technology equipment – Safety – Part 1: General requirements*

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

IEC 60998-1, *Connecting devices for low-voltage circuits for household and similar purposes – Part 1: General requirements*

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IEC 60999-1, *Connecting devices – Electrical copper conductors – Safety requirements for screw-type and screwless-type clamping units – Part 1: General requirements and particular requirements for clamping units for conductors from 0,2 mm² up to 35 mm² (included)*

IEC 60999-2, *Connecting devices – Electrical copper conductors – Safety requirements for screw-type and screwless-type clamping units – Part 2: Particular requirements for clamping units for conductors above 35 mm² up to 300 mm² (included)*

IEC 61039, *Classification of insulating liquids*

IEC 61051-1, *Varistors for use in electronic equipment – Part 1: Generic specification*

IEC 61051-2:1991, *Varistors for use in electronic equipment – Part 2: Sectional specification for surge suppression varistors*
IEC 61051-2:1991/AMD1:2009

IEC 61056-1, *General purpose lead-acid batteries (valve-regulated types) – Part 1: General requirements, functional characteristics – Methods of test*

IEC 61056-2, *General purpose lead-acid batteries (valve-regulated types) – Part 2: Dimensions, terminals and marking*

IEC 61058-1:2016, *Switches for appliances – Part 1: General requirements*

IEC 61099, *Insulating liquids – Specifications for unused synthetic organic esters for electrical purposes*

IEC 61204-7, *Low-voltage power supplies – Part 7: Safety requirements*

IEC 61293, *Marking of electrical equipment with ratings related to electrical supply – Safety requirements*

IEC 61427 (all parts), *Secondary cells and batteries for renewable energy storage – General requirements and methods of test*

IEC TS 61430, *Secondary cells and batteries – Test methods for checking the performance of devices designed for reducing explosion hazards – Lead-acid starter batteries*

IEC 61434, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Guide to designation of current in alkaline secondary cell and battery standards*

IEC 61558-1:2017, *Safety of power transformers, power supplies, reactors and similar products – Part 1: General requirements and tests*

IEC 61558-2-16, *Safety of transformers, reactors, power supply units and similar products for voltages up to 1 100 V – Part 2-16: Particular requirements and tests for switch mode power supply units and transformers for switch mode power supply units*

IEC 61643-11:2011, *Low-voltage surge protective devices – Part 11: Surge protective devices connected to low-voltage power systems – Requirements and test methods*

IEC 61643-331:2017, *Components for low-voltage surge protective devices – Part 331: Performance requirements and test methods for metal oxide varistors (MOV)*

IEC 61810-1:2015, *Electromechanical elementary relays – Part 1: General and safety requirements*

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IEC 61959, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Mechanical tests for sealed portable secondary cells and batteries*

IEC 61965, *Mechanical safety of cathode ray tubes*

IEC 61984, *Connectors – Safety requirements and tests*

IEC 62133 (all parts), *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications*

IEC 62133-1, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications – Part 1: Nickel systems*

IEC 62133-2, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for portable sealed secondary lithium cells, and for batteries made from them, for use in portable applications – Part 2: Lithium systems*

IEC 62281, *Safety of primary and secondary lithium cells and batteries during transport*

IEC TS 62332-1, *Electrical insulation systems (EIS) – Thermal evaluation of combined liquid and solid components – Part 1: General requirements*

IEC 62440:2008, *Electric cables with a rated voltage not exceeding 450/750 V – Guide to use*

IEC 62471:2006, *Photobiological safety of lamps and lamp systems*

IEC 62471-5:2015, *Photobiological safety of lamps and lamp systems – Part 5: Image projectors*

IEC 62485-2, *Safety requirements for secondary batteries and battery installations – Part 2: Stationary batteries*

IEC 62619, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for secondary lithium cells and batteries, for use in industrial applications*

ISO 37, *Rubber, vulcanized or thermoplastic – Determination of tensile stress-strain properties*

ISO 178, *Plastics – Determination of flexural properties*

ISO 179-1, *Plastics – Determination of Charpy impact properties – Part 1: Non-instrumented impact test*

ISO 180, *Plastics – Determination of Izod impact strength*

ISO 306, *Plastics – Thermoplastic materials – Determination of Vicat softening temperature (VST)*

ISO 527 (all parts), *Plastics – Determination of tensile properties*

ISO 871, *Plastics – Determination of ignition temperature using a hot-air furnace*

ISO 1798, *Flexible cellular polymeric materials – Determination of tensile strength and elongation at break*

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ISO 1817:2015, *Rubber, vulcanized or thermoplastic – Determination of the effect of liquids*

ISO 2719, *Determination of flash point – Pensky-Martens closed cup method*

ISO 3231, *Paints and varnishes – Determination of resistance to humid atmospheres containing sulfur dioxide*

ISO 3679, *Determination of flash no-flash and flash point – Rapid equilibrium closed cup method*

ISO 3864 (all parts), *Graphical symbols – Safety colours and safety signs*

ISO 3864-2, *Graphical symbols – Safety colours and safety signs – Part 2: Design principles for product safety labels*

ISO 4892-1, *Plastics – Methods of exposure to laboratory light sources – Part 1: General guidance*

ISO 4892-2, *Plastics – Methods of exposure to laboratory light sources – Part 2: Xenon-arc lamps*

ISO 4892-4, *Plastics – Methods of exposure to laboratory light sources – Part 4: Open-flame carbon-arc lamps*

ISO 7000, *Graphical symbols for use on equipment – Registered symbols,* available from: <http://www.graphical-symbols.info/equipment>

ISO 7010, *Graphical symbols – Safety colours and safety signs – Safety signs used in workplaces and public areas*

ISO 8256, *Plastics – Determination of tensile-impact strength*

ISO 9772, *Cellular plastics – Determination of horizontal burning characteristics of small specimens subjected to a small flame*

ISO 9773, *Plastics – Determination of burning behaviour of thin flexible vertical specimens in contact with a small-flame ignition source*

ISO 14993, *Corrosion of metals and alloys – Accelerated testing involving cyclic exposure to salt mist, "dry" and "wet" conditions*

ISO 21207, *Corrosion tests in artificial atmospheres – Accelerated corrosion tests involving alternate exposure to corrosion-promoting gases, neutral salt-spray and drying*

ASTM D412, *Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers – Tension*

ASTM D471-98, *Standard Test Method for Rubber Property – Effect of Liquids*

ASTM D3574, *Standard Test Methods for Flexible Cellular Materials – Slab, Bonded, and Molded Urethane Foams*

EN 50332-1:2013, *Sound system equipment: Headphones and earphones associated with portable audio equipment – Maximum sound pressure level measurement methodology and limit considerations – Part 1: General method for "one package equipment"*

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EN 50332-2, *Sound system equipment: Headphones and earphones associated with portable audio equipment – Maximum sound pressure level measurement methodology and limit considerations – Part 2: Matching of sets with headphones if either or both are offered separately*

EN 50332-3, *Sound system equipment: Headphones and earphones associated with personal music players – maximum sound pressure level measurement methodology – Part 3: Measurement method for sound dose management*

3 Terms, definitions and abbreviated terms

3.1 Energy source abbreviations

Abbreviation	Description	
ES	Electrical energy source	see 5.2
ES1	Electrical energy source class 1	
ES2	Electrical energy source class 2	
ES3	Electrical energy source class 3	
MS	Mechanical energy source	see 8.2
MS1	Mechanical energy source class 1	
MS2	Mechanical energy source class 2	
MS3	Mechanical energy source class 3	
PS	Power source	see 6.2
PS1	Power source class 1	
PS2	Power source class 2	
PS3	Power source class 3	
RS	Radiation energy source	see 10.2
RS1	Radiation energy source class 1	
RS2	Radiation energy source class 2	
RS3	Radiation energy source class 3	
TS	Thermal energy source	see 9.2
TS1	Thermal energy source class 1	
TS2	Thermal energy source class 2	
TS3	Thermal energy source class 3	

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3.2 Other abbreviations

Abbreviation	Description
CD	compact disc
CD ROM	compact disc read-only memory
CRT	cathode ray tube
CSD	calculated sound dose
CTI	comparative tracking index
DVD	digital versatile disc
E	sound exposure
EIS	electrical insulation system
EUT	equipment under test
FIW	fully insulated winding wire
GDT	gas discharge tube
IC	integrated circuit
ICX	integrated circuit with X-capacitor function
IR	infrared
LED	light emitting diode
LEL	lower explosion limit
LFC	liquid filled component
LPS	limited power source
MEL	momentary exposure level
MOV	metal oxide varistor
NEMA	National Electrical Manufacturers Association
NiCd	nickel cadmium
PIS	potential ignition source
PMP	personal music player
PoE	power over Ethernet
PPE	personal protective equipment
PTC	positive temperature coefficient
PTI	proof tracking index
RC	resistor-capacitor
RG	risk group
Sb	antimony
SEL	sound exposure level
SPD	surge protective device
SRME	slide rail mounted equipment
TSS	thyristor surge suppressor
UPS	uninterruptible power supply
USB	universal serial bus
UV	ultraviolet
VDR	voltage dependent resistor
VRLA	valve regulated lead acid

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3.3 Terms and definitions

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

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

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

For the convenience of the user, the defined terms are listed below in alphabetical order indicating the number of the defined term.

Where the words “voltage” and “current” or their abbreviations are used, they are RMS values unless otherwise specified.

5VA class material	3.3.4.2.1
5VB class material	3.3.4.2.2
abnormal operating condition	3.3.7.1
accessible	3.3.6.1
arcing PIS	3.3.9.2
backfeed	3.3.6.2
backfeed safeguard	3.3.11.1
basic insulation	3.3.5.1
basic safeguard	3.3.11.2
battery	3.3.17.1
calculated sound dose, CSD	3.3.19.1
cell	3.3.17.2
cheesecloth	3.3.6.3
class I equipment	3.3.15.1
class II construction	3.3.15.2
class II equipment	3.3.15.3
class III equipment	3.3.15.4
clearance	3.3.12.1
coin / button cell battery	3.3.17.3
combustible material	3.3.4.1
consumable material	3.3.16.1
creepage distance	3.3.12.2
DC voltage	3.3.14.1
digital signal level relative to full scale, dBFS	3.3.19.5
direct plug-in equipment	3.3.3.1
disconnect device	3.3.6.4
double insulation	3.3.5.2
double safeguard	3.3.11.3
electrical enclosure	3.3.2.1
enclosure	3.3.2.2
equipment safeguard	3.3.11.4

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explosion	3.3.16.2
explosive	3.3.16.3
external circuit	3.3.1.1
fire enclosure	3.3.2.3
fixed equipment	3.3.3.2
fully insulated winding wire, FIW	3.3.18.1
functional earthing	3.3.6.5
functional insulation	3.3.5.3
grade of FIW	3.3.18.2
hand-held equipment	3.3.3.3
hazardous substance	3.3.16.4
HB40 class material	3.3.4.2.3
HB75 class material	3.3.4.2.4
HBF class foamed material	3.3.4.2.5
HF-1 class foamed material	3.3.4.2.6
HF-2 class foamed material	3.3.4.2.7
highest specified charging temperature	3.3.17.4
installation safeguard	3.3.11.5
instructed person	3.3.8.1
instructional safeguard	3.3.11.6
insulating liquid	3.3.5.4
intermittent operation	3.3.7.2
lowest specified charging temperature	3.3.17.5
mains	3.3.1.2
mains transient voltage	3.3.14.2
material flammability class	3.3.4.2
maximum specified charging current	3.3.17.6
maximum specified charging voltage	3.3.17.7
mechanical enclosure	3.3.2.4
momentary exposure level, MEL	3.3.19.2
movable equipment	3.3.3.4
non-clipped output power	3.3.7.3
non-detachable power supply cord	3.3.6.6
normal operating condition	3.3.7.4
ordinary person	3.3.8.2
outdoor enclosure	3.3.2.5
outdoor equipment	3.3.3.5
outdoor location	3.3.6.7
peak response frequency	3.3.7.5
permanently connected equipment	3.3.3.6
personal safeguard	3.3.11.7
pluggable, type A equipment	3.3.3.7
pluggable, type B equipment	3.3.3.8

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pollution degree	3.3.6.8
potential ignition source, PIS	3.3.9.1
precautionary safeguard	3.3.11.8
professional equipment	3.3.3.9
prospective touch voltage	3.3.14.3
protective bonding conductor	3.3.11.9
protective conductor current	3.3.14.4
protective conductor	3.3.11.10
protective current rating	3.3.10.6
protective earthing	3.3.11.11
protective earthing conductor	3.3.11.12
rated current	3.3.10.1
rated frequency	3.3.10.2
rated load impedance	3.3.7.6
rated power	3.3.10.3
rated voltage range	3.3.10.5
rated voltage	3.3.10.4
reasonably foreseeable misuse	3.3.7.7
reinforced insulation	3.3.5.5
reinforced safeguard	3.3.11.13
required withstand voltage	3.3.14.5
resistive PIS	3.3.9.3
restricted access area	3.3.6.9
RMS working voltage	3.3.14.6
routine test	3.3.6.10
safeguard	3.3.11.14
safety interlock	3.3.11.15
sampling test	3.3.6.11
secondary lithium battery	3.3.17.8
short-time operation	3.3.7.8
single fault condition	3.3.7.9
skill safeguard	3.3.11.16
skilled person	3.3.8.3
solid insulation	3.3.5.6
sound exposure, E	3.3.19.3
sound exposure level, SEL	3.3.19.4
stationary equipment	3.3.3.10
stored energy mode	3.3.6.12
supplementary insulation	3.3.5.7
supplementary safeguard	3.3.11.17
temperature limiter	3.3.13.1
temporary overvoltage	3.3.14.7
thermal cut-off	3.3.13.2

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thermostat	3.3.13.3
tool	3.3.6.13
touch current	3.3.6.14
transportable equipment	3.3.3.11
type test	3.3.6.15
V-0 class material	3.3.4.2.8
V-1 class material	3.3.4.2.9
V-2 class material	3.3.4.2.10
VTM-0 class material	3.3.4.2.11
VTM-1 class material	3.3.4.2.12
VTM-2 class material	3.3.4.2.13
wireless power transmitter	3.3.3.12
work cell	3.3.6.16
working voltage	3.3.14.8
wrapping tissue	3.3.6.17

3.3.1 Circuit terms

3.3.1.1
external circuit
electrical circuit that is external to the equipment and is not **mains**

Note 1 to entry: An **external circuit** is classified as ES1, ES2 or ES3, and PS1, PS2, or PS3.

3.3.1.2
mains
AC or DC power distribution system (external to the equipment) that supplies operating power to the equipment and is PS3

Note 1 to entry: **Mains** include public or private utilities and, unless otherwise specified in this document, equivalent sources such as motor-driven generators and uninterruptible power supplies.

3.3.2 Enclosure terms

3.3.2.1
electrical enclosure
enclosure intended as a **safeguard** against electrically-caused injury

[SOURCE: IEC 60050-195:1998, 195-06-13, modified – the term **safeguard** has been used]

3.3.2.2
enclosure
housing affording the type and degree of protection suitable for the intended application

[SOURCE: IEC 60050-195:1998, 195-02-35]

3.3.2.3
fire enclosure
enclosure intended as a **safeguard** against the spread of fire from within the **enclosure** to outside the **enclosure**

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3.3.2.4
mechanical enclosure
enclosure intended as a **safeguard** against mechanically-caused pain and injury

3.3.2.5
outdoor enclosure
enclosure that is intended to provide protection from specific conditions in an **outdoor location**

Note 1 to entry: An **outdoor enclosure** can also perform the functions of another **enclosure**, for example: a **fire enclosure**; an **electrical enclosure**; a **mechanical enclosure**.

Note 2 to entry: A separate cabinet or housing into which the equipment is placed can provide the function of an **outdoor enclosure**.

3.3.3 Equipment terms

3.3.3.1
direct plug-in equipment
equipment in which the **mains** plug forms an integral part of the equipment **enclosure**

3.3.3.2
fixed equipment
equipment that is specified in the installation instructions to only be secured in place by a means defined by the manufacturer

Note 1 to entry: Equipment that has a screw hole or other means to secure the equipment by an **ordinary person**, such as for securement to a table or for earthquake protection, is not considered to be **fixed equipment**.

Note 2 to entry: Typically, **fixed equipment** will be wall, ceiling or floor mounted.

3.3.3.3
hand-held equipment
movable equipment, or a part of any kind of equipment, that is intended to be held in the hand during normal use

3.3.3.4
movable equipment
equipment that is either:

– 18 kg or less in mass and is not **fixed equipment**; or
– provided with wheels, casters, or other means to facilitate movement by an **ordinary person** as required to perform its intended use

3.3.3.5
outdoor equipment
equipment that is installed or exposed in an **outdoor location**, specified by the manufacturer to comply wholly or in part under specific conditions

Note 1 to entry: **Transportable equipment**, for example, a laptop or notebook computer, or a telephone, is not **outdoor equipment** unless specified by the manufacturer for continuous use in an **outdoor location**.

3.3.3.6
permanently connected equipment
equipment that can only be electrically connected to or disconnected from the **mains** by the use of a **tool**

3.3.3.7
pluggable equipment type A
equipment that is intended for connection to the **mains** via a non-industrial plug and socket-outlet or via a non-industrial appliance coupler, or both

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Note 1 to entry: Examples are plugs and socket-outlets covered by standards such as IEC TR 60083 and IEC 60320-1.

3.3.3.8
pluggable equipment type B
equipment that is intended for connection to the **mains** via an industrial plug and socket-outlet or via an industrial appliance coupler, or both

Note 1 to entry: Examples are plugs and socket-outlets covered by standards such as IEC 60309-1.

3.3.3.9
professional equipment
equipment for use in trades, professions or industries and which is not intended for sale to the general public

[SOURCE: IEC 60050-161:1990, 161-05-05]

3.3.3.10
stationary equipment

– **fixed equipment**, or
– **permanently connected equipment**, or
– equipment that, due to its physical characteristics, is normally not moved

Note 1 to entry: **Stationary equipment** is neither **movable equipment** nor **transportable equipment**.

3.3.3.11
transportable equipment
equipment that is intended to be routinely carried

Note 1 to entry: Examples include notebook computers, CD players and portable accessories, including their external power supplies.

3.3.3.12
wireless power transmitter
equipment that uses electromagnetic fields to transfer electrical power for charging **battery** operated hand-held devices

3.3.4 Flammability terms

3.3.4.1
combustible material
material that is capable of being ignited or burned

Note 1 to entry: All thermoplastic materials are considered capable of being ignited or burned regardless of the **material flammability class**.

3.3.4.2
material flammability class
recognition of the burning behaviour of materials and their ability to extinguish if ignited

Note 1 to entry: Materials are classified when tested in accordance with IEC 60695-11-10, IEC 60695-11-20, ISO 9772 or ISO 9773.

3.3.4.2.1
5VA class material
material tested in the thinnest significant thickness used and classified 5VA according to IEC 60695-11-20

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3.3.4.2.2
5VB class material
material tested in the thinnest significant thickness used and classified 5VB according to IEC 60695-11-20

3.3.4.2.3
HB40 class material
material tested in the thinnest significant thickness used and classified HB40 according to IEC 60695-11-10

3.3.4.2.4
HB75 class material
material tested in the thinnest significant thickness used and classified HB75 according to IEC 60695-11-10

3.3.4.2.5
HBF class foamed material
foamed material tested in the thinnest significant thickness used and classified HBF according to ISO 9772

3.3.4.2.6
HF-1 class foamed material
foamed material tested in the thinnest significant thickness used and classified HF-1 according to ISO 9772

3.3.4.2.7
HF-2 class foamed material
foamed material tested in the thinnest significant thickness used and classified HF-2 according to ISO 9772

3.3.4.2.8
V-0 class material
material tested in the thinnest significant thickness used and classified V-0 according to IEC 60695-11-10

3.3.4.2.9
V-1 class material
material tested in the thinnest significant thickness used and classified V-1 according to IEC 60695-11-10

3.3.4.2.10
V-2 class material
material tested in the thinnest significant thickness used and classified V-2 according to IEC 60695-11-10

3.3.4.2.11
VTM-0 class material
material tested in the thinnest significant thickness used and classified VTM-0 according to ISO 9773

3.3.4.2.12
VTM-1 class material
material tested in the thinnest significant thickness used and classified VTM-1 according to ISO 9773

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3.3.4.2.13
VTM-2 class material
material tested in the thinnest significant thickness used and classified VTM-2 according to ISO 9773

3.3.5 Electrical insulation

3.3.5.1
basic insulation
insulation to provide a **basic safeguard** against electric shock

Note 1 to entry: This concept does not apply to insulation used exclusively for functional purposes.

3.3.5.2
double insulation
insulation comprising both **basic insulation** and **supplementary insulation**

[SOURCE: IEC 60050-195:1998, 195-06-08]

3.3.5.3
functional insulation
insulation between conductive parts which is necessary only for the proper functioning of the equipment

3.3.5.4
insulating liquid
insulating material consisting entirely of a liquid

[SOURCE: IEC 60050-212:2010, 212-11-04]

3.3.5.5
reinforced insulation
single insulation system that provides a degree of protection against electric shock equivalent to **double insulation**

3.3.5.6
solid insulation
insulation consisting entirely of solid material

[SOURCE: IEC 60050-212:2010, 212-11-02]

3.3.5.7
supplementary insulation
independent insulation applied in addition to **basic insulation** to provide a **supplementary safeguard** for fault protection against electric shock

3.3.6 Miscellaneous

3.3.6.1
accessible
touchable by a body part

Note 1 to entry: A body part is represented by one or more of the probes specified in Annex V, as applicable.

3.3.6.2
backfeed
condition in which a voltage or energy available within a **battery** backed up supply is fed back to any of the input terminals, either directly or by a leakage path while operating in the **stored energy mode** and with **mains** power not available

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3.3.6.3
cheesecloth
bleached cotton cloth of approximately 40 g/m^2

Note 1 to entry: **Cheesecloth** is a coarse, loosely woven cotton gauze, originally used for wrapping cheese.

3.3.6.4
disconnect device
means to electrically disconnect equipment from the **mains** that, in the open position, complies with the requirements specified for isolation

3.3.6.5
functional earthing
earthing a point or points in a system or in an installation or in equipment, for purposes other than electrical safety

[SOURCE: IEC 60050-195:1998/AMD1:2001, 195-01-13]

3.3.6.6
non-detachable power supply cord
flexible supply cord affixed to or assembled to the equipment and that cannot be removed from the equipment without the use of **tools**

3.3.6.7
outdoor location
location for equipment where protection from the weather and other outdoor influences provided by a building or other structure is limited or non-existent

3.3.6.8
pollution degree
numeral characterizing the expected pollution of the micro-environment

[SOURCE: IEC 60050-581:2008, 581-21-07]

3.3.6.9
restricted access area
area **accessible** only to **skilled persons** and to **instructed persons** with the proper authorization

3.3.6.10
routine test
test to which each individual device is subjected during or after manufacture to ascertain whether it complies with certain criteria

[SOURCE: IEC 60664-1:2007, 3.19.2]

3.3.6.11
sampling test
test on a number of devices taken at random from a batch

[SOURCE: IEC 60664-1:2007, 3.19.3]

3.3.6.12
stored energy mode
stable mode of operation that a **battery** backed up supply attains under specified conditions

Note 1 to entry: In accordance with IEC 62040-1:2017, the specified conditions are as follows:

– AC input power is disconnected or is out of required tolerance;

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– operating and output power is supplied by the energy storage device;

– the load is within the specified rating of the **battery** backed up supply.

3.3.6.13
tool
object that can be used to operate a screw, latch or similar fixing means

Note 1 to entry: Examples of **tools** include coins, tableware, screwdrivers, pliers, etc.

3.3.6.14
touch current
electric current through a human body when body parts touch two or more **accessible** parts or one **accessible** part and earth

3.3.6.15
type test
test on a representative sample with the objective of determining if, as designed and manufactured, it can meet the requirements of this document

3.3.6.16
work cell
space within the equipment of such size that a person can enter completely or partially (for example, entire limb or head) for servicing or operating the equipment and where mechanical hazards may be present

Note 1 to entry: A **work cell** can contain more than one compartment. A compartment can be used for either operational or service purposes.

Note 2 to entry: The equipment containing the **work cell** is typically installed within a **restricted access area**.

3.3.6.17
wrapping tissue
tissue between 12 g/m^2 and 30 g/m^2

Note 1 to entry: The **wrapping tissue** is soft, thin, usually translucent paper used for wrapping delicate articles.

3.3.7 Operating and fault conditions

3.3.7.1
abnormal operating condition
temporary operating condition that is not a **normal operating condition** and is not a **single fault condition** of the equipment itself

Note 1 to entry: **Abnormal operating conditions** are specified in Clause B.3.

Note 2 to entry: An **abnormal operating condition** may be introduced by the equipment or by a person.

Note 3 to entry: An **abnormal operating condition** may result in a failure of a component, a device or a **safeguard**.

3.3.7.2
intermittent operation
operation in a series of cycles, each composed of a period of operation followed by a period with the equipment switched off or running idle

3.3.7.3
non-clipped output power
sine wave power dissipated in the **rated load impedance**, measured at 1 000 Hz at the onset of clipping on either one or both peaks

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3.3.7.4
normal operating condition
mode of operation that represents as closely as possible the range of normal use that can reasonably be expected

Note 1 to entry: Unless otherwise specified, the most severe conditions of normal use are the most unfavourable default values as specified in Clause B.2.

Note 2 to entry: **Reasonably foreseeable misuse** is not covered by **normal operating conditions**. Instead, it is covered by **abnormal operating conditions**.

3.3.7.5
peak response frequency
test frequency that produces the maximum output power measured at the **rated load impedance**

Note 1 to entry: The frequency applied should be within the amplifier/transducer's intended operating range.

3.3.7.6
rated load impedance
impedance or resistance, as declared by the manufacturer, by which an output circuit should be terminated

3.3.7.7
reasonably foreseeable misuse
use of a product, process or service in a way not intended by the supplier, but which can result from readily predictable human behaviour

Note 1 to entry: **Reasonably foreseeable misuse** is considered to be a form of **abnormal operating conditions**.

[SOURCE: ISO/IEC Guide 51:2014, 3.7, modified – In the definition, "product or system" has been replaced by "product, process or service". The Notes to entry have been replaced.]

3.3.7.8
short-time operation
operation under **normal operating conditions** for a specified period, starting when the equipment is cold, the intervals after each period of operation being sufficient to allow the equipment to cool down to room temperature

3.3.7.9
single fault condition
condition of equipment with a fault under **normal operating condition** of a single **safeguard** (but not a **reinforced safeguard**) or of a single component or a device

Note 1 to entry: **Single fault conditions** are specified in Clause B.4.

3.3.8 Persons

3.3.8.1
instructed person
person instructed or supervised by a **skilled person** as to energy sources and who can responsibly use **equipment safeguards** and **precautionary safeguards** with respect to those energy sources

Note 1 to entry: Supervised, as used in the definition, means having the direction and oversight of the performance of others.

Note 2 to entry: In Germany, in many cases, a person may only be regarded as an **instructed person** if certain legal requirements are fulfilled.

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3.3.8.2
ordinary person
person who is neither a **skilled person** nor an **instructed person**

[SOURCE: IEC 60050-826:2004, 826-18-03]

3.3.8.3
skilled person
person with relevant education or experience to enable him or her to identify hazards and to take appropriate actions to reduce the risks of injury to themselves and others

Note 1 to entry: In Germany, in many cases, a person may only be regarded as an **skilled person** if certain legal requirements are fulfilled.

[SOURCE: IEC 60050-826:2004, 826-18-01, modified – The definition has been made applicable to all types of hazards.]

3.3.9 Potential ignition sources

3.3.9.1
potential ignition source
PIS
location where electrical energy can cause ignition

3.3.9.2
arcing PIS
PIS where an arc may occur due to the opening of a conductor or a contact

Note 1 to entry: An electronic protection circuit or additional constructional measures may be used to prevent a location from becoming an **arcing PIS**.

Note 2 to entry: A faulty contact or interruption in an electric connection that may occur in conductive patterns on printed boards is considered to be within the scope of this definition.

3.3.9.3
resistive PIS
PIS where a component may ignite due to excessive power dissipation

Note 1 to entry: An electronic protection circuit or additional constructional measures may be used to prevent a location from becoming a **resistive PIS**.

3.3.10 Ratings

3.3.10.1
rated current
input current of the equipment, as declared by the manufacturer, at **normal operating conditions**

3.3.10.2
rated frequency
supply frequency or frequency range as declared by the manufacturer

3.3.10.3
rated power
input power of the equipment, as declared by the manufacturer, at **normal operating conditions**

3.3.10.4
rated voltage
value of voltage assigned by the manufacturer to a component, device or equipment and to which operation and performance characteristics are referred

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Note 1 to entry: Equipment may have more than one **rated voltage** value or may have a **rated voltage range**.

[SOURCE: IEC 60664-1:2007, 3.9]

3.3.10.5
rated voltage range
supply voltage range, as declared by the manufacturer, expressed by its lower and upper **rated voltages**

3.3.10.6
protective current rating
current rating of an overcurrent protective device that is in the building installation or in the equipment to protect a circuit

3.3.11 Safeguards

3.3.11.1
backfeed safeguard
control scheme that reduces the risk of electric shock due to backfeed

3.3.11.2
basic safeguard
safeguard that provides protection under **normal operating conditions** and under **abnormal operating conditions** whenever an energy source capable of causing pain or injury is present in the equipment

3.3.11.3
double safeguard
safeguard comprising both a **basic safeguard** and a **supplementary safeguard**

3.3.11.4
equipment safeguard
safeguard that is a physical part of the equipment

3.3.11.5
installation safeguard
safeguard that is a physical part of a man-made installation

3.3.11.6
instructional safeguard
instruction invoking specified behaviour

3.3.11.7
personal safeguard
personal protective equipment that is worn on the body and that reduces exposure to an energy source

Note 1 to entry: Examples are shields, goggles, gloves, aprons, face masks or breathing apparatus.

3.3.11.8
precautionary safeguard
instructed person behaviour to avoid contact with or exposure to a class 2 energy source based on supervision or instructions given by a **skilled person**

3.3.11.9
protective bonding conductor
protective conductor in the equipment provided for protective equipotential-bonding of parts required to be earthed for safety purposes

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Note 1 to entry: A **protective bonding conductor** is internal in the equipment.

3.3.11.10
protective conductor
conductor provided for the purposes of safety (for example, protection against electric shock)

Note 1 to entry: A **protective conductor** is either a **protective earthing conductor** or a **protective bonding conductor**.

[SOURCE: IEC 60050-195:1998, 195-02-09]

3.3.11.11
protective earthing
earthing a point or points in a system or in an installation or in equipment for purposes of electrical safety

[SOURCE: IEC 60050-195:1998/AMD1:2001, 195-01-11]

3.3.11.12
protective earthing conductor
protective conductor connecting a main **protective earthing** terminal in the equipment to an earth point in the building installation for **protective earthing**

3.3.11.13
reinforced safeguard
single **safeguard** that is effective under:

– **normal operating conditions**;
– **abnormal operating conditions**; and
– **single fault conditions**

3.3.11.14
safeguard
physical part or system or instruction specifically provided to reduce the likelihood of pain or injury, or, for fire, to reduce the likelihood of ignition or spread of fire

Note 1 to entry: See 0.5 for further explanation of a **safeguard**.

3.3.11.15
safety interlock
means to automatically change an energy source to a lower class energy source prior to the potential for transfer of the higher energy to a body part

Note 1 to entry: A **safety interlock** encompasses the system of components and circuits that are directly involved in the **safeguard** function, including electro-mechanical devices, conductors on printed boards, wiring and their terminations, etc., as applicable.

3.3.11.16
skill safeguard
skilled person behaviour to avoid contact with or exposure to a class 2 or class 3 energy source based on education and experience

3.3.11.17
supplementary safeguard
safeguard applied in addition to the **basic safeguard** that is or becomes operational in the event of failure of the **basic safeguard**

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3.3.12 Spacings

3.3.12.1
clearance
shortest distance in air between two conductive parts

[SOURCE: IEC 60664-1:2007, 3.2]

3.3.12.2
creepage distance
shortest distance along the surface of an insulating material between two conductive parts

[SOURCE: IEC 60664-1:2007, 3.3, modified – In the definition, “solid” has been deleted.]

3.3.13 Temperature controls

3.3.13.1
temperature limiter
device for limiting the temperature of a system, either below or above a particular value, by controlling, either directly or indirectly, the flow of thermal energy into or out of the system

Note 1 to entry: A **temperature limiter** may be of the automatic reset or of the manual reset type.

3.3.13.2
thermal cut-off
device for limiting the temperature of a system, under **single fault conditions**, by controlling, either directly or indirectly, the flow of thermal energy into or out of the system

3.3.13.3
thermostat
device for maintaining the temperature of a system within a range by controlling, either directly or indirectly, the flow of thermal energy into or out of the system

3.3.14 Voltages and currents

3.3.14.1
DC voltage
voltage having a peak-to-peak ripple not exceeding 10 % of the average value

Note 1 to entry: Where peak-to-peak ripple exceeds 10 % of the average value, the requirements related to peak voltage are applicable.

3.3.14.2
mains transient voltage
highest peak voltage expected at the **mains** input to the equipment arising from external transients

3.3.14.3
prospective touch voltage
voltage between simultaneously **accessible** conductive parts or between one **accessible** conductive part and earth when those conductive parts are not being touched

[SOURCE: IEC 60050-195:1998, 195-05-09, modified – In the definition, "or between one **accessible** conductive part and earth" has been added.]

3.3.14.4
protective conductor current
current flowing through the **protective earthing conductor** under **normal operating conditions**

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Note 1 to entry: **Protective conductor current** was previously included in the term “leakage current”.

3.3.14.5
required withstand voltage
peak voltage that the insulation under consideration is required to withstand

3.3.14.6
RMS working voltage
true RMS value of the **working voltage**

Note 1 to entry: True RMS value of the **working voltage** includes any DC component of the waveform.

Note 2 to entry: The resultant RMS value of a waveform having an AC RMS voltage A and a DC component voltage B is given by the following formula:

$$\text{RMS value} = (A^2 + B^2)^{1/2}$$

3.3.14.7
temporary overvoltage
overvoltage at **mains** power frequency of relatively long duration

3.3.14.8
working voltage
voltage across any particular insulation while the equipment is supplied at **rated voltage** or any voltage in the **rated voltage range** under **normal operating conditions**

Note 1 to entry: External transients are disregarded.

Note 2 to entry: Recurring peak voltages are disregarded.

3.3.15 Classes of equipment with respect to protection from electric shock

3.3.15.1
class I equipment
equipment with **basic insulation** used as a **basic safeguard**, and with protective bonding and **protective earthing** used as a **supplementary safeguard**

Note 1 to entry: **Class I equipment** may be provided with **class II construction**.

[SOURCE: IEC 60050-851:2008, 851-15-10, modified – The definition has been adapted to the **safeguard** principle.]

3.3.15.2
class II construction
part of an equipment for which protection against electric shock relies upon **double insulation** or **reinforced insulation**

3.3.15.3
class II equipment
equipment in which protection against electric shock does not rely on **basic insulation** only, but in which a **supplementary safeguard** is provided, there being no provision for **protective earthing** or reliance upon installation conditions

3.3.15.4
class III equipment
equipment in which protection against electric shock relies upon supply from ES1 and in which ES3 is not generated

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3.3.16 Chemical terms

3.3.16.1
consumable material
material that is used by the equipment in performing its intended function, and intended to be periodically or occasionally replaced or replenished, including any material that has a life expectancy less than that of the equipment

Note 1 to entry: Air filters are not considered to be **consumable materials**.

3.3.16.2
explosion
chemical reaction of any chemical compound or mechanical mixture that, when initiated, undergoes a very rapid combustion or decomposition, releasing large volumes of highly heated gases that exert pressure on the surrounding medium

Note 1 to entry: **Explosion** can also be a mechanical reaction in which failure of the container causes sudden release of pressure, and the contents, from within a pressure vessel. Depending on the rate of energy release, an **explosion** can be categorized as a deflagration, a detonation or pressure rupture.

3.3.16.3
explosive
substance or mixture of substances that can undergo a rapid chemical change with or without an outside source of oxygen, generating large quantities of energy generally accompanied by hot gases

3.3.16.4
hazardous substance
substance that has the potential for adversely impacting human health

Note 1 to entry: The criteria for determining whether a substance is classified as hazardous are usually defined by law or regulation.

3.3.17 Batteries

3.3.17.1
battery
assembly of one or more **cells** ready for use as a source of electrical energy characterized by its voltage, size, terminal arrangement, capacity and rate capability

Note 1 to entry: The term **battery** pack is considered to be a **battery**.

3.3.17.2
cell
basic manufactured unit providing a source of electrical energy by direct conversion of chemical energy, that consists of electrodes, separators, electrolyte, container and terminals

3.3.17.3
coin / button cell battery
small, single **cell battery** having a diameter greater than its height

3.3.17.4
highest specified charging temperature
highest temperature specified by the manufacturer at a site on each individual **cell** comprising the **battery** during charging of a secondary **battery**

Note 1 to entry: It is usually assumed that the end-product manufacturer is responsible to specify the safety-sensitive temperature, voltage or current of the **battery**, based on the specifications provided by **battery** supplier.

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3.3.17.5
lowest specified charging temperature
lowest temperature specified by the manufacturer at a site on each individual **cell** comprising the **battery** during charging of a secondary **battery**

Note 1 to entry: It is usually assumed that the end-product manufacturer is responsible to specify the safety sensitive temperature, voltage or current of the **battery**, based on the specifications provided by **battery** supplier.

3.3.17.6
maximum specified charging current
highest charging current specified by the manufacturer during charging of a secondary **battery**

3.3.17.7
maximum specified charging voltage
highest charging voltage specified by the manufacturer during charging of a secondary **battery**

3.3.17.8
secondary lithium battery
battery that

– incorporates one or more secondary lithium **cells**, and
– has a housing and a terminal arrangement, and
– may have electronic control devices, and
– is ready for use

Note 1 to entry: Examples of a **secondary lithium battery** include a rechargeable lithium-ion **battery**, a rechargeable lithium-polymer **battery** and a rechargeable lithium manganese **battery**.

3.3.18 FIW terms

3.3.18.1
fully insulated winding wire
FIW
polyurethane enamelled round copper wire, class 180

Note 1 to entry: The insulating properties are in accordance with IEC 60317-0-7, IEC 60317-56 and IEC 60851-5:2008. These standards also refer to this type of wire as “zero-defect wire”, which they define as “winding wire that exhibits no electrical discontinuities when tested under specific conditions”.

Note 2 to entry: The term “zero-defect wire” is commonly used to refer to **FIW**.

3.3.18.2
grade of FIW
range of overall diameter of a wire (FIW3 to FIW9)

3.3.19 Sound exposure

3.3.19.1
calculated sound dose
CSD
one week rolling estimate of **sound exposure** expressed as a percentage of the maximum regarded as safe

Note 1 to entry: See B.4 of EN 50332-3:2017 for additional information.

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3.3.19.2
momentary exposure level
MEL
metric for estimating 1 s **sound exposure** level from a specific test signal applied to both channels, based on EN 50332-1:2013, 4.2

Note 1 to entry: MEL is measured in dB(A).

Note 2 to entry: See B.3 of EN 50332-3:2017 for additional information.

3.3.19.3
sound exposure
E
A-weighted sound pressure (p) squared and integrated over a stated period of time, T

$$E = \int_0^T p(t)^2 \, \mathrm{d}t$$

Note 1 to entry: The SI unit is Pa^2 s.

3.3.19.4
sound exposure level
SEL
logarithmic measure of **sound exposure** relative to a reference value, E_0

$$\mathrm{SEL} = 10 \log_{10} \left(\frac{E}{E_0} \right)$$

Note 1 to entry: SEL is measured in dB(A).

Note 2 to entry: The reference value E_0 is typically the 1 kHz threshold of hearing in humans.

Note 3 to entry: See B.4 of EN 50332-3:2017 for additional information.

3.3.19.5
digital signal level relative to full scale
dBFS
level of a DC-free 997 Hz sine wave whose undithered positive peak value is positive digital full scale, leaving the code corresponding to negative digital full scale unused

Note 1 to entry: Levels reported in dBFS are always RMS.

Note 2 to entry: It is invalid to use dBFS for non-RMS levels. Because the definition of full scale is based on a sine wave, the level of signals with a crest factor lower than that of a sine wave may exceed 0 dBFS. In particular, square-wave signals may reach +3,01 dBFS.

4 General requirements

4.1 General

4.1.1 Application of requirements and acceptance of materials, components and subassemblies

Requirements are specified in the relevant clauses and, where referenced in those clauses, in the relevant annexes.

Where compliance of materials, components or subassemblies is demonstrated by inspection, such compliance may be by review of published data or previous test results.

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Internal and external components and subassemblies that comply with IEC 60950-1 or IEC 60065 are acceptable as part of equipment covered by this document without further evaluation other than to give consideration to the appropriate use of the component or subassembly in the end-product.

NOTE The paragraph above will be deleted in the next revision of this document, subject to a vote of National Committees at the time. It is added here to provide a smooth transition from the latest editions of IEC 60950-1 and IEC 60065 to this document.

4.1.2 Use of components

Where the component, or a characteristic of a component, is a **safeguard** or a part of a **safeguard**, components shall comply with the requirements of this document or, where specified in a requirements clause, with the safety aspects of the relevant IEC component standards.

NOTE 1 An IEC component standard is considered relevant only if the component in question clearly falls within its scope.

NOTE 2 The applicable test for compliance with a component standard is, in general, conducted separately.

Where use of an IEC component standard is permitted above, evaluation and testing of components shall be conducted as follows:

– a component shall be checked for correct application and use in accordance with its rating;

– a component that has been demonstrated to comply with a standard harmonized with the relevant IEC component standard shall be subjected to the applicable tests of this document, as part of the equipment, with the exception of those tests that are part of the relevant IEC component standard;

– a component that has not been demonstrated to comply with a relevant standard as above shall be subjected to the applicable tests of this document, as part of the equipment, and to the applicable tests of the component standard, under the conditions occurring in the equipment; and

– where components are used in circuits not in accordance with their specified ratings, the components shall be tested under the conditions occurring in the equipment. The number of samples required for test is, in general, the same as required by an equivalent standard.

Compliance is checked by inspection and by the relevant data or tests.

4.1.3 Equipment design and construction

Equipment shall be so designed and constructed that, under **normal operating conditions** as specified in Clause B.2, **abnormal operating conditions** as specified in Clause B.3, and **single fault conditions** as specified in Clause B.4, **safeguards** are provided to reduce the likelihood of injury or, in the case of fire, property damage.

Parts of equipment that could cause injury shall not be **accessible**, and **accessible** parts shall not cause an injury.

Compliance is checked by inspection and by the relevant tests.

4.1.4 Equipment installation

Except as given in 4.1.6, equipment evaluation according to this document shall take into account manufacturer's instructions with regard to installation, relocation, servicing and operation, as applicable.

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Outdoor enclosures providing a **safeguard** function shall comply with Annex Y. **Outdoor equipment** and **outdoor enclosures** shall be suitable for use at any temperature in the range specified by the manufacturer. If not specified by the manufacturer, the range shall be taken as:

– minimum ambient temperature: –33 °C;

– maximum ambient temperature: +40 °C.

Compliance is checked by inspection and by evaluation of the data provided by the manufacturer.

NOTE 1 The temperature values are based on IEC 60721-3-4, Class 4K2. These temperatures do not take into account severe environments (for example, extremely cold or extremely warm), nor do they include provision for heating by radiation from the sun (solar loading).

NOTE 2 Attention is drawn to IEC 61587-1 for additional information on performance levels C1, C2 and C3.

4.1.5 Constructions and components not specifically covered

Where the equipment involves technologies, components and materials or methods of construction not specifically covered in this document, the equipment shall provide **safeguards** not less than that generally afforded by this document and the principles of safety contained herein.

The need for additional detailed requirements to cope with a new situation should be brought promptly to the attention of the appropriate committee.

4.1.6 Orientation during transport and use

Where it is clear that the orientation of use of equipment is likely to have a significant effect on the application of the requirements or the results of tests, all orientations of use specified in the installation or user instructions shall be taken into account. However, if equipment has means for fixing in place by an **ordinary person**, such as the provision of screw holes for direct attachment to a mounting surface or through the use of brackets or the like, either provided with the equipment or readily available in the market, all likely positions of orientation of the equipment shall be taken into account, including the possibility of mounting to a non-vertical surface regardless of the installation or user instructions that are provided by the manufacturer.

In addition, for **transportable equipment**, all orientations of transport shall be taken into account.

4.1.7 Choice of criteria

Where this document indicates a choice between different criteria for compliance, or between different methods or conditions of test, the choice is specified by the manufacturer.

4.1.8 Liquids and liquid filled components (LFC)

Unless specified as an **insulating liquid**, liquids shall be treated as electrically conductive materials.

Constructions and test requirements for pressurized LFCs used inside the equipment where an injury can occur within the meaning of this document due to leaks of the liquid in the LFC shall comply with Clause G.15. However, Clause G.15 does not apply to the following:

– an LFC that is sealed but open to the atmosphere in the equipment; or

– components containing small amounts of liquids not likely to cause any injury (for example, liquid crystal displays, electrolytic capacitors, liquid cooling heat pipes, etc.); or

– wet **cell batteries** (for wet **cell batteries**, see Annex M); or

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– an LFC and its associated parts that comply with P.3.3; or

– equipment with more than 1 l of liquid.

4.1.9 Electrical measuring instruments

Electrical measuring instruments shall have sufficient bandwidth to provide accurate readings, taking into account all components (DC, **mains** frequency, high frequency and harmonic content) of the parameter being measured.

If an RMS value is measured, care shall be taken that the measuring instrument gives a true RMS reading of non-sinusoidal waveforms as well as sinusoidal waveforms.

Measurements shall be made with a meter whose input impedance has a negligible influence on the measurement.

4.1.10 Temperature measurements

Unless otherwise specified, where the result of a test is likely to depend upon the ambient temperature, the manufacturer's specified ambient temperature range of the equipment (T_{ma}) shall be taken into account. When performing the test at a specific ambient temperature (T_{amb}), extrapolation (above and below) the results of the test may be used to consider the impact of T_{ma} on the result. Components and subassemblies may be considered separately from the equipment if the test results and extrapolation is representative of the whole equipment being so tested. Relevant test data and manufacturer's specifications may be examined in order to determine the effect of temperature variability on a component or subassembly (see B.1.5).

4.1.11 Steady state conditions

Steady state conditions are conditions when temperature stability is considered to exist (see B.1.5).

4.1.12 Hierarchy of safeguards

Safeguards that are required for **ordinary persons** are acceptable, but may not be required, for **instructed persons** and **skilled persons**. Likewise, **safeguards** that are required for **instructed persons** are acceptable, but may not be required, for **skilled persons**.

A **reinforced safeguard** may be used in place of a **basic safeguard** or a **supplementary safeguard** or a **double safeguard**. A **double safeguard** may be used in place of a **reinforced safeguard**.

Safeguards, other than **equipment safeguards**, are specified in specific clauses.

4.1.13 Examples mentioned in this document

Where examples are given in this document, other examples, situations, and solutions are not excluded.

4.1.14 Tests on parts or samples separate from the end-product

If a test is conducted on a part or sample separate from the end-product, the test shall be conducted as if the part or sample was in the end-product.

4.1.15 Markings and instructions

Equipment that is required by this document to:

– bear markings; or

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– be provided with instructions; or

– be provided with **instructional safeguards**

shall meet the relevant requirements of Annex F.

Compliance is checked by inspection.

NOTE In Finland, Norway and Sweden, **class I pluggable equipment type A** intended for connection to other equipment or a network shall, if safety relies on connection to reliable earthing or if surge suppressors are connected between the network terminals and **accessible** parts, have a marking stating that the equipment must be connected to an earthed **mains** socket-outlet.

4.2 Energy source classifications

4.2.1 Class 1 energy source

Unless otherwise specified, a class 1 source is an energy source with levels not exceeding class 1 limits under:

– **normal operating conditions**; and

– **abnormal operating conditions** that do not lead to a **single fault condition**; and

– **single fault conditions** that do not result in class 2 limits being exceeded.

A **protective conductor** is a class 1 electrical energy source.

4.2.2 Class 2 energy source

Unless otherwise specified, a class 2 source is an energy source with levels exceeding class 1 limits and not exceeding class 2 limits under **normal operating conditions**, **abnormal operating conditions**, or **single fault conditions**.

4.2.3 Class 3 energy source

A class 3 source is an energy source with levels exceeding class 2 limits under **normal operating conditions**, **abnormal operating conditions**, or **single fault conditions**, or any energy source declared to be a class 3 source, as given in 4.2.4.

A neutral conductor is a class 3 electrical energy source.

4.2.4 Energy source classification by declaration

The manufacturer may declare:

– a class 1 energy source to be either a class 2 energy source or a class 3 energy source;

– a class 2 energy source to be a class 3 energy source.

4.3 Protection against energy sources

4.3.1 General

The terms “persons”, “body”, and “body parts” are represented by the probes of Annex V.

4.3.2 Safeguards for protection of an ordinary person

4.3.2.1 Safeguards between a class 1 energy source and an ordinary person

No **safeguards** are required between a class 1 energy source and an **ordinary person** (see Figure 9). Consequently, a class 1 energy source may be **accessible** to an **ordinary person**.

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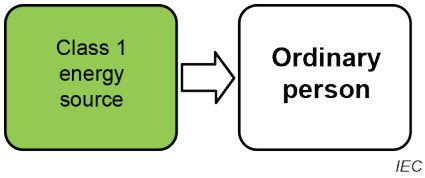


Figure 9 – Model for protection of an ordinary person against a class 1 energy source

4.3.2.2 Safeguards between a class 2 energy source and an ordinary person

At least one **basic safeguard** is required between a class 2 energy source and an **ordinary person** (see Figure 10).

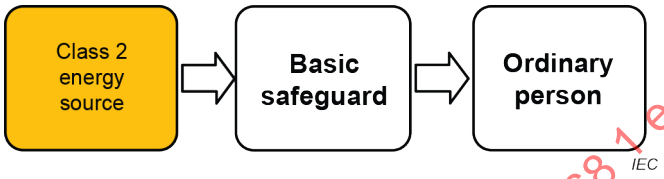


Figure 10 – Model for protection of an ordinary person against a class 2 energy source

4.3.2.3 Safeguards between a class 2 energy source and an ordinary person during ordinary person servicing conditions

If **ordinary person** servicing conditions require a **basic safeguard** to be removed or defeated, an **instructional safeguard** as described in Clause F.5 shall be provided and located in such a way that an **ordinary person** will see the instruction prior to removing or defeating the **basic safeguard** (see Figure 11).

The **instructional safeguard** (see Clause F.5) shall include all of the following:

– identify parts and locations of the class 2 energy source;

– specify actions that will protect persons from that energy source; and

– specify actions to reinstate or restore the **basic safeguard**.

If **ordinary person** servicing conditions require a **basic safeguard** to be removed or defeated, and where the equipment is intended for use in the home, an **instructional safeguard** (see Clause F.5), directed towards adults, shall warn against removing or defeating the **basic safeguard** by children.

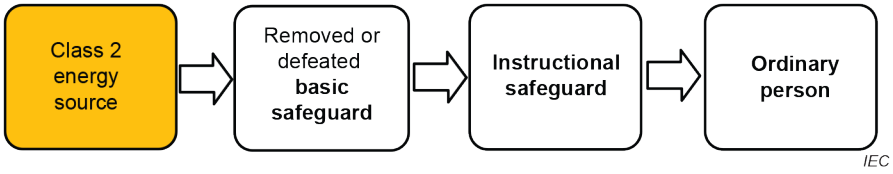


Figure 11 – Model for protection of an ordinary person against a class 2 energy source during ordinary person servicing conditions

4.3.2.4 Safeguards between a class 3 energy source and an ordinary person

Unless otherwise specified,

– an **equipment basic safeguard** and an **equipment supplementary safeguard** (together forming a **double safeguard**); or

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– a **reinforced safeguard**

is required between a class 3 energy source and an **ordinary person** (see Figure 12).

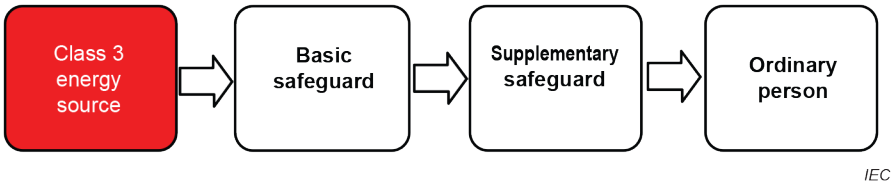


Figure 12 – Model for protection of an ordinary person against a class 3 energy source

4.3.3 Safeguards for protection of an instructed person

4.3.3.1 Safeguards between a class 1 energy source and an instructed person

No **safeguards** are required between a class 1 energy source and an **instructed person** (see Figure 13).

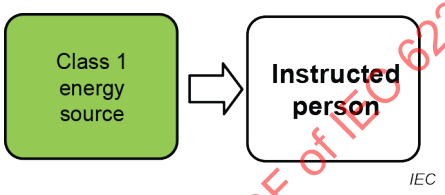


Figure 13 – Model for protection of an instructed person against a class 1 energy source

4.3.3.2 Safeguards between a class 2 energy source and an instructed person

An **instructed person** uses a **precautionary safeguard** (see Figure 14). No additional **safeguards** are required between a class 2 energy source and an **instructed person**. Consequently, a class 2 energy source may be **accessible** to an **instructed person**.



Figure 14 – Model for protection of an instructed person against a class 2 energy source

4.3.3.3 Safeguards between a class 3 energy source and an instructed person

Unless otherwise specified,

– an **equipment basic safeguard** and an **equipment supplementary safeguard** (together forming a **double safeguard**); or

– a **reinforced safeguard**

is required between a class 3 energy source and an **instructed person** (see Figure 15).

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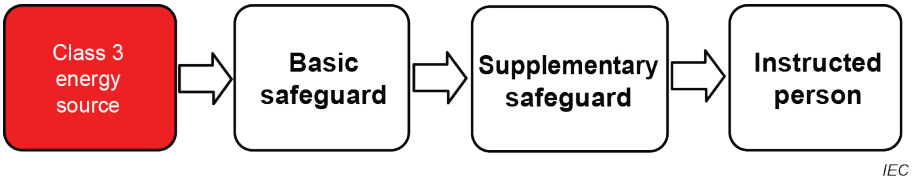


Figure 15 – Model for protection of an instructed person against a class 3 energy source

4.3.4 Safeguards for protection of a skilled person

4.3.4.1 Safeguards between a class 1 energy source and a skilled person

No **safeguard** is required between a class 1 energy source and a **skilled person**. Consequently, a class 1 energy source may be **accessible** to a **skilled person** (see Figure 16).

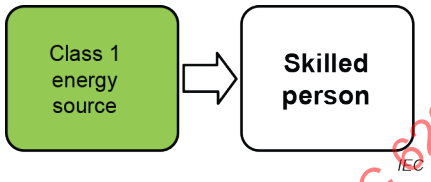


Figure 16 – Model for protection of a skilled person against a class 1 energy source

4.3.4.2 Safeguards between a class 2 energy source and a skilled person

A **skilled person** uses a **skill safeguard** (see Figure 17). No additional **safeguards** are required between a class 2 energy source and a **skilled person**. Consequently, a class 2 energy source may be **accessible** to a **skilled person**.

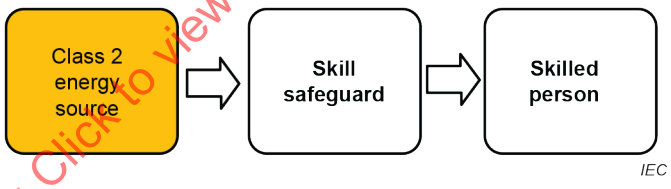


Figure 17 – Model for protection of a skilled person against a class 2 energy source

4.3.4.3 Safeguards between a class 3 energy source and a skilled person

A **skilled person** uses a **skill safeguard** (see Figure 18). Unless otherwise specified (for example, see 8.5.4), no additional **safeguards** are required between a class 3 energy source and a **skilled person**. Consequently, a class 3 energy source may be **accessible** to a **skilled person**.

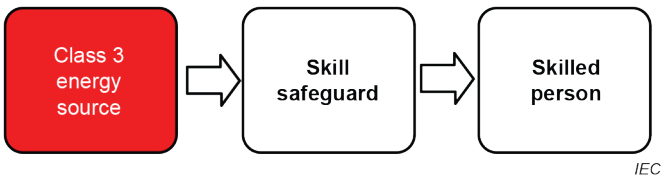


Figure 18 – Model for protection of a skilled person against a class 3 energy source

During equipment servicing conditions on a class 3 energy source, a **safeguard** intended to reduce the likelihood of injury due to an involuntary reaction is required between:

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– another class 3 energy source, not undergoing service and in the same vicinity as the class 3 energy source being serviced; and
– a **skilled person** (see 0.5.7 and Figure 19).

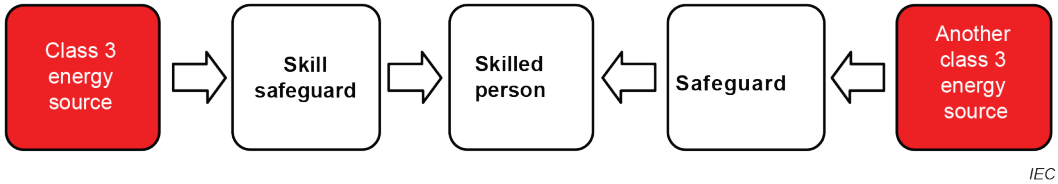


Figure 19 – Model for protection of a skilled person against class 3 energy sources during equipment servicing conditions

4.3.5 Safeguards in a restricted access area

Certain equipment is intended for installation exclusively in **restricted access areas**. Such equipment shall have **safeguards** as required in 4.3.3 for **instructed persons** and 4.3.4 for **skilled persons**.

4.4 Safeguards

4.4.1 Equivalent materials or components

Where this document specifies a particular **safeguard** parameter, such as thermal class of insulation or **material flammability class,** a **safeguard** with a better parameter may be used.

NOTE For a hierarchy of the **material flammability classes** see Table S.1, Table S.2 and Table S.3.

4.4.2 Composition of a safeguard

A **safeguard** may be comprised of one or more elements.

4.4.3 Safeguard robustness

4.4.3.1 General

Where a solid **safeguard** (for example, an **enclosure**, barrier, **solid insulation**, earthed metal, glass, etc.) is **accessible** to an **ordinary person** or to an **instructed person**, the **safeguard** shall comply with the relevant robustness tests as specified in 4.4.3.2 to 4.4.3.10.

For a **safeguard** that is **accessible** after opening an external **enclosure**, see 4.4.3.5.

Requirements for:

– adhesion of metallized coatings; and
– adhesives securing parts serving as **safeguards**; and
– parts that may defeat a **safeguard** if an adhesive fails

are specified in Clause P.4.

4.4.3.2 Steady force tests

An **enclosure** or barrier that is **accessible** and that is used as a **safeguard** of:

– **transportable equipment**; and
– **hand-held equipment**; and
– **direct plug-in equipment**

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shall be subjected to the steady force test of Clause T.4.

A **safeguard** that is **accessible** and that only acts as a **fire enclosure** or fire barrier shall be subjected to the steady force test of Clause T.3.

All other **enclosures** or barriers that are **accessible** and that are used as a **safeguard** shall be subjected to the steady force test of Clause T.5. There are no requirements for the bottom of equipment having a mass of more than 18 kg unless the user instructions permit an orientation in which the bottom of the **enclosure** becomes the top or a side of the equipment.

This subclause does not apply to glass. Requirements for glass are given in 4.4.3.6.

4.4.3.3 Drop tests

The following equipment shall be subjected to the drop test of Clause T.7:

– **hand-held equipment**;
– **direct plug-in equipment**;
– **transportable equipment**;
– **movable equipment** requiring lifting or handling by an **ordinary person** as part of its intended use, including routine relocation;

NOTE An example of such equipment is a paper shredder that rests on a waste container that requires removal of the paper shredder to empty the container.

– desk-top equipment having a mass of 7 kg or less that is intended for use with any one of the following:
  - a cord-connected telephone handset; or
  - another cord-connected hand-held accessory with an acoustic function; or
  - a headset.

4.4.3.4 Impact tests

All equipment, other than that specified in 4.4.3.3, shall be subjected to the impact test of Clause T.6.

The impact test of Clause T.6 is not applied to the following:

– the bottom of an **enclosure**, except if the user instructions permit an orientation in which the bottom of the **enclosure** becomes the top or a side of the equipment;
– glass;

NOTE Impact tests for glass are in 4.4.3.6.

– the surface of the **enclosure** of **stationary equipment**, including equipment for building-in, that is
  - not **accessible**; or
  - protected after installation.

4.4.3.5 Internal accessible safeguard tests

An internal solid **safeguard** that is **accessible** to an **ordinary person** after opening an external **enclosure** and whose failure would allow class 2 or class 3 energy sources to be **accessible** shall be subjected to the steady force test of Clause T.3.

4.4.3.6 Glass impact tests

The requirements below are applicable to all parts made of glass, with the exception of:

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– platen glass used on copiers, scanners and the like, where the glass has been subjected to the steady force test of Clause T.3 and is provided with a cover or device to protect the platen glass; and
– CRTs: Requirements for CRTs are given in Annex U; and
– glass that is laminated or has a construction such that glass particles do not separate from each other if the glass is broken.

NOTE Laminated glass includes constructions such as plastic film affixed to a single side of a glass.

Glass that is **accessible** to an **ordinary person** or to an **instructed person**:

– having a surface area exceeding 0,1 m^2; or
– having a major dimension exceeding 450 mm; or
– that prevents access to class 3 energy sources other than PS3

shall be subjected to the glass impact test of Clause T.9.

4.4.3.7 Glass fixation test

Laminated glass used as a **safeguard** that prevents access to class 3 energy sources other than PS3 shall be subjected to the following fixation tests:

– a glass impact test as given in Clause T.9 with an impact of 1 J applied three times; and
– a push/pull test with 10 N applied in the centre of the glass in the least favourable direction.

NOTE To perform the test, any suitable method can be used, such as using suction handles or gluing a support to the glass.

4.4.3.8 Thermoplastic material tests

If a **safeguard** is of moulded or formed thermoplastic material, the **safeguard** shall be so constructed that any shrinkage or distortion of the material due to release of internal stresses shall not defeat its **safeguard** function. The thermoplastic material shall be subjected to the stress relief test of Clause T.8.

4.4.3.9 Air comprising a safeguard

Where a **safeguard** is comprised of air (for example, a **clearance**), a barrier or **enclosure** shall prevent displacement of the air by a body part or a conductive part. The barrier or **enclosure** shall comply with the mechanical strength test specified in Annex T, as applicable.

4.4.3.10 Compliance criteria

During and after the tests:

– *except for PS3, class 3 energy sources shall not become **accessible** to an **ordinary person** or to an **instructed person**; and*
– *glass shall:*
  - *not break or crack; or*
  - *not expel pieces of glass greater than 30 g in mass or greater than 50 mm in any dimension; or*
  - *pass the fragmentation test of Clause T.10 on a separate test sample; and*
– *all other **safeguards** shall remain effective.*

4.4.4 Displacement of a safeguard by an insulating liquid

If an **insulating liquid** displaces air comprising a **safeguard**:

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– the requirements of 5.4.12 and 6.4.9 apply to the **insulating liquid**; and
– the requirements of 5.4.2 and 5.4.3 apply to the equipment both with and without the **insulating liquid** present.

Partial or total loss of the **insulating liquid** shall be considered an **abnormal operating condition** of the equipment.

If the power supplied to parts immersed in **insulating liquid** is disconnected in the event of partial or total loss of the **insulating liquid**, the requirements of 6.4.2 to 6.4.8 do not apply for the immersed parts. An example of such a disconnect system is a float switch system complying with Annex K.

NOTE The use of **insulating liquids** to replace a **basic insulation**, a **supplementary insulation** or a **reinforced insulation** is not covered by the requirements of this document.

4.4.5 Safety interlocks

Unless otherwise specified, if a **safety interlock** is used as a **safeguard** for protection against:

– a class 2 or a class 3 energy source for an **ordinary person**; or
– a class 3 energy source for an **instructed person**,

the **safety interlock** shall comply with Annex K.

4.5 Explosion

4.5.1 General

Explosion can be caused by:

– chemical reaction;
– mechanical deformation of a sealed container;
– rapid combustion or decomposition, producing a large volume of hot gas;
– high pressure; or
– high temperature.

NOTE 1 Depending on the energy rate, **explosion** can be categorized as a deflagration, a detonation, or pressure rupture.

NOTE 2 An ultracapacitor (for example, a double layer capacitor) is a high energy source and can explode following overcharging and high temperature.

For requirements regarding **explosion** of **batteries**, see Annex M.

4.5.2 Requirements

During **normal operating conditions** and **abnormal operating conditions**, an **explosion** shall not occur.

If an **explosion** occurs during **single fault conditions**, it shall not cause injury and the equipment shall comply with the relevant parts of this document.

Compliance is checked by inspection and tests as specified in Clause B.2, Clause B.3 and Clause B.4.

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4.6 Fixing of conductors

4.6.1 Requirements

Conductors shall be such that displacement cannot defeat a **safeguard**, such as reducing **clearances** or **creepage distances** below the values specified in 5.4.2 and 5.4.3.

The fixing of the conductors shall be such that, if a conductor becomes loose or detached, the conductor cannot defeat a **safeguard**, such as reducing **clearances** or **creepage distances** below the values specified in 5.4.2 and 5.4.3.

For the purpose of these requirements, it is assumed that:

– two independent fixings will not become loose or detached at the same time; and

– parts fixed by means of screws or nuts provided with self-locking washers or other means of locking are not liable to become loose or detached.

NOTE Spring washers and the like can provide satisfactory locking.

4.6.2 Compliance criteria

Compliance is checked by inspection, by measurement or, in case of doubt, by the test of Clause T.2 applied in the most unfavourable direction.

EXAMPLE Constructions regarded as meeting the requirements include:

– close-fitting tubing (for example, a heat shrink or rubber sleeve), applied over the wire and its termination;

– conductors connected by soldering and held in place near to the termination, independently of the soldered connection;

– conductors connected by soldering and securely hooked in before soldering, provided that the hole through which the conductor is passed is not unduly large;

– conductors connected to screw terminals, with an additional fixing near to the terminal that clamps, in the case of stranded conductors, the insulation and not only the conductors;

– conductors connected to screw terminals and provided with terminators that are unlikely to become free (for example, ring lugs crimped onto the conductors),however, the pivoting of such terminators is considered; or

– short rigid conductors that remain in position when the terminal screw is loosened.

4.7 Equipment for direct insertion into mains socket-outlets

4.7.1 General

Equipment incorporating integral pins for insertion into **mains** socket-outlets shall not impose undue torque on the socket-outlet. The means for retaining the pins shall withstand the forces to which the pins are likely to be subjected in normal use.

4.7.2 Requirements

The **mains** plug part shall comply with the relevant standard for the **mains** plug.

The equipment is inserted, as in normal use, into a fixed socket-outlet of a configuration as intended by the manufacturer, which is pivoted about a horizontal axis intersecting the centre lines of the contacts at a distance of 8 mm behind the engagement face of the socket outlet parallel to the engagement face.

4.7.3 Compliance criteria

Compliance is checked by inspection and, the additional torque that has to be applied to the socket-outlet to maintain the engagement face in the vertical plane shall not exceed 0,25 Nm. The torque to keep the socket-outlet itself in the vertical plane is not included in this value.

NOTE 1 In Australia and New Zealand, compliance is checked in accordance with AS/NZS 3112.

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NOTE 2 In the United Kingdom, the torque test is performed using a socket-outlet complying with BS 1363, and the plug part shall be assessed to the relevant clauses of BS 1363.

4.8 Equipment containing coin / button cell batteries

4.8.1 General

These requirements apply to equipment, including remote controls, that:

– are likely to be **accessible** to children; and

– include **coin / button cell batteries** with a diameter of 32 mm or less.

These requirements do not apply to:

– **professional equipment**;

– equipment for use in locations where it is unlikely that children will be present; or

– equipment containing **coin / button cell batteries** that are soldered in place.

4.8.2 Instructional safeguard

Equipment containing one or more **coin / button cell batteries** shall have an **instructional safeguard** in accordance with Clause F.5.

The **instructional safeguard** is not required where these **batteries** are not intended to be replaced or are only **accessible** after damaging the equipment.

The elements of the **instructional safeguard** shall be as follows:

– element 1a: not available

– element 2: “Do not ingest battery, Chemical Burn Hazard” or equivalent wording

– element 3: the following or equivalent text

[The remote control supplied with] This product contains a coin / button cell battery. If the coin / button cell battery is swallowed, it can cause severe internal burns in just 2 hours and can lead to death.

– element 4: the following or equivalent text

Keep new and used batteries away from children.

If the battery compartment does not close securely, stop using the product and keep it away from children.

If you think batteries might have been swallowed or placed inside any part of the body, seek immediate medical attention.

4.8.3 Construction

Equipment having a **battery** compartment door / cover shall be designed to reduce the possibility of children removing the **battery** by one of the following methods:

– a **tool**, such as a screwdriver or coin, is required to open the **battery** compartment, in which case a minimum torque of 0,5 Nm and a minimum angle of 90 degrees of rotation shall be required to open the compartment; or

– the **battery** compartment door / cover requires the application of a minimum of two independent and simultaneous movements to open by hand.

4.8.4 Tests

4.8.4.1 Test sequence

One sample shall be subjected to the applicable tests of 4.8.4.2 to 4.8.4.6. If applicable, the test in 4.8.4.2 shall be conducted first.

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4.8.4.2 Stress relief test

*If the **battery** compartment utilizes moulded or formed thermoplastic materials, the sample consisting of the complete equipment, or of the complete **enclosure** together with any supporting framework, is tested according to the stress relief test of Clause T.8.*

*During the test, the **battery** may be removed.*

4.8.4.3 Battery replacement test

*For equipment with a **battery** compartment door / cover, the **battery** compartment shall be opened and closed and the **battery** removed and replaced ten times to simulate normal replacement according to the manufacturer's instructions.*

*If the **battery** compartment door / cover is secured by one or more screws, the screws are loosened and then tightened applying a continuous linear torque according to Table 37, using a suitable screwdriver, spanner or key. The screws are to be completely removed and reinserted each time.*

4.8.4.4 Drop test

*Portable equipment having a mass of 7 kg or less are subjected to three drops from a height of 1 m onto a horizontal surface in positions likely to produce the maximum force on the **battery** compartment in accordance with Clause T.7.*

If the equipment is a remote control, it shall be subjected to ten drops.

4.8.4.5 Impact test

*The **battery** compartment door / cover shall be subjected to three impacts in a direction perpendicular to the **battery** compartment door / cover according to the test method of Clause T.6 with a force of:*

- *0,5 J (102 mm ± 10 mm height) for glasses for watching, for example, 3 dimensional television; or*
- *2 J (408 mm ± 10 mm height) for all other doors / covers.*

4.8.4.6 Crush test

Hand held remote control devices are to be supported by a fixed rigid supporting surface in a position likely to produce the most adverse results as long as the position can be self-supported. A crushing force of 330 N ± 5 N is applied to the exposed top and back surfaces of remote control devices placed in a stable condition by a flat surface measuring approximately 100 mm by 250 mm for a period of 10 s.

4.8.5 Compliance criteria

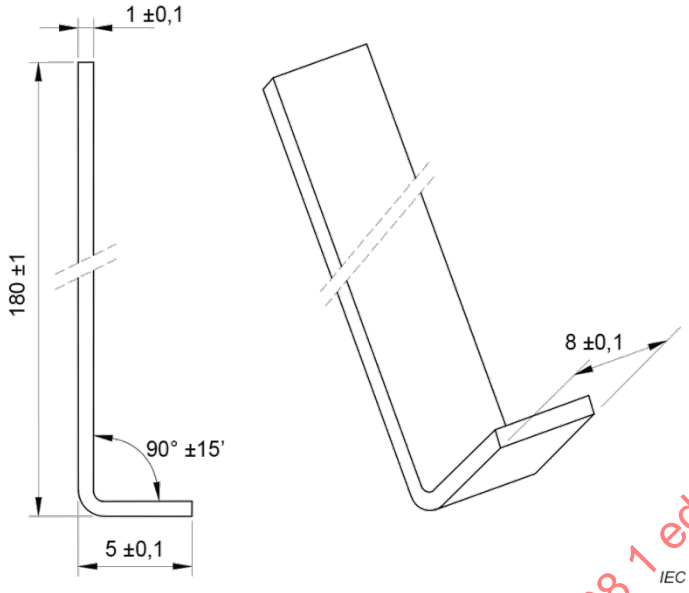
*Compliance is checked by applying a force of 30 N ± 1 N for 10 s to the **battery** compartment door / cover by the straight unjointed version of the test probe of Figure V.1 at the most unfavourable place and in the most unfavourable direction. The force shall be applied in one direction at a time.*

*The **battery** compartment door / cover shall remain functional, and:*

- *the **battery** shall not become **accessible**; or*
- *it shall not be possible remove the **battery** from the product with the test hook of Figure 20 using a force of approximately 20 N.*

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Dimensions in millimetres



Material: steel

Figure 20 – Test hook

4.9 Likelihood of fire or shock due to entry of conductive objects

Where the entry of a conductive object from outside the equipment or from another part of the equipment can result in:

– bridging within PS3 and ES3 circuits; or

– bridging an ES3 circuit to **accessible**, unearthed conductive parts,

top and side openings above PS3 and ES3 circuits shall:

– be located more than 1,8 m above the floor; or

– comply with Annex P.

Compliance is checked by inspection or according to Annex P.

4.10 Components requirements

4.10.1 Disconnect device

Equipment connected to the **mains** shall be provided with a **disconnect device** in accordance with Annex L.

4.10.2 Switches and relays

Switches and relays located in a PS3 circuit or used as a **safeguard** shall comply with Clause G.1 or Clause G.2 respectively.

5 Electrically-caused injury

5.1 General

To reduce the likelihood of painful effects and injury due to electric current passing through the human body, equipment shall be provided with the **safeguards** specified in Clause 5.

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5.2 Classification and limits of electrical energy sources

5.2.1 Electrical energy source classifications

5.2.1.1 ES1

ES1 is a class 1 electrical energy source with current or voltage levels:

– not exceeding ES1 limits under
  - **normal operating conditions**, and
  - **abnormal operating conditions**, and
  - **single fault conditions** of a component, device or insulation not serving as a **safeguard**; and
– not exceeding ES2 limits under **single fault conditions** of a **basic safeguard** or of a **supplementary safeguard**.

NOTE For accessibility requirements, see 5.3.1.

5.2.1.2 ES2

ES2 is a class 2 electrical energy source where:

– both the voltage and the current exceed the limits for ES1; and
– under
  - **normal operating conditions**, and
  - **abnormal operating conditions**, and
  - **single fault conditions**,

either the voltage or the current does not exceed the limit for ES2.

NOTE For accessibility requirements, see 5.3.1.

5.2.1.3 ES3

ES3 is a class 3 electrical energy source where both the voltage and current exceed the limit for ES2.

5.2.2 Electrical energy source ES1 and ES2 limits

5.2.2.1 General

The limits specified in 5.2.2 are with respect to earth or with respect to an **accessible** part.

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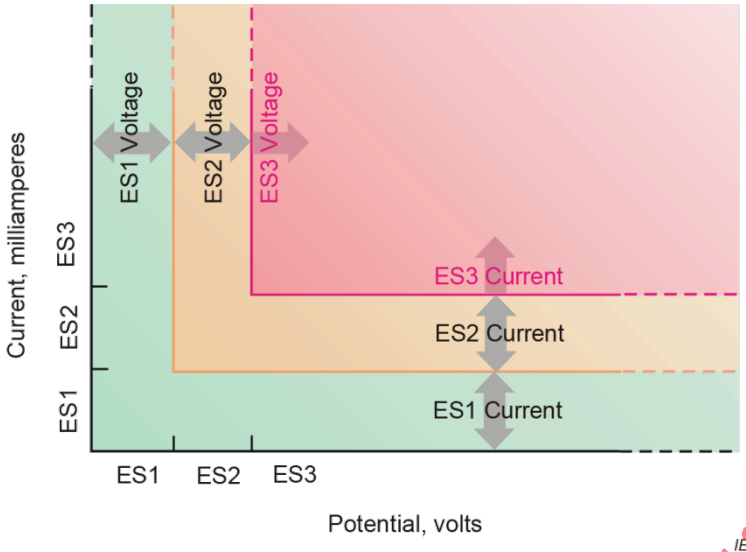


Figure 21 – Illustration showing ES limits for voltage and current

For any voltage up to the voltage limit, there is no limit for the current. Likewise for any current up to the current limit, there is no limit for the voltage, see Figure 21.

5.2.2.2 Steady state voltage and current limits

An electrical energy source class is determined from both the voltage and the current under **normal operating conditions**, **abnormal operating conditions**, and **single fault conditions** (see Table 4).

The values are the maximum that can be delivered by the source. Steady state is considered established when the voltage or current values persist for 2 s or longer, otherwise the limits of 5.2.2.3, 5.2.2.4 or 5.2.2.5 apply, as appropriate.

NOTE In Denmark, a warning (marking **safeguard**) for high **touch current** is required if the **touch current** exceeds the limits of 3,5 mA AC or 10 mA DC.

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Table 4 – Electrical energy source limits for steady state ES1 and ES2

Energy source	ES1 limits		ES2 limits		ES3
	Voltage	**Current** [a, c, d]	**Voltage**	**Current** [b, c, e]	
DC [c]	60 V	2 mA	120 V	25 mA	> ES2
AC up to 1 kHz	30 V RMS 42,4 V peak	0,5 mA RMS 0,707 mA peak	50 V RMS 70,7 V peak	5 mA RMS 7,07 mA peak	
AC > 1 kHz up to 100 kHz	30 V RMS + 0,4 f 42,4 V peak. + 0,4 $\sqrt{2}\,f$		50 V RMS + 0,9 f 70,7 V peak + 0,9 $\sqrt{2}\,f$		
AC above 100 kHz	70 V RMS 99 V peak		140 V RMS 198 V peak		
Combined AC and DC	$\frac{U_{DC}(V)}{60}+\frac{U_{AC\,RMS}(V)}{U_{RMS\,limit}}\le 1$ $\frac{U_{DC}(V)}{60}+\frac{U_{AC\,peak}(V)}{U_{peak\,limit}}\le 1$	$\frac{I_{DC}(mA)}{2}+\frac{I_{AC\,RMS}(mA)}{0,5}\le 1$ $\frac{I_{DC}(mA)}{2}+\frac{I_{AC\,peak}(mA)}{0,707}\le 1$	See Figure 23	See Figure 22	

As an alternative to the requirements above, the values below can be used for purely sinusoidal waveforms

Energy source	ES1 limits	ES2 limits	ES3
	Current [c] RMS	**Current** [c] RMS	
AC up to 1 kHz	0,5 mA	5 mA	> ES2
AC > 1 kHz up to 100 kHz	0,5 mA × f [d]	5 mA + 0,95 f [e]	
AC above 100 kHz	50 mA [d]	100 mA [e]	

f is in kHz.

Peak values shall be used for non-sinusoidal voltage and current. RMS values may be used only for sinusoidal voltage and current.

See 5.7 for measurement of **prospective touch voltage** and **touch current**.

[a] Current is measured using the measuring network specified in Figure 4 of IEC 60990:2016.

[b] Current is measured using the measuring network specified in Figure 5 of IEC 60990:2016.

[c] For sinusoidal waveforms and DC, the current may be measured using a 2 000 Ω resistor.

[d] Above 22 kHz the **accessible** area is limited to 1 cm^2.

[e] Above 36 kHz the **accessible** area is limited to 1 cm^2.

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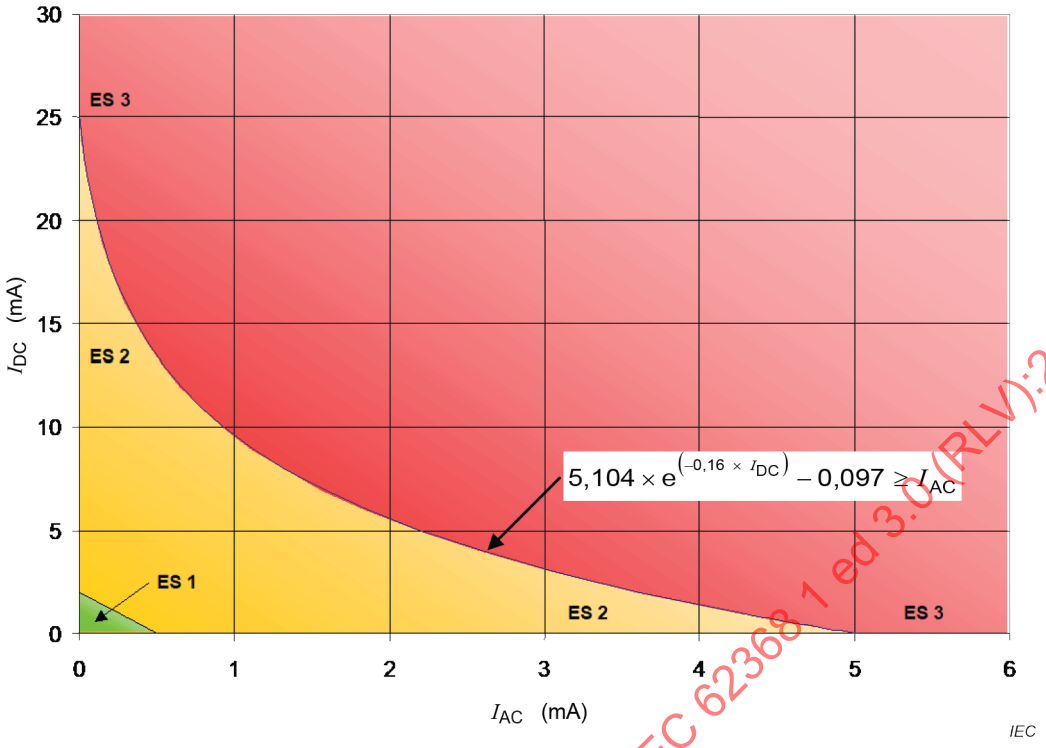


Figure 22 – Maximum values for combined AC current and DC current

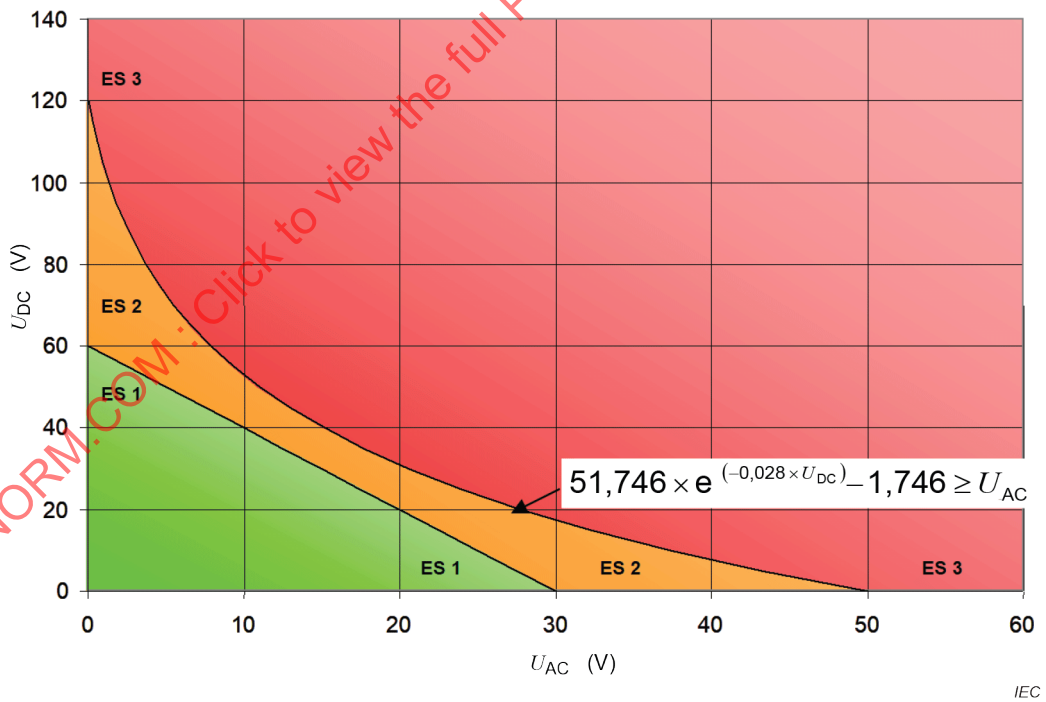


Figure 23 – Maximum values for combined AC voltage and DC voltage

5.2.2.3 Capacitance limits

Where the electrical energy source is a capacitor, the energy source is classified from both the charge voltage and the capacitance.

The capacitance is the rated value of the capacitor plus the specified tolerance.

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The ES1 and ES2 limits for various capacitance values are listed in Table 5.

NOTE 1 The capacitance values for ES2 are derived from Table A.2 of IEC TS 61201:2007.

NOTE 2 The values for ES1 are calculated by dividing the values from Table A.2 of IEC TS 61201:2007, by two (2).

Table 5 – Electrical energy source limits for a charged capacitor

C nF	**ES1** U_{peak} V	**ES2** U_{peak} V	**ES3** U_{peak} V
300 or greater	60	120	> ES2
170	75	150	
91	100	200	
61	125	250	
41	150	300	
28	200	400	
18	250	500	
12	350	700	
8,0	500	1 000	
4,0	1 000	2 000	
1,6	2 500	5 000	
0,8	5 000	10 000	
0,4	10 000	20 000	
0,2	20 000	40 000	
0,133 or less	30 000	60 000	
Linear interpolation may be used between the nearest two points.			

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5.2.2.4 Single pulse limits

Where the electrical energy source is a single pulse, the energy source is classified from both the voltage and the duration or from both the current and the duration. Values are given in Table 6 and Table 7. If the voltage exceeds the limit, then the current shall not exceed the limit. If the current exceeds the limit, the voltage shall not exceed the limit. Currents are measured according to 5.7. For repetitive pulses, see 5.2.2.5.

For pulse durations up to 10 ms, the voltage or current limit for 10 ms applies.

If more than one pulse is detected within a period of 3 s, then the electrical energy source is treated as a repetitive pulse and the limits of 5.2.2.5 apply.

NOTE 1 The pulse limits are calculated from Figure 22 and Table 10 of IEC TS 60479-1:2005.

NOTE 2 These single pulses do not include transients.

NOTE 3 Pulse duration is considered to be the time duration when the voltage or current exceeds ES1 limits.

Table 6 – Voltage limits for single pulses

Pulse duration up to and including ms	ES1 U_{peak} V	ES2 U_{peak} V	ES3 U_{peak} V
10	60	196	> ES2
20		178	
50		150	
80		135	
100		129	
200 and longer		120	

If the time duration lies between the values in any two rows, either the lower ES2 value of U_{peak} shall be used or a linear interpolation may be used between any two adjacent rows with the calculated peak voltage value rounded down to the nearest volt.

If the peak voltage for ES2 lies between the values in any two rows, either the shortest time duration may be used or a linear interpolation may be used between any two adjacent rows with the calculated time duration rounded down to the nearest millisecond.

Table 7 – Current limits for single pulses

Pulse duration up to and including ms	ES1 I_{peak} mA	ES2 I_{peak} mA	ES3 I_{peak} mA
10	2	200	> ES2
20		153	
50		107	
100		81	
200		62	
500		43	
1 000		33	
2 000 and longer		25	

If the time duration lies between the values in any two rows, either the lower ES2 value of I_{peak} shall be used or a linear interpolation may be used between any two adjacent rows with the calculated value rounded down to the nearest milliampere.

If the peak current for ES2 lies between the values in any two rows, either the value of the shortest time duration may be used or a linear interpolation may be used between any two adjacent rows with the calculated time duration rounded down to the nearest millisecond.

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5.2.2.5 Limits for repetitive pulses

Except for pulses covered in Annex H, a repetitive pulse electrical energy source class is determined from either the available voltage or the available current. If the voltage exceeds the limit, then the current shall not exceed the limit. If the current exceeds the limit, the voltage shall not exceed the limit. Currents are measured according to 5.7.

For pulse off times less than 3 s, the peak values of 5.2.2.2 apply. For longer durations, the values of 5.2.2.4 apply.

5.2.2.6 Ringing signals

Where the electrical energy source is an analogue telephone network ringing signal as defined in Annex H, the energy source class is considered to be ES2.

5.2.2.7 Audio signals

For electrical energy sources that are audio signals, the limits are specified in Clause E.1.

5.3 Protection against electrical energy sources

5.3.1 General

Except as given below, protection requirements for parts **accessible** to **ordinary persons**, **instructed persons**, and **skilled persons** are given in 4.3.

ES2 or ES3 circuits, from which **accessible** ES1 or ES2 circuits are derived, shall be separated from ES3 **mains** by a **double safeguard** or a **reinforced safeguard**. In addition, the following applies:

– under **single fault conditions** in the circuit between ES2/ES3 and the **accessible** ES1, the current or voltage levels shall not exceed the ES1 limits; and

– under **single fault conditions** in the circuit between ES2/ES3 and **accessible** ES2, the current or voltage levels shall not exceed the ES2 limits.

NOTE An example for this construction is a rectifier in the insulated (secondary) circuit in a switch mode power supply in which multiple components are present.

Bare conductors at ES3 shall be located or guarded so that unintentional contact with such conductors during service operations by a **skilled person** is unlikely (see Figure 19).

For a **battery** backed up supply capable of backfeeding to the input AC terminals, see 5.8.

5.3.2 Accessibility to electrical energy sources and safeguards

5.3.2.1 Requirements

For **ordinary persons**, the following shall not be **accessible**:

– bare parts at ES2, except for the pins of connectors. However, such pins shall not be **accessible** under **normal operating conditions** by the blunt probe of Figure V.3; and

– bare parts at ES3; and

– an ES3 **basic safeguard**.

For bare parts of **outdoor equipment** that are **accessible** to an **ordinary person** in their intended **outdoor location,** the following shall not be **accessible**:

– bare parts exceeding 0,5 times ES1 voltage limits under **normal operating conditions** and **abnormal operating conditions** and **single fault conditions** of a component, device or insulation not serving as a **safeguard**; and

– bare parts exceeding ES1 voltage limits under **single fault conditions** of a **basic safeguard** or of a **supplementary safeguard** (see 5.2.1.1).

For **instructed persons**, the following shall not be **accessible**:

– bare parts at ES3; and

– an ES3 **basic safeguard**.

5.3.2.2 Contact requirements

For ES3 voltages up to 420 V peak, the appropriate test probe from Annex V shall not contact a bare internal conductive part.

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For ES3 voltages above 420 V peak, the appropriate test probe from Annex V shall not contact a bare internal conductive part and shall have an air gap from that part (see Figure 24).

The air gap shall either:

a) pass an electric strength test in accordance with 5.4.9.1 at a test voltage (DC or peak AC) that is equal to the test voltage for **basic insulation** in Table 26 corresponding to the peak of the **working voltage**; or

b) have a minimum distance according to Table 8.

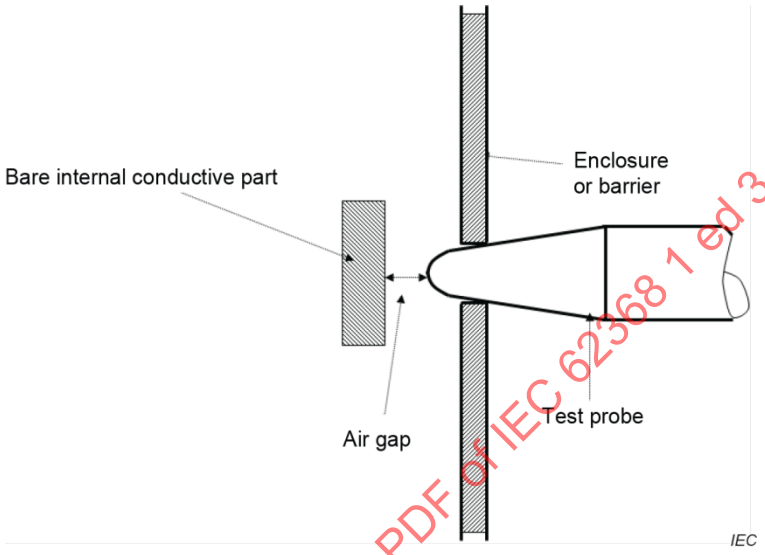


Figure 24 – Contact requirements to bare internal conductive parts

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Table 8 – Minimum air gap distance

Voltage	Air gap distance mm	
V peak or DC up to and including	Pollution degree	
	2	3
> 420 and ≤ 1 000	0,2	0,8
1 200	0,25	
1 500	0,5	
2 000	1,0	
2 500	1,5	
3 000	2,0	
4 000	3,0	
5 000	4,0	
6 000	5,5	
8 000	8,0	
10 000	11	
12 000	14	
15 000	18	
20 000	25	
25 000	33	
30 000	40	
40 000	60	
50 000	75	
60 000	90	
80 000	130	
100 000	170	
Linear interpolation may be used between the nearest two points, the calculated minimum air gap distance being rounded up to the next higher 0,1 mm increment or the value in the next row below whichever is lower. For equipment intended to be used more than 2 000 m above sea level, the values in this table are multiplied by the multiplication factor for the desired altitude according to Table 16.		

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5.3.2.3 Compliance criteria

Compliance is checked by the test of Clause T.3.

In addition, for bare ES3 parts at a voltage above 420 V peak, compliance is checked by distance measurement or by an electric strength test.

Components and subassemblies that comply with their respective IEC standards do not have to be tested when such components and subassemblies are used in the final product.

5.3.2.4 Terminals for connecting stripped wire

The use of a stripped wire to make connection with its associated terminal intended to be used:

– by an **ordinary person** shall not result in contact with ES2 or ES3; and

– by an **instructed person** shall not result in contact with ES3.

For audio signal voltages, see Table E.1 for the values of ES2 and ES3. Parts of audio signal terminals provided with one of the **safeguards** in Table E.1 are not tested.

Compliance is checked by the test of V.1.6 for each wire terminal opening as well as any other openings within 25 mm from the terminal. During the test, no portion of the probe inserted into the terminal or opening shall contact ES2 or ES3.

5.4 Insulation materials and requirements

5.4.1 General

5.4.1.1 Insulation

Insulation consisting of insulating materials, **clearances**, **creepage distances** and **solid insulation**, and that is providing a **safeguard** function is designated **basic insulation**, **supplementary insulation**, **double insulation**, or **reinforced insulation**.

5.4.1.2 Properties of insulating material

The choice and application of insulating material shall take into account the needs for electrical strength, mechanical strength, dimension, frequency of the **working voltage** and other properties for the working environment (temperature, pressure, humidity and pollution) as specified in Clause 5 and Annex T.

Insulating material shall not be hygroscopic as determined by 5.4.1.3.

5.4.1.3 Compliance criteria

Compliance is checked by inspection and, where necessary, by evaluation of the data for the material.

Where necessary, if the data does not confirm that the material is non-hygroscopic, the hygroscopic nature of the material is determined by subjecting the component or subassembly using the insulation in question to the humidity treatment of 5.4.8. The insulation is then subjected to the relevant electric strength test of 5.4.9.1 while still in the humidity chamber, or in the room in which the samples were brought to the prescribed temperature.

5.4.1.4 Maximum operating temperatures for materials, components and systems

5.4.1.4.1 Requirements

Under **normal operating conditions**, insulating material temperatures shall not exceed the temperature limit of the EIS, including insulating materials of components, or the maximum temperature limit of the insulation system as given in Table 9.

For maximum temperatures below or equal to 100 ºC, no declared insulation system is required. An undeclared EIS is considered to be Class 105 (A).

5.4.1.4.2 Test method

Insulating material temperatures are measured in accordance with B.1.5.

*The equipment or parts of the equipment are operated under **normal operating conditions** (see Clause B.2) as follows:*

- *for continuous operation, until steady state conditions are established; and*
- *for **intermittent operation**, until steady state conditions are established, using the rated "ON" and "OFF" periods; and*
- *for **short-time operation**, for the operating time specified by the manufacturer.*

Components and other parts may be tested independently of the end product provided that the test conditions applicable to the end product are applied to the component or part.

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Equipment intended for building-in or rack-mounting, or for incorporation in larger equipment, is tested under the most adverse actual or simulated conditions specified in the installation instructions.

5.4.1.4.3 Compliance criteria

The temperature of the electrical insulation material or EIS shall not exceed the limits in Table 9.

For a single insulating material, the declared relative temperature index information from the material manufacturer can be used if it is suitable for the applicable class of insulation.

For an EIS, the available thermal class data of the EIS as indicated by the manufacturer can be used if it is suitable for the applicable class of insulation.

For thermal classifications above Class 105 (A), the EIS shall comply with IEC 60085.

Table 9 – Temperature limits for materials, components and systems

Part	Maximum temperature T_{max} °C
Insulation, including winding insulation:	
of Class 105 (A) material or EIS	100 [a]
of Class 120 (E) material or EIS	115 [a]
of Class 130 (B) material or EIS	120 [a]
of Class 155 (F) material or EIS	140 [a]
of Class 180 (H) material or EIS	165 [a]
of Class 200 (N) material or EIS	180 [a]
of Class 220 (R) material or EIS	200 [a]
of Class 250 material or EIS	225 [a]
Insulation of internal and external wiring, including power supply cords: – without temperature marking – with temperature marking	 70 Temperature marked on the wire or spool, or rating assigned by the manufacturer
Other thermoplastic insulation	See 5.4.1.10
Components	See also Annex G and 4.1.2
The classes are related to the temperature classes of electrical insulating materials and EIS in accordance with IEC 60085. The assigned letter designations are given in parentheses. For each material, account shall be taken of the data for that material to determine the appropriate maximum temperature.	
[a] If the temperature of a winding is determined by thermocouples, these values are reduced by 10 K, except in the case of: – a motor, or – a winding with embedded thermocouples.	

5.4.1.5 Pollution degrees

5.4.1.5.1 General

The different degrees of pollution of the operating or micro-environment for products covered by this document are given below.

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Pollution degree 1

No pollution or only dry, non-conductive pollution occurs. The pollution has no influence.

NOTE 1 Within the equipment, components or subassemblies that are sealed to exclude dust and moisture are examples of **pollution degree** 1.

Pollution degree 2

Only non-conductive pollution occurs except that occasionally a temporary conductivity caused by condensation is to be expected.

NOTE 2 **Pollution degree** 2 is generally appropriate for equipment covered by the scope of this document.

Pollution degree 3

Conductive pollution occurs or dry non-conductive pollution occurs that becomes conductive due to condensation, which is to be expected.

5.4.1.5.2 Test for pollution degree 1 environment and for an insulating compound

A sample is subjected to the thermal cycling sequence of 5.4.1.5.3.

It is allowed to cool to room temperature and is then subjected to the humidity conditioning of 5.4.8.

*If the test is conducted for verification of the insulating compound forming **solid insulation** as required by 5.4.4.3, the conditioning is immediately followed by the electric strength test of 5.4.9.1.*

*For printed boards, compliance is checked by external visual inspection. There shall be no delamination which affects the **creepage distances** required to fulfil the requirements of **pollution degree** 1.*

For other than printed boards, compliance is checked by inspection of the cross-sectional area, and there shall be no visible voids, gaps or cracks in the insulating material.

5.4.1.5.3 Thermal cycling test procedure

A sample of a component or subassembly is subjected to the following sequence of tests. The sample is subjected 10 times to the following sequence of thermal cycling:

68 h	*at*	*($T_1 \pm 2$) °C;*
1 h	*at*	*(25 ± 2) °C;*
2 h	*at*	*(0 ± 2) °C;*
≥ 1 h	*at*	*(25 ± 2) °C.*

$T_1 = T_2 + T_{ma} - T_{amb} + 10$ K, or 85 °C, whichever is higher. However, the 10 K margin is not added if the temperature is measured by an embedded thermocouple or by the resistance method.

T_2 is the temperature of the parts measured during the test of 5.4.1.4.

The significance of T_{ma} and T_{amb} are as given in B.2.6.1.

The period of time taken for the transition from one temperature to another is not specified, but the transition may be gradual.

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5.4.1.6 Insulation in transformers with varying dimensions

If the insulation of a transformer has different **working voltages** along the length of the winding, the **clearances**, **creepage distances** and distances through insulation may vary in a corresponding fashion.

NOTE An example of such a construction is a 30 kV winding, consisting of multiple bobbins connected in series, and earthed or connected to a common point at one end.

5.4.1.7 Insulation in circuits generating starting pulses

For circuits generating starting pulses exceeding ES1 (for example, to ignite a discharge lamp), the requirements for **basic insulation**, **supplementary insulation** and **reinforced insulation** apply to **creepage distances** and distances through insulation.

NOTE 1 For **working voltages** in the above cases, see 5.4.1.8.1 i).

NOTE 2 If the starting pulse is an AC waveform, the pulse width is determined by connecting the peak values of the AC waveform.

The **clearances** are determined by one of the following methods:

– determine the minimum **clearance** in accordance with 5.4.2; or

– conduct one of the following electric strength tests, with the connection terminals of the starting pulse circuit (for example, a lamp) shorted together:

  - the test given in 5.4.9.1; or
  - apply 30 pulses having an amplitude equal to the required test voltage given in 5.4.9.1 generated by an external pulse generator. The pulse width shall be equal to or greater than that of the internally generated starting pulse.

Compliance is checked by inspection or test. During the test, the insulation shall show no breakdown or flashover.

5.4.1.8 Determination of working voltage

5.4.1.8.1 General

In determining **working voltages**, all of the following requirements apply:

a) unearthed **accessible** conductive parts are assumed to be earthed;

b) if a transformer winding or other part is not connected to a circuit that establishes its potential relative to earth, the winding or other part are assumed to be earthed at a point by which the highest **working voltage** is obtained;

c) except as specified in 5.4.1.6, for insulation between two transformer windings, the highest voltage between any two points in the two windings is the **working voltage**, taking into account the voltages to which the input windings will be connected;

d) except as specified in 5.4.1.6, for insulation between a transformer winding and another part, the highest voltage between any point on the winding and the other part is the **working voltage**;

e) where **double insulation** is used, the **working voltage** across the **basic insulation** is determined by imagining a short-circuit across the **supplementary insulation**, and vice versa. For **double insulation** between transformer windings, the short-circuit is assumed to take place at the point by which the highest **working voltage** is produced across the other insulation;

f) when the **working voltage** is determined by measurement, the input voltage supplied to the equipment shall be the **rated voltage** or the voltage within the **rated voltage range** that results in the highest measured value;

g) the **working voltage** between any point in the circuit supplied by the **mains** and

  – any part connected to earth; and

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– any point in a circuit isolated from the **mains**,

shall be taken as the greater of the following:

– the **rated voltage** or the upper voltage of the **rated voltage range**; and

– the measured voltage;

h) when determining the **working voltage** for an ES1 or ES2 **external circuit**, the normal operating voltages shall be taken into account. If the operating voltages are not known, the **working voltage** shall be taken as the upper limits of ES1 or ES2 as applicable. Short duration signals (such as telephone ringing) shall not be taken into account for determining **working voltage**;

i) for circuits generating starting pulses (for example, discharge lamps, see 5.4.1.7), the **working voltage** is the peak value of the pulses with the lamp connected but before the lamp ignites. The frequency of the **working voltage** to determine the minimum **clearance** shall be taken as less than 30 kHz. The **working voltage** to determine minimum **creepage distances** is the voltage measured after the ignition of the lamp.

5.4.1.8.2 RMS working voltage

In determining the **RMS working voltage**, short-term conditions (for example, cadenced telephone ringing signals in **external circuits**) and non-repetitive transients (for example, due to atmospheric disturbances) are not taken into account.

NOTE The **creepage distances** are determined from the **RMS working voltages**.

5.4.1.9 Insulating surfaces

An **accessible** insulating surface is considered to be covered by a thin metallic foil for determining **clearances**, **creepage distances** and distance through insulation (see Figure O.13).

5.4.1.10 Thermoplastic parts on which conductive metallic parts are directly mounted

5.4.1.10.1 Requirements

Thermoplastic parts on which conductive metallic parts are directly mounted shall be sufficiently resistant to heat if softening of the plastic could result in the failure of a **safeguard**.

Compliance is checked by examination of the Vicat test or ball pressure data from the material manufacturer. If the data is not available, compliance is checked by either the Vicat test of 5.4.1.10.2 or by the ball pressure test of 5.4.1.10.3.

5.4.1.10.2 Vicat test

*The measured temperature during **normal operating conditions**, as specified in Clause B.2, shall be at least 15 K less than the Vicat softening temperature as specified in Vicat test B50 of ISO 306.*

*The measured temperature during **abnormal operating conditions** of Clause B.3 shall be less than the Vicat softening temperature.*

*The Vicat softening temperature of a non-metallic part supporting parts in a circuit supplied from the **mains** shall be not less than 125 °C.*

5.4.1.10.3 Ball pressure test

Compliance is checked by subjecting the part to the ball pressure test according to IEC 60695-10-2. The test is made in a heating cabinet at a temperature of $(T - T_{amb} + T_{ma} + 15\ °C) \pm 2\ °C$ *(see B.2.6.1 for the explanation of* T, T_{ma} *and* T_{amb}*). However, a*

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*thermoplastic part supporting parts in a circuit supplied from the **mains** is tested at a minimum of 125 °C.*

After the test, dimension d (diameter of the indentation) shall not exceed 2 mm.

The test is not made if it is clear from examination of the physical characteristics of the material that it will meet the requirements of this test.

5.4.2 Clearances

5.4.2.1 General requirements

Clearances shall be so dimensioned that the likelihood of breakdown due to:

– **temporary overvoltages**; and

– transient voltages that may enter the equipment; and

– recurring peak voltages and their related frequencies that are generated within the equipment

is reduced.

All required **clearances** and test voltages apply to an altitude up to 2 000 m. For higher altitudes, the multiplication factors of 5.4.2.5 apply after any linear interpolation, but before rounding up, and before any other multiplication factors are applied as stated in Table 10, Table 11, Table 14 and Table 15.

NOTE For air gaps between contacts of **safety interlocks**, see Annex K. For air gaps between contacts of **disconnect devices**, see Annex L. For air gaps between contacts in components, see Annex G. For connectors, see G.4.1.

Unless otherwise specified by the manufacturer and supplied with means to assure minimum **clearances** during all modes of normal operation, the voice coil and adjacent conductive parts of a loudspeaker are considered to be conductively connected.

To determine the **clearance**, the highest value of the following two procedures shall be used:

– Procedure 1: Determine **clearances** according to 5.4.2.2.

– Procedure 2: Determine **clearances** according to 5.2.2.3. Alternatively, the adequacy of **clearances** may be determined using an electric strength test according to 5.2.2.4, in which case the values according to Procedure 1 shall be maintained.

For Overvoltage Category II, **clearances** in circuits connected to an AC **mains** not exceeding 420 V peak (300 V RMS) may be determined per Annex X as an alternative.

5.4.2.2 Procedure 1 for determining clearance

To determine the voltage to be used in Table 10 and Table 11, the highest voltage of the following is used as applicable:

– the peak value of the **working voltage** across the **clearance**;

– the recurring peak voltages, if any, across the **clearance**;

– for circuits connected to the AC **mains**: the **temporary overvoltage**, which is taken as 2 000 V peak if the nominal AC **mains** system voltage does not exceed 250 V and is taken as 2 500 V peak if the nominal AC **mains** system voltage exceeds 250 V but does not exceed 600 V.

  Alternatively, the **temporary overvoltage** may be determined in accordance with 5.3.3.2.3 of IEC 60664-1:2007 at the discretion of the manufacturer, in which case the reference to

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"solid insulation" in 5.3.3.2.3 of IEC 60664-1:2007 is replaced by "clearances". Moreover, the short term value equal to U_n + 1 200 V is taken as the voltage for use in Table 10.

NOTE U_n is the nominal line-to-neutral voltage of the neutral-earthed supply system.

This voltage shall be used to determine the **clearance** as follows:

– **clearance** values of Table 10 for circuits with fundamental frequencies up to 30 kHz; or

– **clearance** values of Table 11 for circuits with fundamental frequencies higher than 30 kHz; or

– the highest **clearance** values of Table 10 and Table 11 for circuits where both frequencies lower than 30 kHz and higher than 30 kHz are present.

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Table 10 – Minimum clearances for voltages with frequencies up to 30 kHz

Voltage up to and including peak	Basic insulation or supplementary insulation mm			Reinforced insulation mm		
	Pollution degree			Pollution degree		
	1 [a]	2	3	1 [a]	2	3
330	0,01	0,2	0,8	0,02	0,4	1,5
400	0,02			0,04		
500	0,04			0,08		
600	0,06			0,12		
800	0,13			0,26		
1 000	0,26	0,26		0,52	0,52	
1 200	0,42			0,84		
1 500	0,76			1,52		1,6
2 000	1,27			2,54		
2 500	1,8			3,6		
3 000	2,4			4,8		
4 000	3,8			7,6		
5 000	5,7			11,0		
6 000	7,9			15,8		
8 000	11,0			20		
10 000	15,2			27		
12 000	19			33		
15 000	25			42		
20 000	34			59		
25 000	44			77		
30 000	55			95		
40 000	77			131		
50 000	100			175		
60 000	120			219		
80 000	175			307		
100 000	230			395		

Linear interpolation may be used between the nearest two points, the calculated minimum **clearances** being rounded up to the next higher specified increment. For values:

– not exceeding 0,5 mm, the specified increment is 0,01 mm; and

– exceeding 0,5 mm, the specified increment is 0,1 mm.

[a] The values for **pollution degree** 1 may be used if a sample complies with the tests of 5.4.1.5.2.

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Table 11 – Minimum clearances for voltages with frequencies above 30 kHz

Voltage up to and including peak	Basic insulation or supplementary insulation mm	Reinforced insulation mm
600	0,07	0,14
800	0,22	0,44
1 000	0,6	1,2
1 200	1,68	3,36
1 400	2,82	5,64
1 600	4,8	9,6
1 800	8,04	16,08
2 000	13,2	26,4
Linear interpolation may be used between the nearest two points, the calculated minimum **clearances** being rounded up to the next higher specified increment. For values: – not exceeding 0,5 mm, the specified increment is 0,01 mm; and – exceeding 0,5 mm, the specified increment is 0,1 mm. For **pollution degree** 1, use a multiplication factor of 0,8. For **pollution degree** 3, use a multiplication factor of 1,4.		

5.4.2.3 Procedure 2 for determining clearance

5.4.2.3.1 General

The dimension for a **clearance** that is subject to transient voltages from the **mains** or an **external circuit** is determined from the **required withstand voltage** for that **clearance**.

Each **clearance** shall be determined using the following steps:

– determine the transient voltage according to 5.4.2.3.2; and
– determine the **required withstand voltage** according to 5.4.2.3.3; and
– determine the minimum **clearance** according to 5.4.2.3.4.

5.4.2.3.2 Determining transient voltages

5.4.2.3.2.1 General

Transient voltages can be determined based on their origin, or can be measured in accordance with 5.4.2.3.2.5.

If different transient voltages affect the same **clearance**, the largest of those voltages is used. The values are not added together.

Outdoor equipment connected to the **mains** shall be suitable for the highest **mains transient voltage** expected in the installation location.

Consideration shall be given to the following:

– the prospective fault current of the supply to **outdoor equipment** can be higher than for indoor equipment, see IEC 60364-4-43; and
– the **mains transient voltage** for **outdoor equipment** can be higher than for indoor equipment.

Components within **outdoor equipment** that reduce the **mains transient voltage** or the prospective fault current shall comply with the requirements of the IEC 61643 -series.

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NOTE 1 The overvoltage category of **outdoor equipment** is normally considered to be one of the following:

– if powered via the normal building installation wiring, Overvoltage Category II;

– if powered directly from the **mains** distribution system, Overvoltage Category III;

– if at, or in the proximity of, the origin of the electrical installation, Overvoltage Category IV.

NOTE 2 For further information regarding protection from overvoltages, see IEC 60364-5-53.

Compliance is checked by inspection of the equipment, the installation instructions and, where necessary, by the applicable component tests specified in the IEC 61643-series.

5.4.2.3.2.2 Determining AC mains transient voltages

For equipment to be supplied from the AC **mains**, the value of the **mains transient voltage** depends on the overvoltage category and the AC **mains** voltage and is given in Table 12. In general, **clearances** in equipment intended to be connected to the AC **mains**, shall be designed for Overvoltage Category II.

NOTE See Annex I for further guidance on the determination of overvoltage categories.

Equipment that is likely, when installed, to be subjected to transient voltages that exceed those for its design overvoltage category requires additional transient voltage protection to be provided external to the equipment. In this case, the installation instructions shall state the need for such external protection.

Table 12 – Mains transient voltages

AC mains voltage [a] up to and including V RMS	**Mains transient voltage [b]** V peak			
	Overvoltage Category			
	I	**II**	**III**	**IV**
50	330	500	800	1 500
100 [c]	500	800	1 500	2 500
150 [d]	800	1 500	2 500	4 000
300 [e]	1 500	2 500	4 000	6 000
600 [f]	2 500	4 000	6 000	8 000

[a] For equipment designed to be connected to a three-phase 3-wire supply, where there is no neutral conductor, the AC **mains** supply voltage is the line-to-line voltage. In all other cases, where there is a neutral conductor, it is the line-to-neutral voltage.

[b] The **mains transient voltage** is always one of the values in the table. Interpolation is not permitted.

[c] In Japan, the value of the **mains transient voltages** for the nominal AC **mains** supply voltage of 100 V is determined from columns applicable to the nominal AC **mains** supply voltage of 150 V.

[d] Including 120/208 V and 120/240 V.

[e] Including 230/400 V and 277/480 V.

[f] Including 400/690 V.

5.4.2.3.2.3 Determining DC mains transient voltages

If an earthed DC power distribution system is entirely within a single building, the transient voltage is selected as follows:

– if the DC power distribution system is earthed at a single point, the transient voltage is taken to be 500 V peak; or

– if the DC power distribution system is earthed at the source and the equipment, the transient voltage is taken to be 350 V peak; or

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NOTE The connection to protective earth can be at the source of the DC power distribution system or at the equipment location, or both (see ITU-T Recommendation K.27).

– if the cabling associated with the DC power distribution system is shorter than 4 m or is installed entirely in continuous metallic conduit, the transient voltage is taken to be 150 V peak.

If a DC power distribution system is not earthed or is not within the same building, the transient voltage with respect to earth shall be taken to be equal to the **mains transient voltage** in the **mains** from which the DC power is derived.

If the DC power distribution system is not within the same building, and is constructed using installation and protection techniques similar to those of **external circuits**, the transient voltage shall be determined using the relevant classification from 5.4.2.3.2.4.

If equipment is supplied from a dedicated **battery** that has no provision for charging from a **mains** supply without removal from the equipment, the transient voltage shall be disregarded.

When determining the DC **mains transient voltage**, the installation and the source of the DC **mains** shall be taken into account. If these are not known, the **mains transient voltage** on the DC **mains** supply for an **outdoor equipment** shall be taken as 1,5 kV.

If the DC power distribution system is not within the same building, the manufacturer shall declare the **mains transient voltage** on the DC **mains** supply in the installation instructions.

5.4.2.3.2.4 Determining external circuit transient voltages

The applicable value of the transient voltage that may occur on an **external circuit** shall be determined using Table 13. Where more than one location or condition is applicable, the highest transient voltage applies. A ringing or other interrupted signal shall not be taken into account if the voltage of this signal is less than that of the transient voltage.

If the transient voltage is less than the peak voltage of a short duration signal (such as a telephone ringing signal), the peak voltage of the short duration signal shall be used as the transient voltage.

If the **external circuit** transient voltages are known to be higher than indicated in Table 13, the known value shall be used.

NOTE 1 Australia has published its overvoltage limits in AS/ACIF G624:2005.

NOTE 2 It is assumed that adequate measures have been taken to reduce the likelihood that the transient voltages presented to the equipment exceed the values specified in Table 13. In installations where transient voltages presented to the equipment are expected to exceed the values specified in Table 13, additional measures such as surge suppression can be necessary.

NOTE 3 In Europe, the requirement for interconnection with an **external circuit** is in addition given in EN 50491-3:2009, *General requirements for Home and Building Electronic Systems (HBES) and Building Automation and Control Systems (BACS) – Part 3: Electrical safety requirements*.

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Table 13 – External circuit transient voltages

ID	Cable type	Additional conditions	Transient voltages
1	Paired conductor [a] – shielded or unshielded	The building or structure may or may not have equipotential bonding.	1 500 V 10/700 µs Only differential if one conductor is earthed in the equipment
2	Any other conductors	The **external circuit** is not earthed at either end, but there is an earth reference (for example, from connection to **mains)**.	**Mains transient voltage** or **external circuit** transient voltage of the circuit from which the circuit in question is derived whichever is higher.
3	Coaxial cable in the cable distribution network	Equipment other than power-fed coaxial repeaters. Cable shield is earthed at the equipment.	4 000 V 10/700 µs Centre conductor to shield
4	Coaxial cable in the cable distribution network	Power fed coaxial repeaters (up to 4,4 mm coaxial cable). Cable shield is earthed at the equipment.	5 000 V 10/700 µs Centre conductor to shield
5	Coaxial cable in the cable distribution network	Equipment other than power-fed coaxial repeaters. Cable shield is not earthed at the equipment. Cable shield is earthed at building entrance.	4 000 V 10/700 µs Centre conductor to shield 1 500 V 1,2/50 µs shield to earth
6	Coaxial cable	Cable connects to an outdoor antenna	no transient [b]
7	Paired conductor [a]	Cable connects to an outdoor antenna	no transient [b]
8	Coaxial cable within the building	The connection of the cable coming from outside the building is made via a transfer point. The shield of the coaxial cable from outside the building and the shield of the coaxial cable of the cable within the building are connected together and are connected to earth.	Not applicable

In general, for **external circuits** installed wholly within the same building structure, transients are not taken into account. However, a conductor is considered to leave the building if it terminates on equipment earthed to a different earthing network.

The effects of unwanted steady state voltages generated outside the equipment (for example, earth potential differences and voltages induced on telecommunication networks by electric train systems) are controlled by installation practices. Such practices are application dependent and are not dealt with by this document.

For a shielded cable to affect a reduction in transients, the shield shall be continuous, earthed at both ends, and have a maximum transfer impedance of 20 Ω/km (for f less than 1 MHz).

NOTE 1 Home appliances like audio, video and multimedia products are addressed by ID 6, 7 and 8.

NOTE 2 In Norway and Sweden, the cable shield on coaxial cables is normally not earthed at the building entrance (see the note in 5.7.7). For installation conditions, see IEC 60728-11.

[a] A paired conductor includes a twisted pair.

[b] These cables are not subject to any transients but they may be affected by a 10 kV electrostatic discharge voltage (from a 1 nF capacitor). The effect of such electrostatic discharge voltages is not taken into account when determining **clearances**. Compliance is checked by the test of G.10.4.

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5.4.2.3.2.5 Determining transient voltage levels by measurement

The transient voltage across the **clearance** is measured using the following procedure.

During the measurement, the equipment is not connected to the **mains** or to any **external circuit**. Only surge suppressors internal to the equipment in circuits connected to the **mains** are disconnected. If the equipment is intended to be used with a separate power supply, it is connected to the equipment during the measurement.

To measure the transient voltage across a **clearance**, the appropriate impulse test generator of Annex D is used to generate impulses. At least three impulses of each polarity, with intervals of at least 1 s between impulses, are applied between each relevant point.

a) Transient voltages from an AC **mains**

The impulse test generator circuit 2 of Table D.1 is used to generate 1,2/50 μs impulses equal to the AC **mains transient voltages** between the following points:

– line-to-line;
– all line conductors conductively joined together and neutral;
– all line conductors conductively joined together and protective earth; and
– neutral and protective earth.

b) Transient voltages from a DC **mains**

The impulse test generator circuit 2 of Table D.1 is used to generate 1,2/50 μs impulses equal to the DC **mains transient voltages**, at the following points:

– the positive and negative supply connection points; and
– all supply connection points joined together and protective earth.

c) Transient voltages from an **external circuit**

The appropriate test generator of Annex D is used to generate impulses as applicable and described in Table 13 and are applied between each of the following **external circuit** connection points of a single interface type:

– each pair of terminals (for example, A and B or tip and ring) in an interface; and
– all terminals of a single interface type joined together and earth.

A voltage measuring device is connected across the **clearance** in question.

Where there are several identical circuits, only one is tested.

5.4.2.3.3 Determining required withstand voltage

The **required withstand voltage** is equal to the transient voltage as determined in 5.4.2.3.2, except for the following cases:

– If a circuit isolated from the **mains** is connected to the main **protective earthing** terminal through a **protective bonding conductor**, the **required withstand voltage** may be one overvoltage category lower or one AC **mains** voltage lower in Table 12. For an AC **mains** up to and including 50 V RMS, no adjustments are made.
– In a circuit isolated from the **mains** supplied by a DC source with capacitive filtering, and connected to protective earth, the **required withstand voltage** shall be assumed to be equal to the peak value of the **DC voltage** of the source, or the peak of the **working voltage** of the circuit isolated from the **mains**, whichever is higher.
– If equipment is supplied from a dedicated **battery** that has no provision for charging from the **mains** supply without removal from the equipment, the transient voltage is zero and the **required withstand voltage** is equal to the peak of the **working voltage**.

5.4.2.3.4 Determining clearances using required withstand voltage

Each **clearance** shall comply with the relevant value of Table 14.

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Table 14 – Minimum clearances using required withstand voltage

Required withstand voltage	Basic insulation or supplementary insulation mm			Reinforced insulation mm		
V peak or DC up to and including	Pollution degree			Pollution degree		
	1 [a]	2	3	1 [a]	2	3
330	0,01	0,2	0,8	0,02	0,4	1,5
400	0,02			0,04		
500	0,04			0,08		
600	0,06			0,12		
800	0,10			0,2		
1 000	0,15			0,3		
1 200	0,25			0,5		
1 500	0,5			1,0		
2 000	1,0			2,0		
2 500	1,5			3,0		
3 000	2,0			3,8		
4 000	3,0			5,5		
5 000	4,0			8,0		
6 000	5,5			8,0		
8 000	8,0			14		
10 000	11			19		
12 000	14			24		
15 000	18			31		
20 000	25			44		
25 000	33			60		
30 000	40			72		
40 000	60			98		
50 000	75			130		
60 000	90			162		
80 000	130			226		
100 000	170			290		

Linear interpolation may be used between the nearest two points, the calculated minimum **clearances** shall be rounded up to the next higher specified increment. For values:

– not exceeding 0,5 mm, the specified increment is 0,01 mm; and

– exceeding 0,5 mm, the specified increment is 0,1 mm.

[a] The values for **pollution degree** 1 may be used if a sample complies with the tests of 5.4.1.5.2.

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5.4.2.4 Determining the adequacy of a clearance using an electric strength test

*The **clearances** shall withstand an electric strength test. The test may be conducted using an impulse voltage or an AC voltage or a **DC voltage**. The **required withstand voltage** is determined as given in 5.4.2.3.*

The impulse withstand voltage test is carried out with a voltage having an appropriate waveform (see Annex D) with the values specified in Table 15. Five impulses of each polarity are applied with an interval of at least 1 s between pulses.

The AC voltage test is conducted using a sinusoidal voltage with a peak value as specified in Table 15 and is applied for 5 s.

*The **DC voltage** test is conducted using a **DC voltage** specified in Table 15 and applied for 5 s in one polarity and then for 5 s in reverse polarity.*

Table 15 – Electric strength test voltages

Required withstand voltage up to and including kV peak	**Test voltage for electric strength for clearances for basic insulation or supplementary insulation** kV peak (impulse or AC or DC)
0,33	0,36
0,5	0,54
0,8	0,93
1,5	1,75
2,5	2,92
4,0	4,92
6,0	7,39
8,0	9,85
12,0	14,77
U [a]	1,23 × U [a]
Linear interpolation may be used between the nearest two points, the calculated minimum test voltage being rounded up to the next higher 0,01 kV increment. For **reinforced insulation**, the test voltage for electric strength is 160 % of the value for the **basic insulation** after which this calculated test voltage is rounded up to the next higher 0,01 kV increment. If the EUT fails the AC or DC test, the impulse test shall be used. If the test is conducted at an altitude of 200 m or more above sea level, Table F.5 of IEC 60664-1:2007 may be used, in which case linear interpolation between 200 m and 500 m altitudes and between the corresponding impulse test voltages of Table F.5 of IEC 60664-1:2007 may be used.	
[a] U is any **required withstand voltage** higher than 12,0 kV.	

5.4.2.5 Multiplication factors for altitudes higher than 2 000 m above sea level

For equipment intended and designed to be used more than 2 000 m above sea level, the minimum **clearances** in Table 10, Table 11 and Table 14 and the electric strength test voltages in Table 15 are multiplied by the multiplication factor for the desired altitude according to Table 16.

NOTE 1 Higher altitudes can be simulated in a vacuum chamber.

NOTE 2 In China, special requirements in choosing multiplication factors for altitudes above 2 000 m exist.

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Table 16 – Multiplication factors for clearances and test voltages

Altitude m	Normal barometric pressure kPa	Multiplication factor for clearances	Multiplication factor for electric strength test voltages		
			< 1 mm	≥ 1 mm to < 10 mm	≥ 10 mm to < 100 mm
2 000	80,0	1,00	1,00	1,00	1,00
3 000	70,0	1,14	1,05	1,07	1,10
4 000	62,0	1,29	1,10	1,15	1,20
5 000	54,0	1,48	1,16	1,24	1,33
Linear interpolation may be used between the nearest two points, the calculated minimum multiplication factor being rounded up to the next higher 0,01 increment.					

5.4.2.6 Compliance criteria

Compliance is checked by measurement and test taking into account the relevant clauses of Annex O and Annex T.

The following conditions apply:

– *movable parts are placed in their most unfavourable positions;*

– ***clearances** from an **enclosure** of insulating material through a slot or opening are measured according to Figure O.13, point X;*

– *during the force tests, metal **enclosures** shall not come into contact with bare conductive parts of:*

- *ES2 circuits, unless the product is in a **restricted access area**, or*
- *ES3 circuits;*

– *after the tests of Annex T:*

- *the dimensions for **clearances** are measured, and*
- *the relevant electric strength test shall be applied, and*
- *for the glass impact test of Clause T.9, damage to the finish, small dents that do not reduce **clearances** below the specified values, surface cracks and the like are ignored. If a through crack appears, **clearances** shall not be reduced. For cracks not visible to the naked eye, an electric strength test shall be conducted; and*

– *components and parts, other than parts serving as an **enclosure**, are subjected to the test of Clause T.2. After the application of the force, **clearances** shall not be reduced below the required values.*

For circuits connected to coaxial cable distribution or outdoor antennas, compliance is checked by the tests of 5.5.8.

5.4.3 Creepage distances

5.4.3.1 General

Creepage distances shall be so dimensioned that, for a given **RMS working voltage**, **pollution degree** and material group, no flashover or breakdown of insulation (for example, due to tracking) will occur.

Creepage distances for **basic insulation** and **supplementary insulation** for frequencies up to 30 kHz shall comply with Table 17. **Creepage distances** for **basic insulation** and **supplementary insulation** for frequencies greater than 30 kHz and up to 400 kHz shall comply with Table 18.

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The **creepage distance** requirements for frequencies up to 400 kHz can be used for frequencies over 400 kHz until additional data is available.

NOTE **Creepage distances** for frequencies higher than 400 kHz are under consideration.

The **creepage distance** between the outer insulating surface (see 5.4.3.2) of a connector (including an opening in the **enclosure**) and conductive parts that are connected to ES2 within the connector (or in the **enclosure**) shall comply with the requirements for **basic insulation**.

The **creepage distance** between the outer insulating surface (see 5.4.3.2) of a connector (including an opening in the **enclosure**) and conductive parts that are connected to ES3 within the connector (or in the **enclosure**) shall comply with the requirements for **reinforced insulation**.

As an exception, the **creepage distance** may comply with the requirements for **basic insulation** if the connector is:

– fixed to the equipment; and
– located internally to the outer **electrical enclosure** of the equipment; and
– only **accessible** after removal of a subassembly that
  - is required to be in place during **normal operating conditions**, and
  - is provided with an **instructional safeguard** to replace the removed subassembly.

For all other **creepage distances** in connectors, including connectors that are not fixed to the equipment, the minimum values determined in accordance with 5.4.3 apply.

The above minimum **creepage distances** for connectors do not apply to connectors listed in Clause G.4.

If the minimum **creepage distance** derived from Table 17 or Table 18 is less than the minimum **clearance**, then the minimum **clearance** shall be applied as the minimum **creepage distance**.

For glass, mica, glazed ceramic or similar inorganic materials, if the minimum **creepage distance** is greater than the applicable minimum **clearance**, the value of minimum **clearance** may be applied as the minimum **creepage distance**.

For **reinforced insulation**, the values for **creepage distances** are twice the values for **basic insulation** in Table 17 or Table 18.

5.4.3.2 Test method

The following conditions apply:

– *movable parts are placed in their most unfavourable positions;*
– *for equipment incorporating ordinary **non-detachable power supply cords**, **creepage distance** measurements are made with supply conductors of the largest cross-sectional area specified in Clause G.7, and also without conductors;*
– *when measuring **creepage distances** from an **accessible** outer surface of an **enclosure** of insulating material through a slot or opening in the **enclosure** or through an opening in an **accessible** connector, the **accessible** outer surface of the **enclosure** shall be considered to be conductive as if it were covered by a metal foil during the test of V.1.2, applied without appreciable force (see Figure O.13, point X);*
– *the dimensions for **creepage distances** functioning as **basic insulation**, **supplementary insulation** and **reinforced insulation** are measured after the tests of Annex T according to 4.4.3;*

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– *for the glass impact test of Clause T.9, damage to the finish, small dents that do not reduce **creepage distances** below the specified values, surface cracks and the like are ignored. If a through crack appears, **creepage distances** shall not be reduced;*

– *components and parts, other than parts serving as an **enclosure**, are subjected to the test of Clause T.2. After the application of the force, **creepage distances** shall not be reduced below the required values.*

5.4.3.3 Material group and CTI

Material groups are based on the CTI and are classified as follows:

Material Group I	600 ≤ CTI
Material Group II	400 ≤ CTI < 600
Material Group IIIa	175 ≤ CTI < 400
Material Group IIIb	100 ≤ CTI < 175

The material group is checked by evaluation of the test data for the material according to IEC 60112 using 50 drops of solution A.

If the material group is not known, Material Group IIIb shall be assumed.

If a CTI of 175 or greater is needed, and the data is not available, the material group can be established with a test for proof tracking index (PTI) as detailed in IEC 60112. A material may be included in a group if its PTI established by these tests is equal to, or greater than, the lower value of the comparative tracking index (CTI) specified for the group.

5.4.3.4 Compliance criteria

Compliance is checked by measurement taking into account Annex O, Annex T and Annex V.

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Table 17 – Minimum creepage distances for basic insulation and supplementary insulation in mm

RMS working voltage up to and including	Pollution degree						
	1 [a]	2			3		
	Material group						
V	I, II, IIIa, IIIb	I	II	IIIa, IIIb	I	II	IIIa, IIIb [b]
10	0,08	0,4	0,4	0,4	1,0	1,0	1,0
12,5	0,09	0,42	0,42	0,42	1,05	1,05	1,05
16	0,1	0,45	0,45	0,45	1,1	1,1	1,1
20	0,11	0,48	0,48	0,48	1,2	1,2	1,2
25	0,125	0,5	0,5	0,5	1,25	1,25	1,25
32	0,14	0,53	0,53	0,53	1,3	1,3	1,3
40	0,16	0,56	0,8	1,1	1,4	1,6	1,8
50	0,18	0,6	0,85	1,2	1,5	1,7	1,9
63	0,2	0,63	0,9	1,25	1,6	1,8	2,0
80	0,22	0,67	0,95	1,3	1,7	1,9	2,1
100	0,25	0,71	1,0	1,4	1,8	2,0	2,2
125	0,28	0,75	1,05	1,5	1,9	2,1	2,4
160	0,32	0,8	1,1	1,6	2,0	2,2	2,5
200	0,42	1,0	1,4	2,0	2,5	2,8	3,2
250	0,56	1,25	1,8	2,5	3,2	3,6	4,0
320	0,75	1,6	2,2	3,2	4,0	4,5	5,0
400	1,0	2,0	2,8	4,0	5,0	5,6	6,3
500	1,3	2,5	3,6	5,0	6,3	7,1	8,0
630	1,8	3,2	4,5	6,3	8,0	9.0	10
800	2,4	4,0	5,6	8,0	10	11	12,5
1 000	3,2	5,0	7,1	10	12,5	14	16
1 250	4,2	6,3	9,0	12,5	16	18	20
1 600	5,6	8,0	11	16	20	22	25
2 000	7,5	10	14	20	25	28	32
2 500	10	12,5	18	25	32	36	40
3 200	12,5	16	22	32	40	45	50
4 000	16	20	28	40	50	56	63
5 000	20	25	36	50	63	71	80
6 300	25	32	45	63	80	90	100
8 000	32	40	56	80	100	110	125
10 000	40	50	71	100	125	140	160
12 500	50	63	90	125			
16 000	63	80	110	160			
20 000	80	100	140	200			
25 000	100	125	180	250			
32 000	125	160	220	320			
40 000	160	200	280	400			
50 000	200	250	360	500			
63 000	250	320	450	600			

Linear interpolation may be used between the nearest two points, the calculated minimum **creepage distance** being rounded to the next higher 0,1 mm increment or the value in the next row below whichever is lower.

For **reinforced insulation**, the rounding to the next higher 0,1 mm increment or to double the value in the next row is done after doubling the calculated value for **basic insulation**.

[a] The values for **pollution degree** 1 may be used if a sample complies with the tests of 5.4.1.5.2.

[b] Material Group IIIb is not recommended for applications in **pollution degree** 3 with an **RMS working voltage** above 630 V.

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Table 18 – Minimum values of creepage distances (in mm) for frequencies higher than 30 kHz and up to 400 kHz

Voltage kV	30 kHz < f ≤ 100 kHz	100 kHz < f ≤ 200 kHz	200 kHz < f ≤ 400 kHz
0,1	0,016 7	0,02	0,025
0,2	0,042	0,043	0,05
0,3	0,083	0,09	0,1
0,4	0,125	0,13	0,15
0,5	0,183	0,23	0,25
0,6	0,267	0,38	0,4
0,7	0,358	0,55	0,68
0,8	0,45	0,8	1,1
0,9	0,525	1,0	1,9
1	0,6	1,15	3

The values for the **creepage distances** in the table apply for **pollution degree** 1. For **pollution degree** 2 a multiplication factor of 1,2 and for **pollution degree** 3, a multiplication factor of 1,4 shall be used.

Linear interpolation may be applied, the result being rounded up to the next significant digit.

The data given in this Table 18 (from Table 2 of IEC 60664-4:2005) does not take into account the influence of tracking phenomena. For that purpose, Table 17 has to be taken into account. Therefore, if values in Table 18 are smaller than those in Table 17, the values of Table 17 apply.

5.4.4 Solid insulation

5.4.4.1 General requirements

The requirements of this subclause apply to **solid insulation**, including compounds and gel materials used as insulation.

Solid insulation shall not break down:

– due to overvoltages, including transients, that enter the equipment, and peak voltages that may be generated within the equipment; and

– due to pinholes in thin layers of insulation.

Enamelled coatings shall not be used for **basic insulation**, **supplementary insulation** or **reinforced insulation** except as given in G.6.2.

Except for printed boards, **solid insulation** shall either:

– comply with minimum distances through insulation in accordance with 5.4.4.2; or

– meet the requirements and pass the tests in 5.4.4.3 to 5.4.4.7, as applicable.

Glass used as **solid insulation** shall comply with the glass impact test as specified in Clause T.9. Damage to the finish, small dents that do not reduce **clearances** below the specified values, surface cracks and the like are ignored. If a through crack appears, **clearances** and **creepage distances** shall not be reduced below the specified values.

For printed boards, see Clause G.13. For antenna terminals, see 5.4.5. For **solid insulation** on internal wiring, see 5.4.6.

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5.4.4.2 Minimum distance through insulation

Except where another subclause of Clause 5 applies, distances through insulation shall be dimensioned according to the application of the insulation and as follows (see Figure O.15 and Figure O.16):

– if the **working voltage** does not exceed ES2 voltage limits, there is no requirement for distance through insulation;
– if the **working voltage** exceeds ES2 voltage limits, the following rules apply:
  - for **basic insulation**, no minimum distance through insulation is specified;
  - for **supplementary insulation** or **reinforced insulation** comprised of a single layer, the minimum distance through insulation shall be 0,4 mm;
  - for **supplementary insulation** or **reinforced insulation** comprised of multiple layers, the minimum distance through insulation shall comply with 5.4.4.6.

5.4.4.3 Insulating compound forming solid insulation

There is no minimum internal **clearance** or **creepage distance** required if:

– the insulating compound completely fills the casing of a component or subassembly, including a semiconductor device (for example, an optocoupler); and
– the component or subassembly meets the minimum distances through insulation of 5.4.4.2; and
– a single sample passes the tests of 5.4.1.5.2.

NOTE Some examples of such treatment are variously known as potting, encapsulation and vacuum impregnation.

Such constructions containing cemented joints shall also comply with 5.4.4.5.

Alternative requirements for semiconductor devices are given in 5.4.4.4.

For printed boards, see Clause G.13 and for wound components, see 5.4.4.7.

Compliance is checked by sectioning the sample. There shall be no visible voids in the insulating material.

5.4.4.4 Solid insulation in semiconductor devices

There is no minimum internal **clearance** or **creepage distance**, and no minimum distance through insulation for **supplementary insulation** or **reinforced insulation** consisting of an insulating compound completely filling the casing of a semiconductor component (for example, an optocoupler) provided that the component:

– passes the **type tests** and inspection criteria of 5.4.7; and passes **routine tests** for electric strength during manufacturing, using the appropriate test in 5.4.9.2; or
– complies with Clause G.12.

Such constructions containing cemented joints shall also comply with 5.4.4.5.

Alternatively, a semiconductor may be evaluated according to 5.4.4.3.

5.4.4.5 Insulating compound forming cemented joints

The requirements specified below apply when an insulating compound forms a cemented joint between two non-conductive parts or between another non-conductive part and itself. These requirements do not apply to optocouplers that comply with IEC 60747-5-5.

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Where the path between conductive parts is filled with insulating compound, and the insulating compound forms a cemented joint between two non-conductive parts or between a non-conductive part and itself (see Figure O.14, Figure O.15 and Figure O.16), one of the following a), b) or c) applies.

a) The distance along the path between the two conductive parts shall be not less than the minimum **clearances** and **creepage distances** for **pollution degree** 2. The requirements for distance through insulation of 5.4.4.2 do not apply along the joint.

b) The distance along the path between the two conductive parts shall not be less than the minimum **clearances** and **creepage distances** for **pollution degree** 1. Additionally, one sample shall pass the test of 5.4.1.5.2. The requirements for distance through insulation in 5.4.4.2 do not apply along the joint.

c) The requirements for distance through insulation of 5.4.4.2 apply between the conductive parts along the joint. Additionally, three samples shall pass the test of 5.4.7.

For a) and b) above, if the insulating materials involved have different material groups, the worst case is used. If a material group is not known, Material Group IIIb shall be used.

For b) and c) above, the tests of 5.4.1.5.2 and 5.4.7 are not applied to the inner layers of a printed board made using pre-preg if the temperature of the printed board measured during the heating test of 5.4.1.4 does not exceed 90 °C.

NOTE Some examples of cemented joints are as follows:

– two non-conductive parts cemented together (for example, two layers of a multilayer board, see Figure O.14) or the split bobbin of a transformer where the centre limb is secured by adhesive (see Figure O.16);

– spirally wrapped insulation on a winding wire, sealed by adhesive insulating compound, is an example of PD1; or

– the joint between a non-conductive part (the casing) and the insulating compound itself in an optocoupler (see Figure O.15).

5.4.4.6 Thin sheet material

5.4.4.6.1 General requirements

There is no dimensional or constructional requirement for insulation in thin sheet material used as **basic insulation**.

NOTE An instrument to carry out the electric strength test on thin sheets of insulating material is described in Figure 29.

Insulation in thin sheet materials may be used for **supplementary insulation** and **reinforced insulation**, irrespective of the distance through insulation, provided that:

– two or more layers are used; and

– the insulation is within the equipment **enclosure**; and

– the insulation is not subject to handling or abrasion during **ordinary person** or **instructed person** servicing; and

– the requirements and tests of 5.4.4.6.2 (for separable layers) or 5.4.4.6.3 (for non-separable layers) are met.

The two or more layers are not required to be fixed to the same conductive part. The two or more layers can be:

– fixed to one of the conductive parts requiring separation; or

– shared between the two conductive parts; or

– not fixed to either conductive part.

For insulation in three or more layers of non-separable thin sheet materials:

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– minimum distances through insulation are not required; and
– each layer of insulation does not have to be of the same material.

5.4.4.6.2 Separable thin sheet material

In addition to the requirements of 5.4.4.6.1, for:

– **supplementary insulation** consisting of two layers of material, each layer shall pass the electric strength test for **supplementary insulation**; or
– **supplementary insulation** consisting of three layers of material, any combination of two layers shall pass the electric strength test for **supplementary insulation**; or
– **reinforced insulation** consisting of two layers of material, each layer shall pass the electric strength test for **reinforced insulation**; or
– **reinforced insulation** consisting of three layers of material, any combination of two layers shall pass the electric strength test for **reinforced insulation**.

If more than three layers are used, layers may be divided into two or three groups of layers. Each group of layers shall pass the electric strength test for the appropriate insulation.

A test on a layer or group of layers is not repeated on an identical layer or group.

There is no requirement for all layers of insulation to be of the same material and thickness.

5.4.4.6.3 Non-separable thin sheet material

For insulation consisting of non-separable thin sheet materials, in addition to the requirements of 5.4.4.6.1, the test procedures in Table 19 are applied. There is no requirement for all layers of insulation to be of the same material and thickness.

Compliance is checked by inspection and by the tests specified in Table 19.

Table 19 – Tests for insulation in non-separable layers

Number of layers	Test procedure
Supplementary insulation	
Two or more layers:	The test procedure of 5.4.4.6.4 is applied
Reinforced insulation	
Two layers:	The test procedure of 5.4.4.6.4 is applied
Three or more layers:	The test procedures of 5.4.4.6.4 and 5.4.4.6.5 [a] are applied
NOTE The purpose of the tests in 5.4.4.6.5 is to ensure that the material has adequate strength to resist damage when hidden in inner layers of insulation. Therefore, the tests are not applied to insulation in two layers. The tests in 5.4.4.6.5 are not applied to **supplementary insulation**.	
[a] Where the insulation is integral to winding wire, the test does not apply.	

5.4.4.6.4 Standard test procedure for non-separable thin sheet material

For non-separable layers, electric strength tests are applied in accordance with 5.4.9.1 to all layers together. The test voltage is:

– *200 % of* U_{test} *if two layers are used; or*
– *150 % of* U_{test} *if three or more layers are used,*

where U_{test} *is the test voltage specified in 5.4.9.1 for* ***supplementary insulation*** *or* ***reinforced insulation*** *as appropriate.*

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NOTE Unless all the layers are of the same material and have the same thickness, there is a possibility that the test voltage will be divided unequally between layers, causing breakdown of a layer that would have passed if tested separately.

5.4.4.6.5 Mandrel test

*The test requirements for **reinforced insulation** made of three or more thin insulating sheets of material that are inseparable are specified below.*

NOTE This test is based on IEC 61558-1 and will give the same results.

*Three test samples, each individual sample consisting of three or more layers of non-separable thin sheet material forming **reinforced insulation**, are used. One sample is fixed to the mandrel of the test fixture given in Figure 25. The fixing shall be performed as shown in Figure 26.*

Dimensions in millimetres

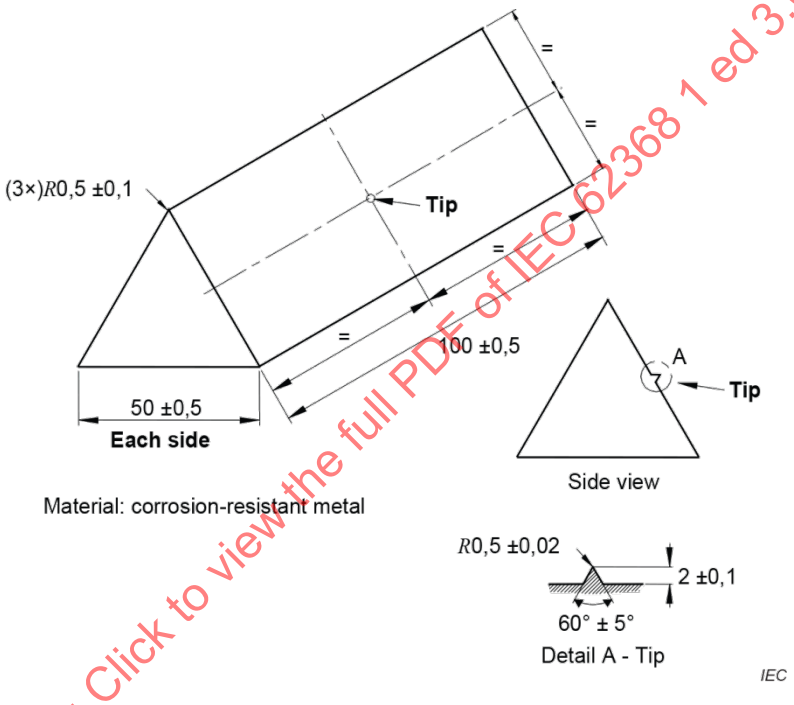


Figure 25 – Mandrel

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Dimensions in millimetres

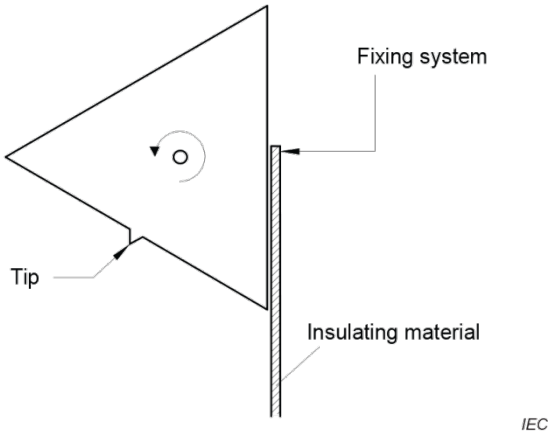
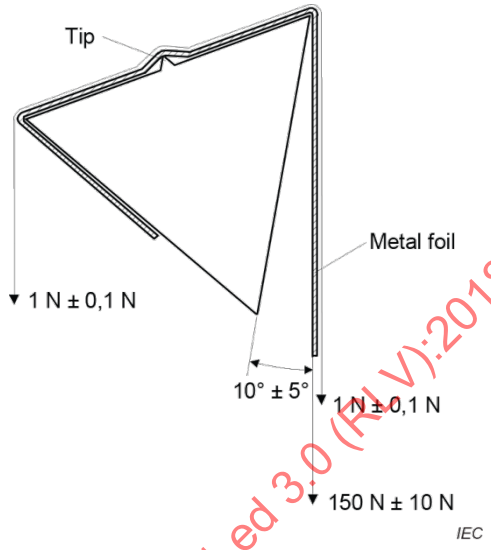


Figure 26 – Initial position of mandrel



The final position of the mandrel is rotated 230° ± 5° from the initial position.

Figure 27 – Final position of mandrel

A pull is applied to the free end of the sample, using an appropriate clamping device. The mandrel is rotated:

- *from the initial position (Figure 26) to the final position (Figure 27) and back;*
- *a second time from the initial position to the final position.*

If a sample breaks during rotation where it is fixed to the mandrel or to the clamping device, this does not constitute a failure. If a sample breaks at any other place, the test has failed.

After the above test, a sheet of metal foil, 0,035 mm ± 0,005 mm thick, at least 200 mm long, is placed along the surface of the sample, hanging down on each side of the mandrel (see Figure 27). The surface of the foil in contact with the sample shall be conductive, not oxidized or otherwise insulated. The foil is positioned so that its edges are not less than 18 mm from the edges of the sample (see Figure 28). The foil is then tightened by two equal weights, one at each end, using appropriate clamping devices.

Dimensions in millimetres

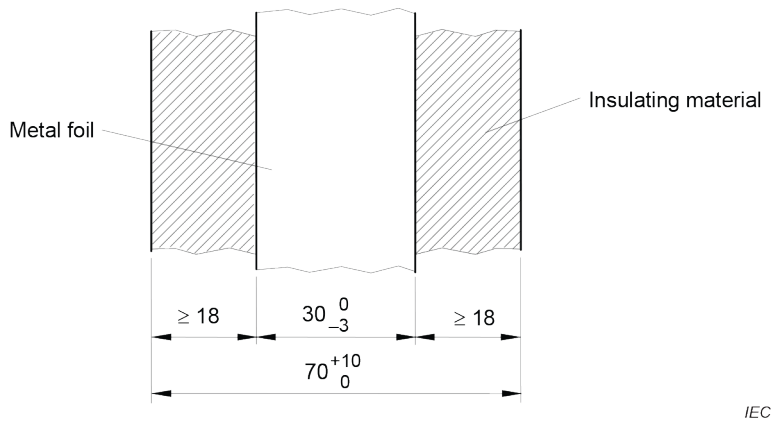


Figure 28 – Position of metal foil on insulating material

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*While the mandrel is in its final position, and within the 60 s following the final positioning, an electric strength test is applied between the mandrel and the metal foil in accordance with 5.4.9.1. The test voltage is 150 % of U_{test}, but not less than 5 kV RMS, U_{test} is the test voltage specified in 5.4.9.1 for **reinforced insulation** as appropriate.*

The test is repeated on the other two samples.

5.4.4.7 Solid insulation in wound components

Basic insulation, **supplementary insulation** or **reinforced insulation** in a wound component may be provided by:

– the insulation on wound components (see Clause G.5); or

– the insulation on other wire (see Clause G.6); or

– a combination of the two.

Wound components containing cemented joints shall also comply with 5.4.4.5.

Planar transformers shall comply with the requirements of Clause G.13.

5.4.4.8 Compliance criteria

Compliance with the requirements of 5.4.4.2 to 5.4.4.7 for the adequacy of solid insulation is checked by inspection and measurement, taking into account Annex O, by the electric strength tests of 5.4.9.1 and the additional tests required in 5.4.4.2 to 5.4.4.7, as applicable.

5.4.4.9 Solid insulation requirements at frequencies higher than 30 kHz

The suitability of the **solid insulation** shall be determined as follows:

– Determine the value of the breakdown electric field strength of the insulation material at **mains** power frequency E_P in kV/mm (RMS) for the insulating material. One of the following methods shall be used to determine the value of E_P:

  - the value declared by the manufacturer based on material manufacturer's data; or
  - the value from Table 20; or
  - the value based on the test specified in IEC 60243-1.

  The manufacturer is responsible for determining the value.

– Determine the reduction factor K_R for the breakdown electric field strength of the insulating material at the applicable frequency from Table 21 or Table 22. If the material is not one listed in Table 21 or Table 22, use the average reduction factor in the last row of Table 21 or Table 22 as applicable.

– Determine the value of the breakdown electric field strength at the applicable frequency E_F by multiplying the value E_P with the reduction factor K_R.

$$E_F = E_P \times K_R$$

– Determine the actual electric strength V_W of the insulating material by multiplying the value E_F with the total thickness (d in mm) of the insulating material.

$$V_W = E_F \times d$$

– For **basic insulation** or **supplementary insulation**, V_W shall exceed the measured high frequency peak of the **working voltage** V_{PW} by 20 %.

$$V_W > 1{,}2 \times V_{PW} / 1{,}41$$

– For **reinforced insulation**, V_W shall exceed twice the measured high frequency peak of the **working voltage** V_{PW} by 20 %.

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$$V_W > 1{,}2 \times 2 \times V_{PW} / 1{,}41$$

As an alternative to the above, the electric strength test according to 5.4.9.1 may be applied except that the **mains** frequency test voltage shall be as follows:

– for **basic insulation**: $1{,}2 \times V_{PW} / K_R$

– for **reinforced insulation**: $1{,}2 \times 2 \times V_{PW} / K_R$

There shall be no breakdown.

Table 20 – Electric field strength E_P for some commonly used materials

Material	Breakdown electric field strength E_p kV/mm				
	Thickness of the material mm				
	0,75	**0,08**	**0,06**	**0,05**	**0,03**
Porcelain [a]	9,2	-	-	-	-
Silicon-glass [a]	14	-	-	-	-
Phenolic [a]	17	-	-	-	-
Ceramic [a]	19	-	-	-	-
Teflon® [a] [1]	27	-	-	-	-
Melamine-glass [a]	27	-	-	-	-
Mica [a]	29	-	-	-	-
Paper phenolic [a]	38	-	-	-	-
Polyethylene [b]	49	-	-	52	-
Polystyrene [c]	55	65	-	-	-
Glass [a]	60	-	-	-	-
Kapton® [a] [2]	303	-	-	-	-
FR530L [a]	33	-	-	-	-
Mica-filled phenolic [a]	28	-	-	-	-
Glass-silicone laminate [a]	18	-	-	-	-
Cellulose-acetobutyrate [d]	-	-	120	-	210
Polycarbonate [d]	-	-	160	-	270
Cellulose-triacetate [d]	-	-	120	-	210

NOTE Missing values in the above and the values for other materials not in the list are under investigation.

[a] For the breakdown electric field strength of the specified materials, the EP value of 0,75 mm thickness may be used for all thicknesses.

[b] The EP value of 0,05 mm thickness is used for the insulation equal to or thinner than 0,05 mm. The EP value of 0,75 mm thickness is used otherwise.

[c] The EP value of 0,08 mm thickness is used for the insulation equal to or thinner than 0,08 mm. The EP value of 0,75 mm thickness is used otherwise.

[d] The EP value of 0,03 mm thickness is used for the insulation equal to or thinner than 0,03 mm. The EP value of 0,06 mm thickness is used for the insulation equal to or thinner than 0,06 mm and greater than 0,03 mm.

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1 Teflon® is the trademark of a product supplied by DuPont. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

2 Kapton® is the trademark of a product supplied by DuPont. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

Table 21 – Reduction factors for the value of breakdown electric field strength E_P at higher frequencies

Material [a]	Frequency kHz										
	30	100	200	300	400	500	1 000	2 000	3 000	5 000	10 000
	Reduction factor K_R										
Porcelain	0,52	0,42	0,40	0,39	0,38	0,37	0,36	0,35	0,35	0,34	0,30
Silicon-glass	0,79	0,65	0,57	0,53	0,49	0,46	0,39	0,33	0,31	0,29	0,26
Phenolic	0,82	0,71	0,53	0,42	0,36	0,34	0,24	0,16	0,14	0,13	0,12
Ceramic	0,78	0,64	0,62	0,56	0,54	0,51	0,46	0,42	0,37	0,35	0,29
Teflon®	0,57	0,54	0,52	0,51	0,48	0,46	0,45	0,44	0,41	0,37	0,22
Melamine-glass	0,48	0,41	0,31	0,27	0,24	0,22	0,16	0,12	0,10	0,09	0,06
Mica	0,69	0,55	0,48	0,45	0,41	0,38	0,34	0,28	0,26	0,24	0,20
Paper phenolic	0,58	0,47	0,40	0,32	0,26	0,23	0,16	0,11	0,08	0,06	0,05
Polyethylene	0,36	0,28	0,22	0,21	0,20	0,19	0,16	0,13	0,12	0,12	0,11
Polystyrene	0,35	0,22	0,15	0,13	0,13	0,11	0,08	0,06	0,06	0,06	0,06
Glass	0,37	0,21	0,15	0,13	0,11	0,10	0,08	0,06	0,05	0,05	0,04
Other materials	0,43	0,35	0,30	0,27	0,25	0,24	0,20	0,17	0,16	0,14	0,12
If the frequency lies between the values in any two columns, the reduction factor value in the next column shall be used or a logarithmic interpolation may be used between any two adjacent columns with the calculated value rounded down to the nearest 0,01 value.											
[a] This data is for materials that are 0,75 mm thick.											

Table 22 – Reduction factors for the value of breakdown electric field strength E_P at higher frequencies for thin materials

Thin material	Frequency kHz										
	30	100	200	300	400	500	1 000	2 000	3 000	5 000	10 000
	Reduction factor K_R										
Cellulose-acetobutyrate (0,03 mm)	0,67	0,43	0,32	0,27	0,24	0,20	0,15	0,11	0,09	0,07	0,06
Cellulose-acetobutyrate (0,06 mm)	0,69	0,49	0,36	0,30	0,26	0,23	0,17	0,13	0,11	0,08	0,06
Polycarbonate (0,03 mm)	0,61	0,39	0,31	0,25	0,23	0,20	0,14	0,10	0,08	0,06	0,05
Polycarbonate (0,06 mm)	0,70	0,49	0,39	0,33	0,28	0,25	0,19	0,13	0,11	0,08	0,06
Cellulose-triacetate (0,03 mm)	0,67	0,43	0,31	0,26	0,23	0,20	0,14	0,10	0,09	0,07	0,06
Cellulose-triacetate (0,06 mm)	0,72	0,50	0,36	0,31	0,27	0,23	0,17	0,13	0,10	0,10	0,06
Other thin foil materials	0,68	0,46	0,34	0,29	0,25	0,22	0,16	0,12	0,10	0,08	0,06
If the frequency lies between the values in any two columns, the reduction factor value in the next column shall be used or a logarithmic interpolation may be used between any two adjacent columns with the calculated value rounded down to the nearest 0,01 value.											

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5.4.5 Antenna terminal insulation

5.4.5.1 General

The insulation

– between **mains** and antenna terminals; and
– between **mains** and **external circuits** providing non-**mains** supply voltages to other equipment having antenna terminals

shall withstand electrostatic discharges at the antenna terminals.

This test does not apply to equipment where one antenna terminal on the equipment is connected to earth in accordance with 5.6.7.

NOTE In China, connection of the CATV to the main **protective earthing** terminal of equipment is not permitted.

5.4.5.2 Test method

*The sample is subjected to 50 discharges from the antenna interface test generator (circuit 3) of Clause D.2, at not more than 12 discharges per minute, with U_C equal to 10 kV. The equipment shall be placed on an insulating surface. The antenna interface test generator output shall be connected to the antenna terminals connected together and to the mains terminals connected together. If the equipment has external circuits providing non-mains supply voltages to other equipment having antenna terminals, the test is repeated with the generator connected to the mains terminals connected together and the **external circuit** terminals connected together. The equipment is not energized during these tests.*

NOTE Test personnel are cautioned not to touch the equipment during this test.

5.4.5.3 Compliance criteria

Compliance is checked by measuring the insulation resistance with 500 V DC.

The equipment complies with the requirement if the insulation resistance measured after 1 min is not less than the values given in Table 23.

Table 23 – Values for insulation resistance

Insulation requirements between parts	Insulation resistance MΩ
Between parts separated by **basic insulation** or by **supplementary insulation**	2
Between parts separated by **double insulation** or **reinforced insulation**	4

*As an alternative to the above, compliance may be checked by an electric strength test in accordance with 5.4.9.1 for **basic insulation** or **reinforced insulation** as applicable. The test voltage shall be the highest of the test voltages determined by methods 1, 2 and 3. There shall be no insulation breakdown.*

5.4.6 Insulation of internal wire as a part of a supplementary safeguard

The requirements of this subclause apply where the insulation of an internal wire, alone, meets the requirements for **basic insulation**, but does not meet the requirements for **supplementary insulation**.

Where wire insulation is used as part of a **supplementary insulation** system and the wire insulation is **accessible** to an **ordinary person**:

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– the wire insulation does not need to be handled by the **ordinary person**; and

– the wire is placed such that the **ordinary person** is unlikely to pull on it, or the wire shall be so fixed that the connecting points are relieved from strain; and

– the wire is routed and fixed such as not to touch unearthed **accessible** conductive parts; and

– the wire insulation passes the electric strength test of 5.4.9.1 for **supplementary insulation**; and

– the distance through the wire insulation shall be at least as given in Table 24.

Table 24 – Distance through insulation of internal wiring

Working voltage in case of failure of basic insulation		Minimum distance through insulation
V peak or DC	V RMS (sinusoidal)	mm
> 71 ≤ 350	> 50 ≤ 250	0,17
> 350	> 250	0,31

Compliance is checked by inspection and measurement, and by the test of 5.4.9.1.

5.4.7 Tests for semiconductor components and for cemented joints

Three samples are subjected to the thermal cycling sequence of 5.4.1.5.3. Before testing a cemented joint, any winding of enamelled wire used in the component is replaced by metal foil or by a few turns of bare wire, placed close to the cemented joint.

The three samples are then tested as follows:

– *one of the samples is subjected to the electric strength test of 5.4.9.1, immediately after the last period at (T_1 ± 2) °C during thermal cycling, except that the test voltage is multiplied by 1,6; and*

– *the other samples are subjected to the relevant electric strength test of 5.4.9.1 after the humidity conditioning of 5.4.8, except that the test voltage is multiplied by 1,6.*

Compliance is checked by test and the following inspections:

Except for cemented joints on the same inner surface of a printed board, compliance is checked by inspection of the cross-sectional area, and there shall be no visible voids, gaps or cracks in the insulating material.

In the case of insulation between conductors on the same inner surface of printed boards and the insulation between conductors on different surfaces of multilayer boards, compliance is checked by external visual inspection. There shall be no delamination.

5.4.8 Humidity conditioning

Humidity conditioning is carried out for 48 h in a cabinet or room containing air with a relative humidity of (93 ± 3) %. The temperature of the air, at all places where samples can be located, is maintained within ± 2 °C of any value T between 20 °C and 30 °C so that condensation does not occur. During this conditioning, the component or subassembly is not energized.

For tropical conditions the time duration shall be 120 h at a temperature of (40 ± 2) °C and a relative humidity of (93 ± 3) %.

Before the humidity conditioning, the sample is brought to a temperature between the specified temperature T and (T + 4) °C.

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5.4.9 Electric strength test

5.4.9.1 Test procedure for type testing of solid insulation

Unless otherwise specified, compliance is checked either:

– *immediately following the temperature test in 5.4.1.4; or*

– *if a component or subassembly is tested separately outside the equipment, it is brought to the temperature attained by that part during the temperature test in 5.4.1.4 (for example, by placing it in an oven) prior to performing the electric strength test.*

*Alternatively, thin sheet material for **supplementary insulation** or **reinforced insulation** may be tested at room temperature.*

*Unless otherwise specified, the test voltage for the electric strength of **basic insulation**, **supplementary insulation** or **reinforced insulation** is the highest value of the following three methods:*

– *Method 1: Determine the test voltage according to Table 25 using the **required withstand voltage** (based on transient voltages from the AC **mains** or DC **mains** or from **external circuits**).*

– *Method 2: Determine the test voltage according to Table 26 using the peak of the **working voltage** or the recurring peak voltages, whichever is higher.*

– *Method 3: Determine the test voltage according to Table 27 using the nominal AC **mains** voltage (to cover **temporary overvoltages**).*

The insulation is subjected to the highest test voltage as follows:

– *by applying an AC voltage of substantially sine-wave form having a frequency of 50 Hz or 60 Hz; or*

– *by applying a **DC voltage** for the time specified below.*

*The voltage applied to the insulation under test is gradually raised from zero to the prescribed voltage and maintained at that value for 60 s (for **routine tests** see 5.4.9.2).*

Where necessary, the insulation is tested with a metal foil in contact with the insulating surface. This procedure is limited to places where the insulation is likely to be weak (for example, where there are sharp metal edges under the insulation). If practicable, insulating linings are tested separately. Care is taken that the metal foil is so placed that no flashover occurs at the edges of the insulation. Where adhesive metal foil is used, the adhesive shall be conductive.

To avoid damage to components or insulations that are not involved in the test, ICs or the like, may be disconnected and equipotential bonding may be used. A varistor complying with Clause G.8 may be removed during the test.

*For equipment incorporating **basic insulation** and **supplementary insulation** in parallel with **reinforced insulation**, care is taken that the voltage applied to the **reinforced insulation** does not overstress **basic insulation** or **supplementary insulation**.*

Where capacitors are in parallel with the insulation under test (for example, radio-frequency filter capacitors) and the capacitors can affect the test results, DC test voltages shall be used.

Components providing a DC path in parallel with the insulation to be tested, such as discharge resistors for filter capacitors and voltage limiting devices, may be disconnected.

Where insulation of a transformer winding varies along the length of the winding in accordance with 5.4.1.6, an electric strength test method is used that stresses the insulation accordingly.

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EXAMPLE Such a test method may be an induced voltage test that is applied at a frequency sufficiently high to avoid saturation of the transformer. The input voltage is raised to a value that would induce an output voltage equal to the required test voltage.

Table 25 – Test voltages for electric strength tests based on transient voltages

Required withstand voltage up to and including	Test voltage for basic insulation or supplementary insulation	Test voltage for reinforced insulation
kV peak	kV peak or DC	
0,33	0,33	0,5
0,5	0,5	0,8
0,8	0,8	1,5
1,5	1,5	2,5
2,5	2,5	4
4	4	6
6	6	8
8	8	12
12	12	18
U_R [a]	U_R [a]	1,5 × U_R [a]
Linear interpolation may be used between the nearest two points.		
[a] U_R is any **required withstand voltage** higher than 12 kV.		

Table 26 – Test voltages for electric strength tests based on the peak of the working voltages and recurring peak voltages

Voltage up to and including	Test voltage for basic insulation or supplementary insulation	Test voltage for reinforced insulation
kV peak	kV peak or DC	
0,33	0,43	0,53
0,5	0,65	0,8
0,8	1,04	1,28
1,5	1,95	2,4
2,5	3,25	4
4	5,2	6,4
6	7,8	9,6
8	10,4	12,8
12	15,6	19,2
U_P [a]	1,3 × U_P [a]	1,6 × U_P [a]
Linear interpolation may be used between the nearest two points.		
[a] U_P is any voltage higher than 12 kV.		

Table 27 – Test voltages for electric strength tests based on temporary overvoltages

Nominal mains system voltage	Test voltage for basic insulation or supplementary insulation	Test voltage for reinforced insulation
V RMS	kV peak or DC	
Up to and including 250	2	4
Over 250 up to and including 600	2,5	5

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Dimensions in millimetres

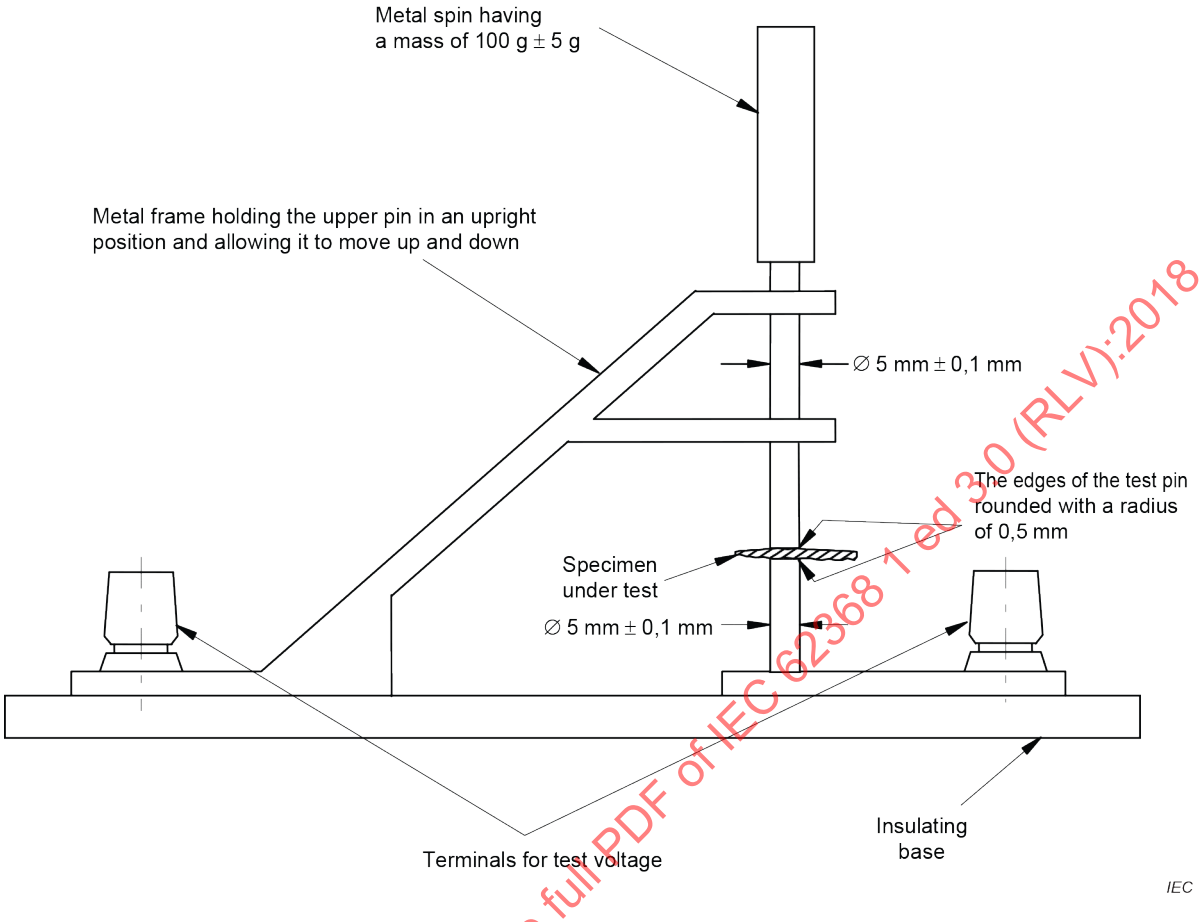


Figure 29 – Example of electric strength test instrument for solid insulation

NOTE Thin sheet insulation can be tested using the instrument of Figure 29. When applying the test fixture, ensure that the specimen sample diameter is of sufficient size to prevent breakdown around the edges.

There shall be no insulation breakdown during the test. Insulation breakdown is considered to have occurred when the current that flows as a result of the application of the test voltage, rapidly increases in an uncontrolled manner, that is, the insulation does not restrict the flow of the current. Corona discharge or a single momentary flashover is not regarded as insulation breakdown.

5.4.9.2 Test procedure for routine tests

Where required, ***routine tests*** *are performed according to 5.4.9.1, except for the following:*

– *the test may be performed at room temperature; and*

– *the duration of the electric strength test shall be between 1 s to 4 s; and*

– *the test voltage may be reduced by 10 %.*

NOTE **Routine testing** for equipment is specified in IEC 62911.

There shall be no insulation breakdown during the test. Insulation breakdown is considered to have occurred when the current that flows as a result of the application of the test voltage, rapidly increases in an uncontrolled manner, that is, the insulation does not restrict the flow of the current. Corona discharge or a single momentary flashover is not regarded as insulation breakdown.

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5.4.10 Safeguards against transient voltages from external circuits

5.4.10.1 Requirements

Adequate electrical separation shall be provided between the circuitry intended to be connected to **external circuits** as indicated in Table 13, ID number 1, Figure 30 and:

a) non-conductive parts and unearthed conductive parts of the equipment expected to be held or otherwise maintained in continuous contact with the body during normal use (for example, a telephone handset or head set or the palm rest surface of a laptop or notebook computer);

b) **accessible** parts and circuitry, except for the pins of connectors. However, such pins shall not be **accessible** under **normal operating conditions** by the blunt probe of Figure V.3;

c) another ES1 or ES2 part separated from the circuitry intended to be connected to an **external circuit**. The requirement for separation applies whether or not the ES1 or ES2 part is **accessible**.

These requirements do not apply where circuit analysis and equipment investigation indicate that adequate protection is assured by other means (for example, between two circuits each of which has a permanent connection to protective earth).

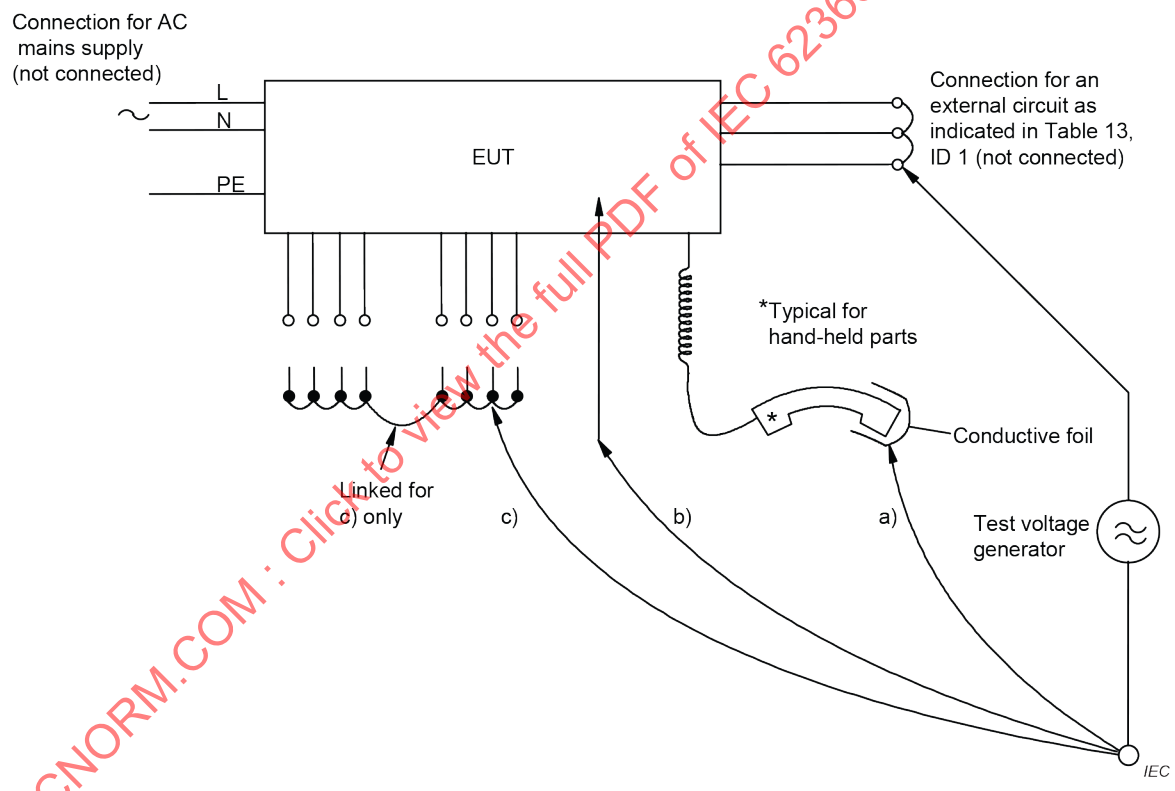


Figure 30 – Application points of test voltage

5.4.10.2 Test methods

5.4.10.2.1 General

The separation is checked by the test of either 5.4.10.2.2 or 5.4.10.2.3.

NOTE In Australia, the tests of both 5.4.10.2.2 and 5.4.10.2.3 apply.

During the test:

– *all conductors intended to be connected to the **external circuit** are connected together, including any conductors that may be connected to earth in the **external circuit**; and*

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– *all conductors intended to be connected to other **external circuits** are also connected together.*

Table 28 – Test values for electric strength tests

Parts	Impulse test (see Annex D)		Steady state test
	U_c	Test generator	
Parts indicated in 5.4.10.1 a) [a]	2,5 kV	circuit 1	1,5 kV
Parts indicated in 5.4.10.1 b) and c) [b]	1,5 kV	circuit 1 [c]	1,0 kV

[a] Surge suppressors shall not be removed.

[b] Surge suppressors may be removed, provided that such devices pass the impulse test of 5.4.10.2.2 when tested as components outside the equipment.

[c] During this test, it is allowed for a surge suppressor to operate and for a sparkover to occur in a GDT.

5.4.10.2.2 Impulse test

The electrical separation is subjected to ten impulses of alternating polarity as given in Table 28. The interval between successive impulses is 60 s. U_c is the value to which the capacitor needs to be charged.

NOTE In Australia, a value of U_c = 7,0 kV is used for hand-held telephones and for headsets and 2,5 kV for other equipment in 5.4.10.1 a). The 7 kV impulse simulates lightning surges on typical rural and semi-rural network lines.

5.4.10.2.3 Steady state test

The electrical separation is subjected to an electric strength test according to 5.4.9.1, with a voltage as given in Table 28.

NOTE In Australia, the steady state test voltage is 3 kV for 5.4.10.1 a), and 1,5 kV for 5.4.10.1 b) and c). These values have been determined considering the low-frequency induced voltages from the power supply distribution system.

5.4.10.3 Compliance criteria

During the tests of 5.4.10.2.2 and 5.4.10.2.3:

– *there shall be no insulation breakdown; and*

– *except as indicated in Table 28, footnote [c], a surge suppressor shall not operate, or a sparkover shall not occur within a GDT.*

For the electric strength test, insulation breakdown is considered to have occurred when the current that flows as a result of the application of the test voltage rapidly increases in an uncontrolled manner.

For the impulse tests, insulation breakdown is verified in one of the following two ways:

– *during the application of the impulses, by observation of oscillograms, surge suppressor operation or breakdown through insulation is judged from the shape of an oscillogram;*

– *after application of all the impulses, by an insulation resistance test. Disconnection of surge suppressors is permitted while insulation resistance is being measured. The test voltage is 500 V DC or, if surge suppressors are left in place, a DC test voltage that is 10 % less than the surge suppressor operating or striking voltage. The insulation resistance shall not be less than 2 MΩ.*

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5.4.11 Separation between external circuits and earth

5.4.11.1 General

These requirements apply only to equipment intended to be connected to **external circuits** indicated in Table 13, ID number 1.

These requirements do not apply to:

– **permanently connected equipment**; or

– **pluggable equipment type B**; or

– **stationary pluggable equipment type A**, that is intended to be used in a location having equipotential bonding (such as a telecommunication centre, a dedicated computer room or a **restricted access area**) and has installation instructions that require verification of the **protective earthing** connection of the socket-outlet by a **skilled person**; or

– **stationary pluggable equipment type A**, that has provision for a permanently connected **protective earthing conductor**, including instructions for the installation of that conductor to building earth by a **skilled person**.

5.4.11.2 Requirements

There shall be separation between circuitry intended to be connected to **external circuits** mentioned above and any parts or circuitry that will be earthed in some applications, either within the EUT or via other equipment.

SPDs that bridge the separation between ES1 or ES2 circuitry intended to be connected to **external circuits** and earth shall have a minimum rated operating voltage U_{op} (for example, the sparkover voltage of a gas discharge tube) of:

$$U_{op} = U_{peak} + \Delta U_{sp} + \Delta U_{sa}$$

where:

U_{peak} is one of the following values:

– for equipment intended to be installed in an area where the nominal voltage of the AC **mains** exceeds 130 V: 360 V;

– for all other equipment: 180 V.

ΔU_{sp} is the negative tolerance of the rated operating voltage due to variations in SPD production, obtained by subtracting the minimum rated operating voltage from the nominal rated operating voltage. If this is not specified by the SPD manufacturer, ΔU_{sp} shall be taken as 10 % of the rated operating voltage of the SPD.

ΔU_{sa} is the change of the rated operating voltage due to the SPD ageing over the expected life of the equipment, obtained by subtracting the minimum operating voltage after ageing from the rated operating voltage. If this is not specified by the SPD manufacturer, ΔU_{sa} shall be taken as 10 % of the rated operating voltage of the SPD.

($\Delta U_{sp} + \Delta U_{sa}$) may be a single value provided by the component manufacturer.

5.4.11.3 Test method and compliance criteria

*Compliance is checked by inspection and by the electric strength test of 5.4.9.1 with a test voltage according to Table 25 for **basic insulation** or **supplementary insulation** based on the **required withstand voltage** for the **mains** voltage of the equipment.*

Components, other than capacitors, that bridge the separation, may be removed during electric strength testing. Components that are left in place during the test shall not be damaged.

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If components are removed, the following additional test with a test circuit according to Figure 31 is performed with all components in place.

*For equipment powered from AC **mains**, the test is performed with a voltage equal to the **rated voltage** of the equipment or to the upper voltage of the **rated voltage range**. For equipment powered from DC **mains**, the test is performed with a voltage equal to the highest nominal voltage of the AC **mains** in the region where the equipment is to be used (for example, 230 V for Europe or 120 V for North America).*

The current flowing in the test circuit of Figure 31 shall not exceed 10 mA.

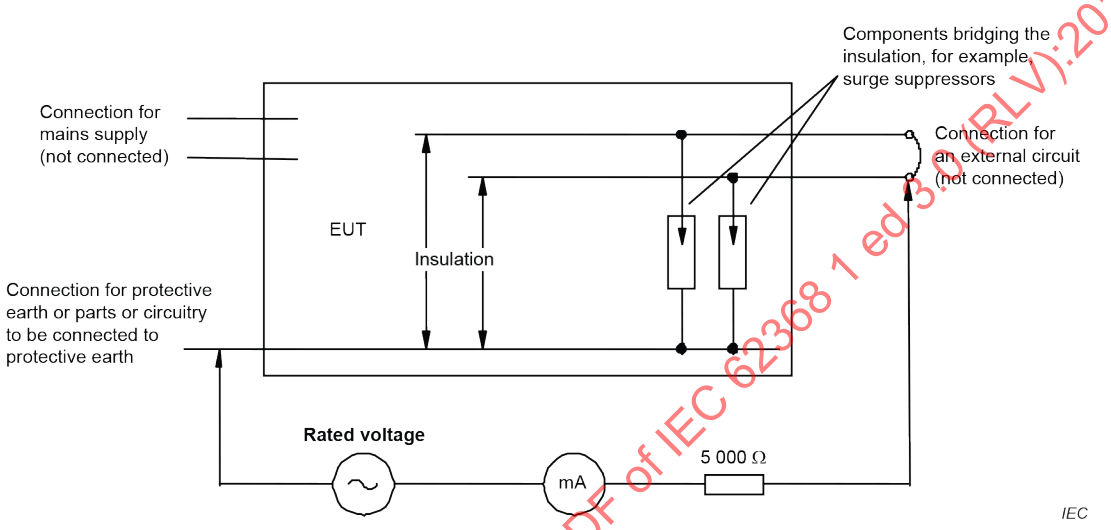


Figure 31 – Test for separation between an external circuit and earth

5.4.12 Insulating liquid

5.4.12.1 General requirements

An **insulating liquid** shall not break down due to overvoltages, including transients, that enter the equipment, and peak voltages that may be generated within the equipment.

The **insulating liquid** shall comply with 5.4.12.2 and 5.4.12.3. The container for the **insulating liquid** shall comply with 5.4.12.4.

5.4.12.2 Electric strength of an insulating liquid

The electric strength of the **insulating liquid** shall comply with the electric strength test in 5.4.9 with the **insulating liquid** in the equipment.

5.4.12.3 Compatibility of an insulating liquid

The **insulating liquid** shall not react with or otherwise deteriorate **safeguards**, such as:

– **solid insulation;** or

– the **insulating liquid** itself.

*For **insulating liquids** with a thermal classification of IEC 60085 Class 105 (A), compliance is checked by operating the immersed equipment for 60 days followed by an electric strength test in accordance with 5.4.9. There shall be no breakdown and there shall be no visible damage or deformation of the other immersed **equipment safeguards**.*

For higher thermal classes the requirements of 5.4.1.4.3 are applicable.

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5.4.12.4 Container for insulating liquid

The container for the **insulating liquid** shall be provided with a means of pressure relief if there is a closed vessel.

The **insulating liquid** container shall comply with G.15.2.1 for a closed vessel.

For an **insulating liquid** that is also considered to be a **hazardous substance**, the container shall also comply with the requirements of 7.2.

Compliance is checked by the relevant tests.

5.5 Components as safeguards

5.5.1 General

A component is considered a **safeguard** if the classification of the energy source changes due to a failure of the component.

A component used as a **safeguard** shall:

– comply with all the applicable requirements for that **safeguard**; and

– be used within its rating.

NOTE See Annex G for the qualification of components used as a **safeguard**.

5.5.2 Capacitors and RC units

5.5.2.1 General requirements

Capacitors and RC units that serve as (electrical) **safeguards** shall comply with IEC 60384-14. RC units may consist of discrete components.

Capacitors or RC units with one or multiple capacitors shall:

– comply with Clause G.11; however, the requirements of Clause G.11 do not apply to the capacitor and RC unit used as a **basic safeguard** between:
  - ES3 isolated from the **mains** and protective earth; and
  - ES2 and protective earth; and
  - ES2 and ES1;

  and

– pass the electric strength test of 5.4.9.1, taking into account the total **working voltage** across the capacitor(s) and RC unit. Capacitors complying with IEC 60384-14 do not need to be tested if:
  - the required peak impulse test voltage of Table G.12; and
  - the required RMS test voltage of Table G.12 multiplied by 1,414

  are equal to or greater than the required test voltage of 5.4.9.1.

  When multiple capacitors are used, the test voltages of Table G.12 are multiplied by the number of capacitors used.

Under **single fault conditions,** if a capacitor or RC unit consists of more than one capacitor, the voltage on each of the remaining individual capacitors shall not exceed the voltage rating of the relevant individual capacitors.

NOTE In Norway, due to the IT power system used, capacitors are required to be rated for the applicable line-to-line voltage (230 V).

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Class X capacitors may be used as **basic safeguards** in circuits isolated from the **mains** but shall not be used as a:

– **basic safeguard** in circuits connected to the **mains**; or

– **supplementary safeguard**.

Class X capacitors shall not be used as a **reinforced safeguard**.

5.5.2.2 Capacitor discharge after disconnection of a connector

Where a capacitor voltage becomes **accessible** upon disconnection of a connector (for example, the **mains** connector) the **accessible** voltage measured 2 s after disconnection of the connector, shall comply with:

– the ES1 limits of Table 5 under **normal operating conditions** for an **ordinary person**; and

– the ES2 limits of Table 5 under **normal operating conditions** for an **instructed person**; and

– the ES2 limits of Table 5 under **single fault conditions** for both an **ordinary person** and an **instructed person**.

A resistor or a group of resistors used as a **safeguard** against capacitor discharge is not subjected to simulated **single fault conditions** if the resistor or the group of resistors complies with 5.5.6.

If an IC that includes a capacitor discharge function (ICX) is used to comply with the above:

– the **accessible** voltage (for example, at the **mains** connector) shall not exceed the limits given above under a **single fault condition** of an ICX or of any one component in the associated capacitor discharge circuit; or

– the ICX with the associated circuitry as provided in the equipment shall comply with the requirements of Clause G.16. Any impulse attenuating components (such as varistors and GDTs) are disconnected; or

– three samples of the ICX tested separately shall comply with the requirements of Clause G.16.

The measurement is made with an instrument having an input impedance consisting of a resistance of 100 MΩ ± 5 MΩ in parallel with an input capacitance of 25 pF or less.

If a switch (for example, the **mains** switch) has an influence on the test result, it is placed in the most unfavourable position. The disconnection of the connector (start of discharge time) has to be done at the moment when the input capacitor of the device under test is charged to its peak value.

Other methods that give a similar result as the above method may be used.

5.5.3 Transformers

Transformers used as a **safeguard** shall comply with G.5.3.

5.5.4 Optocouplers

Insulation of optocouplers used as a **safeguard** shall comply with the requirements of 5.4 or with Clause G.12.

5.5.5 Relays

Insulation of relays used as a **safeguard** shall comply with the requirements of 5.4.

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5.5.6 Resistors

The following resistor applications shall comply with the relevant tests as indicated in Table 29:

– a single resistor used as a **reinforced safeguard** or for bridging **reinforced insulation**;

– a resistor or a group of resistors serving as a **safeguard** between a circuit connected to the **mains** and a circuit intended to be connected to coaxial cable;

– resistors serving as a capacitor discharge **safeguard**.

NOTE In Finland, Norway and Sweden, resistors used as a **basic safeguard** or for bridging **basic insulation** in **class I pluggable equipment type A** shall comply with the relevant requirements of Clause G.10.

In addition, resistors that bridge **basic insulation**, **supplementary insulation** or **reinforced insulation** shall comply with each of the following:

– a single resistor or a group of resistors shall comply with **clearance** and **creepage distance** requirements of 5.4.2 and 5.4.3, respectively, between its terminations for the total **working voltage** across the insulation (see Figure O.4);

– for a group of resistors used as a **reinforced safeguard** or for bridging **reinforced insulation**, the **clearance** and **creepage distance** are assessed as if each resistor were short-circuited in turn unless the group complies with the relevant requirements of Clause G.10.

Table 29 – Overview of tests for resistor applications

Resistor application	Conditioning	Resistor test	Voltage surge test	Impulse test	Overload test
	G.10.2	G.10.3	G.10.4	G.10.5	G.10.6
Reinforced safeguard or bridging **reinforced insulation**	X	X			
Between a **mains** connected circuit and a coaxial cable	X		X [a]	X [b]	
Capacitor discharge **safeguard**	X				X

[a] For an **external circuit** indicated in Table 13, ID 6 and 7.

[b] For an **external circuit** indicated in Table 13, ID 3, 4 and 5.

5.5.7 SPDs

Where a varistor is used between a **mains** circuit at ES3 voltage and **protective earthing**:

– the earth connection shall comply with 5.6.7; and

– the varistor shall comply with Clause G.8.

Where a varistor is used between line and neutral or between lines, it shall comply with Clause G.8.

Where an SPD is used between the **mains** and **protective earthing**, it shall consist of a varistor and a GDT connected in series, where the following applies:

– the varistor shall comply with Clause G.8;

– the GDT shall comply with:

- the electric strength test of 5.4.9.1 for **basic insulation**; and
- the external **clearance** and **creepage distance** requirements of 5.4.2 and 5.4.3 respectively for **basic insulation**.

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NOTE 1 Some examples of SPDs are MOVs, varistors and GDTs. A varistor is sometimes referred to as a VDR or a metal oxide varistor (MOV).

The above requirements do not apply to SPDs connected to reliable earthing (see 5.6.7).

NOTE 2 It is not a requirement of this document that surge suppressors comply with any particular component standard. However, attention is drawn to the IEC 61643 series of standards, in particular:

– IEC 61643-21 (surge suppressors in telecommunications application)
– IEC 61643-311 (gas discharge tubes)
– IEC 61643-321 (avalanche breakdown diodes)
– IEC 61643-331 (metal oxide varistors)
– IEC 61643-341 (thyristor surge suppressors TSS).

NOTE 3 SPDs between an **external circuit** and earth are not considered to be a **safeguard**. Requirements for those SPDs are covered in 5.4.11.2.

5.5.8 Insulation between the mains and an external circuit consisting of a coaxial cable

The insulation between the **mains** and the connection to a coaxial cable, including any resistor in parallel with this insulation, shall be able to withstand surges from the **external circuit** and from the **mains**.

This requirement does not apply in any of the following equipment:

– equipment for indoor use provided with a built-in (integral) antenna and not provided with a connection to a coaxial cable; or
– equipment connected to a reliable earthing in accordance with 5.6.7.

The combination of the insulation with the resistor is tested after the conditioning of G.10.2 as follows:

– *for equipment intended to be connected to a coaxial cable connected to an outdoor antenna, the voltage surge test of G.10.4; or*
– *for equipment intended to be connected to another coaxial cable, the impulse test of G.10.5; or*
– *for equipment intended to be connected to both an outdoor antenna and other coaxial connections, the voltage surge test of G.10.4 and the impulse test of G.10.5.*

After the tests:

– *the insulation shall comply with 5.4.5.3 and the resistor may be removed during this test; and*
– *the resistors shall comply with G.10.3, unless available data shows compliance of the resistor.*

5.5.9 Safeguards for socket-outlets in outdoor equipment

A residual current protective device (RCD) with rated residual operating current not exceeding 30 mA shall be used in the **mains** supply to socket-outlets intended for general use.

The RCD shall be an integral part of the **outdoor equipment** or shall be part of the building installation. If the RCD is not an integral part of the equipment, the instructions shall provide the installation requirements for the RCD.

Compliance is checked by inspection.

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5.6 Protective conductor

5.6.1 General

Under **normal operating conditions**, a **protective conductor** may serve:

– as a **basic safeguard** to prevent **accessible** conductive parts from exceeding ES1 limits; and

– as a means to limit transient voltages in an earthed circuit.

Under **single fault conditions**, a **protective conductor** may serve as a **supplementary safeguard** to prevent **accessible** conductive parts from exceeding ES2 limits.

5.6.2 Requirements for protective conductors

5.6.2.1 General requirements

Protective conductors shall not contain switches, current limiting devices or overcurrent protective devices.

The current-carrying capacity of **protective conductors** shall be adequate for the duration of the fault current under **single fault conditions**.

The connections for the **protective conductors** shall make earlier and shall break later than the supply connections in each of the following:

– a connector (on a cable) or a connector attached to a part or a subassembly that can be removed by other than a **skilled person**;

NOTE It is good practice that this construction also be applied when it is expected that the **skilled person** will replace powered parts and assemblies while the equipment is operational.

– a plug on a power supply cord;

– an appliance coupler.

Solder shall not serve as the sole means to provide mechanical securement of a **protective conductor**.

A **protective conductor** termination shall be made such that it is not likely to be loosened during servicing, other than servicing of the actual conductor itself. A single terminal may be used to connect multiple **protective bonding conductors**. A **protective earthing conductor** termination shall not serve as a means to secure any component or part other than a **protective bonding conductor**.

A single wiring terminal of the screw or stud type may be used to secure both the **protective earthing conductor** and the **protective bonding conductor** in equipment having a **non-detachable power supply cord**. In this case, the wiring termination of the **protective earthing conductor** shall be separated by a nut from that of the **protective bonding conductor**. The **protective earthing conductor** shall be on the bottom of the stack, so that it is the last connection disturbed.

5.6.2.2 Colour of insulation

The insulation of the **protective earthing conductor** shall be green-and-yellow.

If a **protective bonding conductor** is insulated, the insulation shall be green-and-yellow except in the following two cases:

– for an earthing braid, the insulation, if provided, may be transparent;

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– a **protective bonding conductor** in assemblies such as ribbon cables, bus bars, printed wiring, etc., may be of any colour provided that no misinterpretation of the use of the conductor is likely to arise.

Compliance is checked by inspection.

5.6.3 Requirements for protective earthing conductors

Protective earthing conductors shall comply with the minimum conductor sizes in Table G.7.

NOTE 1 For **permanently connected equipment** provided with terminal(s) for connection to **mains** supply, reference is made to the national building wiring requirements for the size of the **protective earthing conductor**.

NOTE 2 IEC 60364-5-54 can also be used to determine the minimum conductor size.

For cord connected equipment supplied from a DC **mains**, the **protective earthing** connection may be provided by a separate terminal.

A **protective earthing conductor** serving as a **reinforced safeguard** may be used on **pluggable equipment type B** or on **permanently connected equipment** only and shall:

– be included in and protected by a sheathed supply cord that complies with G.7.1 and which is not lighter than heavy duty as specified in Annex C of IEC 62440:2008; or

– have a minimum conductor size not less than 4 mm^2 if not protected from physical damage; or

– have a minimum conductor size not less than 2,5 mm^2 if protected from physical damage; or

– be protected by a conduit intended to be connected to the equipment and have a minimum size in accordance with Table 30.

NOTE 3 For **mains** supply cords, see also Clause G.7.

NOTE 4 A heavy duty cord jacket is considered suitable for protection against physical damage.

Table 30 – Protective earthing conductor sizes for reinforced safeguards for permanently connected equipment

Protection provided by	Minimum protective earthing conductor size mm^2
Non-metallic flexible conduit	4
Metallic flexible conduit	2,5
Non-flexible metal conduit	1,5
The **protective earthing conductor** is intended for installation by a **skilled person**.	

A **protective earthing conductor** serving as a **double safeguard** may be used on **pluggable equipment type B** or on **permanently connected equipment** only and shall consist of two independent **protective earthing conductors**.

*Compliance is checked by inspection and measurement of **protective earthing conductor** sizes in accordance with Table 30 or Table G.7 as applicable.*

5.6.4 Requirements for protective bonding conductors

5.6.4.1 Requirements

Protective bonding conductors of parts required to be earthed for safety purposes shall comply with one of the following:

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– the minimum conductor sizes in Table G.7; or

– if either the **rated current** of the equipment or the **protective current rating** of the circuit exceeds 25 A, with the minimum conductor sizes in Table 31; or

– if both the **rated current** of the equipment and the **protective current rating** of the circuit do not exceed 25 A; either

  - with the minimum conductor sizes in Table 31; or
  - with the limited short-circuit test of Annex R; or

– for components only, be not smaller than the conductors supplying power to the component.

If the **rated current** of the equipment is not declared by the manufacturer, it is the calculated value of the **rated power** divided by **rated voltage**.

NOTE The value of the **protective current rating** is used in Table 31 and in the test of 5.6.6.2.

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Table 31 – Minimum protective bonding conductor size of copper conductors

Smaller of the rated current of the equipment or the protective current rating of the circuit under consideration A **up to and including**	**Minimum conductor sizes**	
	Cross-sectional area mm^2	**AWG** [cross-sectional area in mm^2]
3	0,3	22 [0,324]
6	0,5	20 [0,519]
10	0,75	18 [0,8]
13	1,0	16 [1,3]
16	1,25	16 [1,3]
25	1,5	14 [2]
32	2,5	12 [3]
40	4,0	10 [5]
63	6,0	8 [8]
80	10	6 [13]
100	16	4 [21]
125	25	2 [33]
160	35	1 [42]
190	50	0 [53]
230	70	000 [85]
260	95	0000 [107]
		kcmil [cross-sectional area in mm^2]
300	120	250 [126]
340	150	300 [152]
400	185	400 [202]
460	240	500 [253]
NOTE AWG and kcmil sizes are provided for information only. The associated cross-sectional areas have been rounded to show significant figures only. AWG refers to the American Wire Gage and the term "cmil" refers to circular mils where one circular mil is equal to (diameter in mils)^2. These terms are commonly used to designate wire sizes in North America.		

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5.6.4.2 Determination of the protective current rating

5.6.4.2.1 Mains supply as the source

Where the source is the **mains** supply, the **protective current rating** of the circuit is the rating of the overcurrent protective device provided in the building installation, or as part of the equipment.

Where the overcurrent protective device is provided in the building installation, then:

– for **pluggable equipment type A**, the **protective current rating** is the rating of an overcurrent protective device provided external to the equipment (for example, in the building wiring, in the **mains** plug or in an equipment rack), with a minimum of 16 A;

NOTE 1 In most countries, 16 A is considered to be suitable as the **protective current rating** of the circuit supplied from the **mains**.

NOTE 2 In Canada and the USA, the **protective current rating** of the circuit supplied from the **mains** is taken as 20 A.

NOTE 3 In the UK and Ireland, the **protective current rating** is taken to be 13 A, this being the largest rating of fuse used in the **mains** plug.

NOTE 4 In France, in certain cases, the **protective current rating** of the circuit supplied from the **mains** is taken as 20 A instead of 16 A.

– for **pluggable equipment type B**, and **permanently connected equipment** the **protective current rating** is the maximum rating of the overcurrent protective device specified in the equipment installation instructions to be provided external to the equipment.

5.6.4.2.2 Other than mains supply as the source

Where the source is an external supply having the maximum current inherently limited by the internal source impedance (such as an impedance protected transformer), the **protective current rating** of the circuit is the highest current available from that supply into any load.

Where the maximum current from the external supply source is limited by electronic components in the source, the **protective current rating** shall be taken as the maximum output current with any resistive load, including a short-circuit. If the current is limited by an impedance, a fuse, a PTC device or a circuit breaker, the current is measured 60 s after the application of the load. If the current is limited by other means, the current is measured 5 s after the application of the load.

5.6.4.2.3 Internal circuit as the source

Where the source is a circuit within the equipment, the **protective current rating** of the circuit is:

– the rating of the overcurrent protective device if the current is limited by an overcurrent protective device; or

– the maximum output current, if the current is limited by the source impedance of the supply. The output current is measured with any resistive load including a short-circuit measured 60 s after the application of the load if current is limited by impedance or the current limiting device is a fuse, a circuit breaker or a PTC device, or 5 s in other cases.

5.6.4.2.4 Current limiting and overcurrent protective devices

A current limiting device (a PTC device) or an overcurrent protective device (a fuse or a circuit breaker) shall not be connected in parallel with any other component that could fail to a low-resistance state.

5.6.4.3 Compliance criteria

*Compliance is checked by inspection and measurement of the **protective bonding conductor** sizes in accordance with Table 31 or Table G.7 and the test of 5.6.6 or Annex R as applicable.*

5.6.5 Terminals for protective conductors

5.6.5.1 Requirements

Terminals for connecting **protective earthing conductors** shall comply with the minimum terminal sizes in Table 32.

Terminals for connecting **protective bonding conductors** shall comply with one of the following:

– the minimum terminal sizes in Table 32; or

– if either the **rated current** of the equipment or the **protective current rating** of the circuit exceeds 25 A, with terminal sizes that are not more than one size smaller than in Table 32; or

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– if both the **rated current** of the equipment and the **protective current rating** of the circuit do not exceed 25 A; either
  - with terminal sizes that are not more than one size smaller than in Table 32; or
  - with the limited short-circuit test of Annex R;

  or
– for components only, be not smaller than the terminal sizes supplying power to the component.

Table 32 – Sizes of terminals for protective conductors

Conductor size mm² (from Table G.7)	Minimum nominal thread diameter mm		Area of cross section mm²	
	Pillar type or stud type	Screw type [a]	Pillar type or stud type	Screw type [a]
1	3,0	3,5	7	9,6
1,5	3,5	4,0	9,6	12,6
2,5	4,0	5,0	12,6	19,6
4	4,0	5,0	12,6	19,6
6	5,0	5,0	19,6	19,6
10 [b]	6,0	6,0	28	28
16 [b]	7,9	7,9	49	49

[a] "Screw type" refers to a terminal that clamps the conductor under the head of a screw, with or without a washer.

[b] As an alternative to the requirements of this table, the **protective earthing conductor** may be attached to special connectors, or suitable clamping means (for example, an upturned spade or closed loop pressure type; clamping unit type; saddle clamping unit type; mantle clamping unit type; etc.) that is secured by a screw and nut mechanism to the metal chassis of the equipment. The sum of the cross-sectional areas of the screw and the nut shall not be less than three times the cross-sectional area of the conductor size in Table 31 or Table G.7 as applicable. The terminals shall comply with IEC 60998-1 and IEC 60999-1 or IEC 60999-2.

Compliance is checked by inspection and measurement of protective terminal sizes in accordance with Table 32, the test of 5.6.6 or Annex R as applicable.

5.6.5.2 Corrosion

Conductive parts in contact at the main **protective earthing** terminal, protective bonding terminals and connections shall be selected in accordance with Annex N so that the potential difference between any two different metals is 0,6 V or less.

Compliance is checked by inspection of the materials of the conductors and terminals and associated parts and determination of the potential difference.

5.6.6 Resistance of the protective bonding system

5.6.6.1 Requirements

Protective bonding conductors and their terminations shall not have excessive resistance.

NOTE A protective bonding system in the equipment consists of a single conductor or a combination of conductive parts, connecting a main **protective earthing** terminal to a part of the equipment that is to be earthed for safety purposes.

Protective bonding conductors that meet the minimum conductor sizes in Table G.7 throughout their length and whose terminals all meet the minimum sizes in Table 32 are considered to comply without test.

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On equipment where the protective earth connection to a subassembly or to a separate unit is made by means of one core of a multicore cable that also supplies power to that subassembly or unit and where the cable is protected by a suitably rated protective device that takes into account the size of the conductor, the resistance of the **protective bonding conductor** in that cable is not included in the measurement.

5.6.6.2 Test method

*The test current can be either AC or DC and the test voltage shall not exceed 12 V. The measurement is made between the main **protective earthing** terminal and the point in the equipment that is required to be earthed.*

*The resistance of the **protective earthing conductor** and of any earthed conductor in other external wiring is not included in the measurement. However, if the **protective earthing conductor** is supplied with the equipment, the conductor may be included in the test circuit but the measurement of the voltage drop is made only from the main **protective earthing** terminal to the part required to be earthed.*

Care is taken that the contact resistance between the tip of the measuring probe and the conductive part under test does not influence the test results. The test current and duration of the test are as follows:

*a) For equipment powered from the **mains** where the **protective current rating** of the circuit under test is 25 A or less, the test current is 200 % of the **protective current rating** applied for 2 min.*

*b) For equipment powered from the AC **mains** where the **protective current rating** of the circuit under test exceeds 25 A, the test current is 200 % of the **protective current rating** or 500 A, whichever is less, and the duration of the test is as shown in Table 33.*

Table 33 – Test duration, mains connected equipment

Protective current rating of the circuit A up to and including	**Duration of the test** min
30	2
60	4
100	6
200	8
over 200	10

*c) As an alternative to b), the tests are based on the time-current characteristic of the overcurrent protective device that limits the fault current in the **protective bonding conductor**. This device is either one provided in the EUT or specified in the installation instructions to be provided external to the equipment. The tests are conducted at 200 % of the **protective current rating**, for the duration corresponding to 200 % on the time-current characteristic. If the duration for 200 % is not given, the nearest point on the time-current characteristic may be used.*

*d) For equipment powered from a DC **mains**, if the **protective current rating** of the circuit under test exceeds 25 A, the test current and duration are as specified by the manufacturer.*

*e) For equipment receiving its power from an **external circuit**, the test current is 1,5 times the maximum current available from the **external circuit** or 2 A, whichever is greater, for a duration of 2 min. For parts connected to the **protective bonding conductor** to limit the transients or to limit **touch current** to an **external circuit** and that do not exceed an ES2 level during **single fault conditions**, the test is conducted in accordance with the relevant test method of either a), b), c) or d) based on the power source assumed.*

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5.6.6.3 Compliance criteria

*Where the **protective current rating** does not exceed 25 A, the resistance of the protective bonding system, calculated from the voltage drop, shall not exceed 0,1 Ω.*

*Where the **protective current rating** exceeds 25 A, the voltage drop over the protective bonding system shall not exceed 2,5 V.*

5.6.7 Reliable connection of a protective earthing conductor

For **permanently connected equipment**, earthing is considered to be reliable.

For cord connected **mains** equipment, earthing is also considered to be reliable for:

– **pluggable equipment type B**; or

– **stationary pluggable equipment type A**,

- that is intended to be used in a location having equipotential bonding (such as a telecommunication centre, a dedicated computer room, or a **restricted access area**); and
- has installation instructions that require verification of the **protective earthing** connection of the socket-outlet by a **skilled person**; or

– **stationary pluggable equipment type A**,

- that has provision for a permanently connected **protective earthing conductor**; and
- has instructions for the installation of that conductor to building earth by a **skilled person**.

For equipment connected to an **external circuit** as indicated in Table 13, ID numbers 1, 2, 3, 4 and 5, earthing is considered to be reliable for **pluggable equipment type A** and **pluggable equipment type B** that have provision for:

– a permanently connected **protective earthing conductor**; and

– has instructions for the installation of that conductor to building earth by a **skilled person**.

5.6.8 Functional earthing

If a **protective earthing conductor** in the **mains** supply cord is only used for establishing **functional earthing**:

– the requirements for conductor size as given in G.7.2 apply to the earthing conductor of the **mains** supply cord; and

– the marking for **class II equipment** with **functional earthing** shall be used as specified in F.3.6.2; and

– the appliance inlet, if used, shall comply with the **creepage distance** and **clearance** requirements for **double insulation** or **reinforced insulation**.

NOTE 1 Some appliance inlets for **class I equipment** do not have sufficient insulation to serve as **double insulation** or **reinforced insulation** between the phases and the **protective earthing** terminal. Equipment using such an inlet is not considered to be **class II equipment**.

NOTE 2 In Norway, equipment connected with an earthed **mains** plug is classified as **class I equipment**. See the marking requirement in the country note to 4.1.15. The symbol IEC 60417-6092, as specified in F.3.6.2, is accepted.

5.7 Prospective touch voltage, touch current and protective conductor current

5.7.1 General

Measurements of **prospective touch voltage**, **touch current**, and **protective conductor current** are made with the EUT supplied at the most unfavourable supply voltage (see B.2.3).

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5.7.2 Measuring devices and networks

5.7.2.1 Measurement of touch current

For measurements of **touch current**, the instrument used for measuring U_2 and U_3 specified in Figures 4 and 5 respectively in IEC 60990:2016 shall indicate peak voltage. If the **touch current** waveform is sinusoidal, an RMS indicating instrument may be used.

5.7.2.2 Measurement of voltage

Equipment, or parts of equipment, that are intended to be earthed in the intended application, but are unearthed as provided, shall be connected to earth during the measurement at the point by which the highest **prospective touch voltage** is obtained.

5.7.3 Equipment set-up, supply connections and earth connections

The equipment set-up, equipment supply connections and equipment earthing shall be in accordance with Clause 4, 5.3 and 5.4 of IEC 60990:2016.

Equipment provided with a connection to earth separate from the **protective earthing conductor** shall be tested with that connection disconnected.

Systems of interconnected equipment with separate connections to the **mains** shall have each equipment tested separately.

Systems of interconnected equipment with one connection to the **mains** shall be tested as a single equipment.

NOTE 1 Systems of interconnected equipment are specified in more detail in Annex A of IEC 60990:2016.

Equipment that is designed for multiple connections to the **mains**, where only one connection is required at a time, shall have each connection tested while the other connections are disconnected.

Equipment that is designed for multiple connections to the **mains**, where more than one connection is required, shall have each connection tested while the other connections are connected, with the **protective earthing conductors** connected together. If the **touch current** exceeds the limit in 5.2.2.2, the **touch current** shall be measured individually.

NOTE 2 It is not necessary that the EUT operates normally during this test.

5.7.4 Unearthed accessible parts

Under **normal operating conditions**, **abnormal operating conditions** and **single fault conditions** (except for a **safeguard** fault), touch voltage or **touch current** shall be measured from all unearthed **accessible** conductive parts. **Touch current** (current [a] and current [b] of Table 4) shall be measured in accordance with 5.1, 5.4 and 6.2.1 of IEC 60990:2016.

Under **single fault conditions** of a relevant **basic safeguard** or a **supplementary safeguard**, including 6.2.2.2 of IEC 60990:2016, touch voltage or **touch current** shall be measured from all unearthed **accessible** conductive parts. **Touch current** (current [b] of Table 4) shall be measured with the network specified in Figure 5 of IEC 60990:2016.

For an **accessible** non-conductive part, the test is made with a metal foil as specified in 5.2.1 of IEC 60990:2016.

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5.7.5 Earthed accessible conductive parts

At least one earthed **accessible** conductive part shall be tested for **touch current** following supply connection faults in accordance with 6.1 and 6.2.2 of IEC 60990:2016, except 6.2.2.8. Except as permitted in 5.7.6, the **touch current** shall not exceed the ES2 limits in 5.2.2.2.

Subclause 6.2.2.3 of IEC 60990:2016 does not apply to equipment with a switch or other **disconnect device** that disconnects all poles of the supply.

NOTE An appliance coupler is an example of a **disconnect device**.

5.7.6 Requirements when touch current exceeds ES2 limits

Where the **touch current** exceeds the ES2 limits in 5.2.2.2 under the supply fault conditions specified in 6.2.2.2 of IEC 60990:2016, all of the following conditions apply:

– the **protective conductor current** measured according to Clause 8 of IEC 60990:2016 shall not exceed 5 % of the input current measured under **normal operating conditions**;

– the construction of the **protective earthing conductor** circuit and its connections shall have:

  - a **protective earthing conductor** serving as a **reinforced safeguard** as specified in 5.6.3 or two independent **protective earthing conductors** serving as a **double safeguard**, and
  - a reliable connection to **protective earthing** as specified in 5.6.7;

– the manufacturer shall indicate the value of the **protective conductor current** in the installation instructions if the current exceeds 10 mA;

– an **instructional safeguard** shall be provided in accordance with Clause F.5, except that element 3 is optional. The elements of the **instructional safeguard** shall be as follows:

  - element 1a:  , IEC 60417-6042 (2010-11); and

    , IEC 60417-6173 (2012-10); and

     , IEC 60417-5019 (2006-08)
  - element 2: “Caution” or equivalent word or text, and “High touch current” or equivalent text
  - element 3: optional
  - element 4: “Connect to earth before connecting to supply” or equivalent text

The elements of the **instructional safeguard** that are required to be placed on the equipment shall be affixed to the equipment adjacent to the equipment supply connection.

NOTE In Denmark, the installation instruction shall be affixed to the equipment if the **protective conductor current** exceeds the limits of 3,5 mA AC or 10 mA DC.

5.7.7 Prospective touch voltage and touch current associated with external circuits

5.7.7.1 Touch current from coaxial cables

If the equipment is connected to **external circuits** with a coaxial cable and if such connection is likely to create a hazard, the manufacturer shall provide instructions to connect the shield of the coaxial cable to the building earth in accordance with 6.2 g) and 6.2 l) of IEC 60728-11:2016.

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NOTE 1 In Norway and Sweden, the screen of the television distribution system is normally not earthed at the entrance of the building and there is normally no equipotential bonding system within the building. Therefore the **protective earthing** of the building installation needs to be isolated from the screen of a cable distribution system.

It is however accepted to provide the insulation external to the equipment by an adapter or an interconnection cable with galvanic isolator, which may be provided by a retailer, for example.

The user manual shall then have the following or similar information in Norwegian and Swedish language respectively, depending on in what country the equipment is intended to be used in:

"Apparatus connected to the **protective earthing** of the building installation through the **mains** connection or through other apparatus with a connection to **protective earthing** – and to a television distribution system using coaxial cable, may in some circumstances create a fire hazard. Connection to a television distribution system therefore has to be provided through a device providing electrical isolation below a certain frequency range (galvanic isolator, see IEC 60728-11)".

NOTE 2 In Norway, due to regulation for CATV-installations, and in Sweden, a galvanic isolator shall provide electrical insulation below 5 MHz. The insulation shall withstand a dielectric strength of 1,5 kV RMS, 50 Hz or 60 Hz, for 1 minute.

Translation to Norwegian (the Swedish text will also be accepted in Norway):

"Apparater som er koplet til beskyttelsesjord via nettplugg og/eller via annet jordtilkoplet utstyr – og er tilkoplet et koaksialbasert kabel-TV nett, kan forårsake brannfare. For å unngå dette skal det ved tilkopling av apparater til kabel-TV nett installeres en galvanisk isolator mellom apparatet og kabel-TV nettet."

Translation to Swedish:

"Apparater som är kopplad till skyddsjord via jordat vägguttag och/eller via annan utrustning och samtidigt är kopplad till kabel-TV nät kan i vissa fall medföra risk för brand. För att undvika detta skall vid anslutning av apparaten till kabel-TV nät galvanisk isolator finnas mellan apparaten och kabel-TV nätet."

5.7.7.2 Prospective touch voltage and touch current associated with paired conductor cables

For circuits intended to be connected to **external circuits** such as those described in ID 1 of Table 13:

– the **prospective touch voltage** shall comply with ES2; or

– the **touch current** shall not exceed 0,25 mA.

The above requirements do not apply if the corresponding **external circuits** are connected to a **protective earthing conductor**.

Compliance is checked by measurement according 5.7.2 and 5.7.3 by using the measurement arrangement in Figure 32 for single-phase equipment and Figure 33 for three-phase equipment.

NOTE For other power distribution systems, see IEC 60990:2016.

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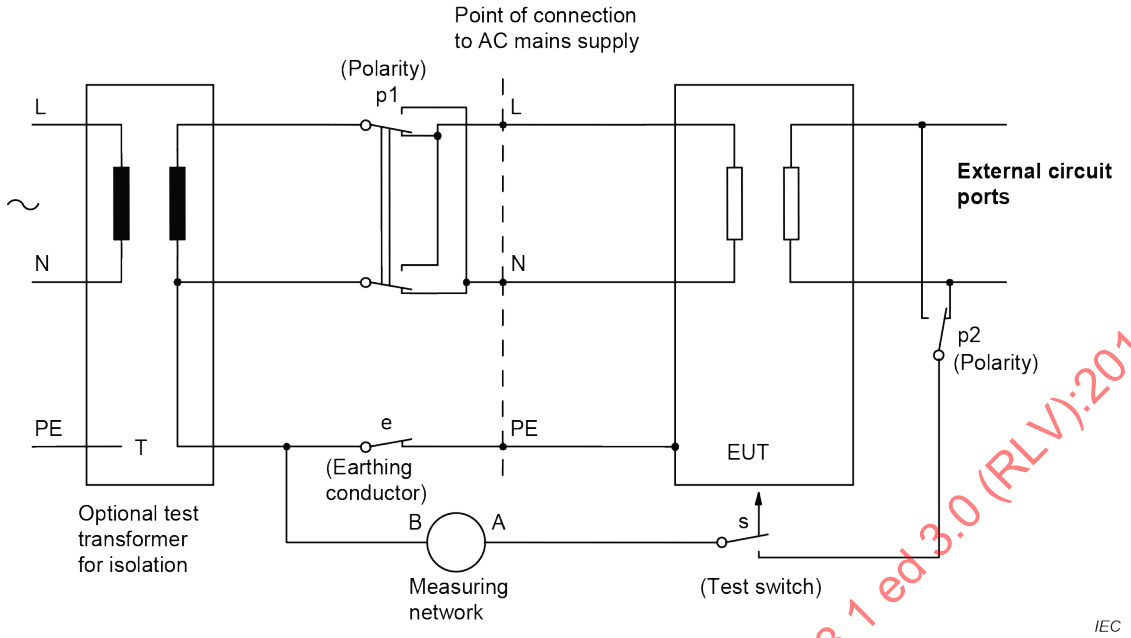


Figure 32 – Test circuit for touch current of single-phase equipment

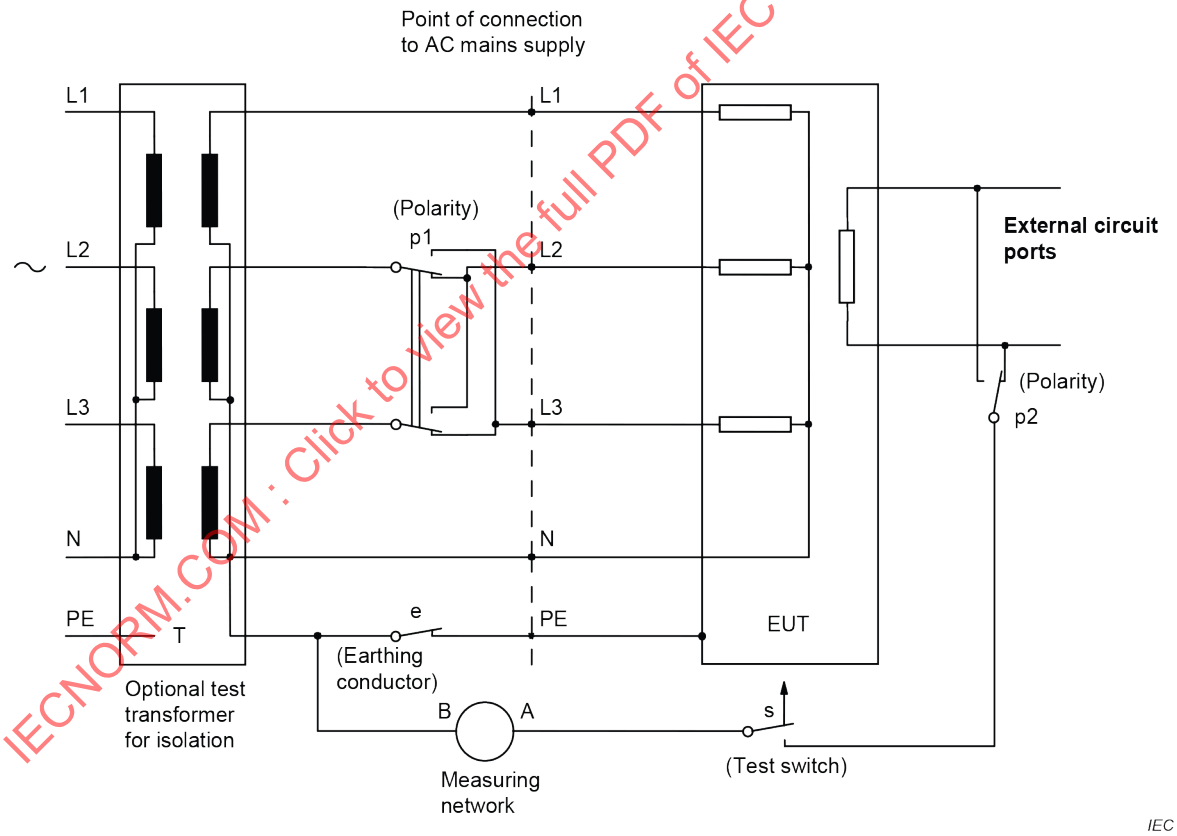


Figure 33 – Test circuit for touch current of three-phase equipment

5.7.8 Summation of touch currents from external circuits

The requirements below specify when a permanently connected **protective earthing conductor** is required for **pluggable equipment type A** or **pluggable equipment type B**, should the **mains** connection be disconnected.

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The requirements apply only to equipment intended to be connected to an **external circuit** such as described in Table 13, ID numbers 1, 2, 3 and 4.

NOTE These types of **external circuits** are typically telecommunication networks.

The summation of **touch currents** from equipment that provides multiple **external circuits**, shall not exceed the limits for ES2 (see Table 4).

The following abbreviations are used:

– I_1: **touch current** received from other equipment via an external network;
– $S(I_1)$: summation of **touch current** received from all other equipment via an external network;
– I_2: **touch current** due to the **mains** of the equipment.

It shall be assumed that each circuit of the equipment connected to an **external circuit** receives 0,25 mA (I_1) from the other equipment, unless the actual current from the other equipment is known to be lower.

The following requirements, a) or b) as applicable, shall be met:

a) Equipment connected to an earthed **external circuit**

For equipment in which each circuit that can be connected to an **external circuit** is connected to a terminal for the **protective earthing conductor** of the equipment, the following shall be considered:

1) If $S(I_1)$ (not including I_2) exceeds ES2 limits of Table 4:
   – the equipment shall have provision for a permanent connection to protective earth in addition to the **protective earthing conductor** in the power supply cord of **pluggable equipment type A** or **pluggable equipment type B**; and
   – the installation instructions shall specify the provision of a permanent connection to protective earth with a cross-sectional area of not less than 2,5 mm^2, if mechanically protected, or otherwise 4,0 mm^2; and
   – provide a marking in accordance with 5.7.6 and Clause F.3.
2) Such equipment shall comply with 5.7.6. The value of I_2 shall be used to calculate the 5 % input current limit per phase specified in 5.7.6.
3) The sum of $S(I_1)$ and I_2 shall comply with the limits of Table 4.

Compliance with item a) is checked by inspection and if necessary by test.

If the equipment has provision for a permanent protective earth connection in accordance with item 1) above, it is not necessary to make any measurements, except that I_2 shall comply with the relevant requirements of 5.7.

***Touch current** tests, if necessary, are made using the relevant measuring instrument described in IEC 60990:2016, Figure 5, or any other instrument giving the same results. A source (for example, a capacitively coupled AC source of the same line frequency and phase as the AC **mains**) is applied to each **external circuit** and adjusted so that 0,25 mA, or the actual current from other equipment, if known to be lower, is available to flow into that **external circuit**. The current flowing in the earthing conductor is then measured.*

b) Equipment connected to an unearthed **external circuit**

If each circuit of the equipment that can be connected to an **external circuit** does not have a common connection, the **touch current** for each circuit shall not exceed the ES2 limits of Table 4.

If all circuits of the equipment that can be connected to an **external circuit** or any groups of such ports have a common connection, the total **touch current** from each common connection shall not exceed the ES2 limits of Table 4.

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Compliance with item b) is checked by inspection and, if there are common connection points, by the following test.

*A capacitively coupled AC source of the same frequency and phase as the AC **mains** is applied to each circuit of the equipment that can be connected to an **external circuit** so that 0,25 mA, or the actual current from the other equipment if known to be lower, is available to flow into that circuit. Common connection points are tested in accordance with 5.7.3, whether or not the points are **accessible**.*

5.8 Backfeed safeguard in battery backed up supplies

A **battery** backed up supply that is an integral part of the equipment and is capable of backfeeding shall prevent greater than ES1 from being present on the **mains** terminals after interruption of the **mains** power.

No hazard shall exist at the **mains** terminals when measured 1 s after de-energization of the **mains** for **pluggable type A equipment**, 5 s for **pluggable type B equipment** or 15 s for **permanently connected equipment** using the measurement instruments described in 5.7.2. Where the measured open-circuit voltage does not exceed the ES1 limits, the **touch current** does not have to be measured.

*Compliance is checked by inspection of the equipment and the relevant circuit diagram, by measurement and by **single fault conditions** in accordance with B.4.*

NOTE 1 For standards related to **battery** backed up power supply systems that are not an integral part of the equipment, see standards related to UPS, such as IEC 62040-1. For transfer switches, see IEC 62310-1:2005.

NOTE 2 See also the explanatory information in IEC TR 62368-2.

When an air gap is employed as a **backfeed safeguard**, the requirements of 5.4.2 for **clearances** and 5.4.3 for **creepage distances** apply in addition to the following:

– subject to confirmation from the manufacturer, the **battery** backed up supply output, in **stored energy mode** may be considered a transient free circuit of Overvoltage Category I;

– the **clearances** and **creepage distances** shall comply with the requirements for **pollution degree** 2 or higher if expected in the intended installation location;

– **reinforced insulation** shall be applied between the unit output and the unit input if during **stored energy mode** of operation not all input poles are isolated by the **backfeed safeguard** device. In all other cases, **basic insulation** shall be applied.

Compliance is checked by inspection.

6 Electrically-caused fire

6.1 General

To reduce the likelihood of injury or property damage due to an electrically-caused fire originating within the equipment, equipment shall be provided with the **safeguards** specified in Clause 6.

6.2 Classification of power sources (PS) and potential ignition sources (PIS)

6.2.1 General

Electrical sources of heating can be classified into available power levels PS1, PS2 and PS3 (see 6.2.2.4, 6.2.2.5 and 6.2.2.6) that may cause resistive heating of both components and connections. These power sources are based on available energy to a circuit.

Within a power source, a **PIS** may arise due to arcing of either broken connections or opening of contacts (**arcing PIS**) or from components dissipating more than 15 W (**resistive PIS**).

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Depending on the power source classification of each circuit, one or more **safeguards** are required either to reduce the likelihood of ignition or to reduce the likelihood of spread of fire beyond the equipment.

6.2.2 Power source circuit classifications

6.2.2.1 General

An electric circuit is classified PS1, PS2, or PS3 based on the electrical power available to the circuit from the power source.

The electrical power source classification shall be determined by measuring the maximum power under each of the following conditions:

– for load circuits: a power source under **normal operating conditions** as specified by the manufacturer into a worst-case fault (see 6.2.2.2);

– for power source circuits: a worst-case power source fault into the specified normal load circuit (see 6.2.2.3).

The power is measured at points X and Y in Figure 34 and Figure 35.

6.2.2.2 Power measurement for worst-case fault

With reference to Figure 34:

– *the measurement may be performed without the load circuit L_{NL} connected, unless the maximum power is dependent on the connection of the load;*

– *at points X and Y, insert a wattmeter (or a voltmeter, V_A, and a current meter, I_A);*

– *connect a variable resistor, L_{VR}, as shown;*

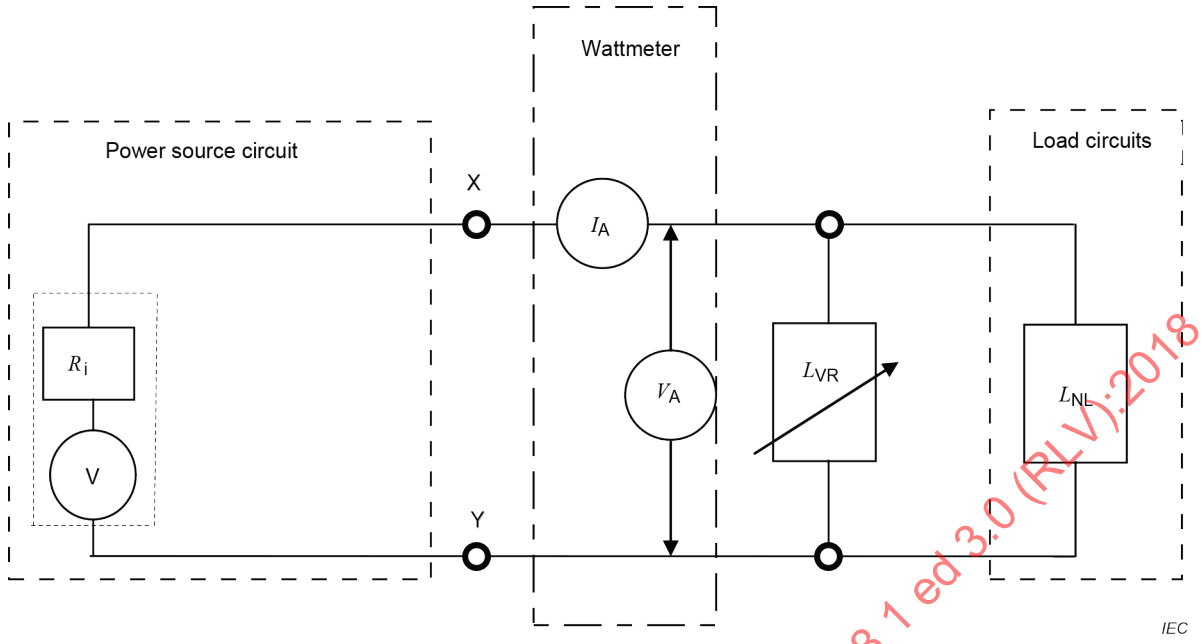
– *adjust the variable resistor, L_{VR}, for maximum power. Measure the maximum power and classify the power source according to 6.2.2.4, 6.2.2.5 or 6.2.2.6.*

If an overcurrent protective device operates during the test, the measurement shall be repeated at 125 % of the current rating of the overcurrent protective device.

If a power limiting device or circuit operates during the test, the measurement shall be repeated at a point just below the current at which the power limiting device or circuit operated.

When evaluating accessories connected via cables to the equipment, the impedance of the cable may be taken into account in the determination of PS1 or PS2 on the accessory side.

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Key

V voltage source

R_i internal resistance of the power source

I_A current from the power source

V_A voltage at the points where determination of PS power is made

L_{VR} variable resistor load

L_{NL} normal load

Figure 34 – Power measurement for worst-case fault

6.2.2.3 Power measurement for worst-case power source fault

With reference to Figure 35:

- *At points X and Y, insert a wattmeter (or a voltmeter, V_A, and a current meter, I_A).*
- *Within the power source circuit, simulate any **single fault condition** that will result in maximum power to the circuit being classified. All relevant components in the power source circuits shall be short-circuited or disconnected one at a time at each measurement.*
- *Equipment containing audio amplifiers shall also be tested under **abnormal operating conditions** as specified in Clause E.3.*
- *Measure the maximum power as specified and classify circuits supplied by the power source according to 6.2.2.4, 6.2.2.5 or 6.2.2.6.*

If an overcurrent protective device operates during the test, the measurement shall be repeated at 125 % of the current rating of the overcurrent protective device.

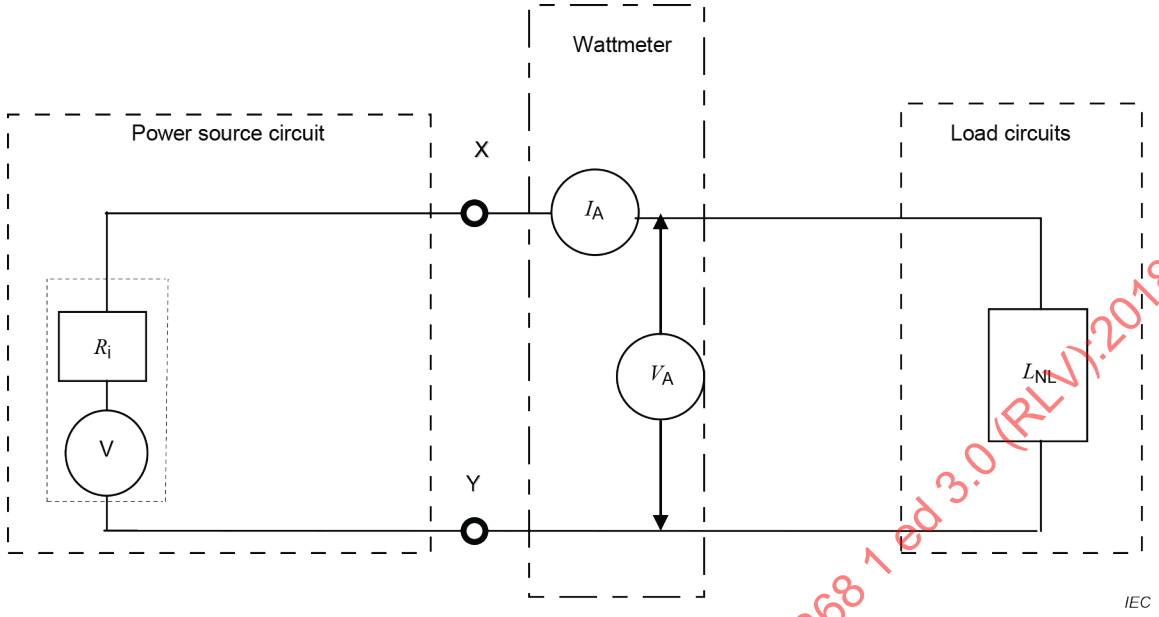
If a power limiting device or circuit operates during the test, the measurement shall be repeated at a point just below the current at which the power limiting device or circuit operated.

When the tests are repeated, a variable resistance may be used to simulate the component under fault.

To avoid damage to the components of the normal load, a resistor (equal to the normal load) may be substituted for the normal load.

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NOTE Experimentation can be used to identify the single component fault that produces maximum power.



Key

V voltage source

R_i internal resistance of the power source

I_A current from the power source

V_A voltage at the points where determination of PS power is made

L_{NL} normal load

Figure 35 – Power measurement for worst-case power source fault

6.2.2.4 PS1

PS1 is a circuit where the power source, (see Figure 36) measured according to 6.2.2, does not exceed 15 W measured after 3 s.

The power available from **external circuits** described in Table 13, ID numbers 1 and 2, are considered to be limited to PS1.

6.2.2.5 PS2

PS2 is a circuit where the power source, (see Figure 36) measured according to 6.2.2:

– exceeds PS1 limits; and

– does not exceed 100 W measured after 5 s.

6.2.2.6 PS3

PS3 is a circuit whose power source exceeds PS2 limits, or any circuit whose power source has not been classified (see Figure 36).

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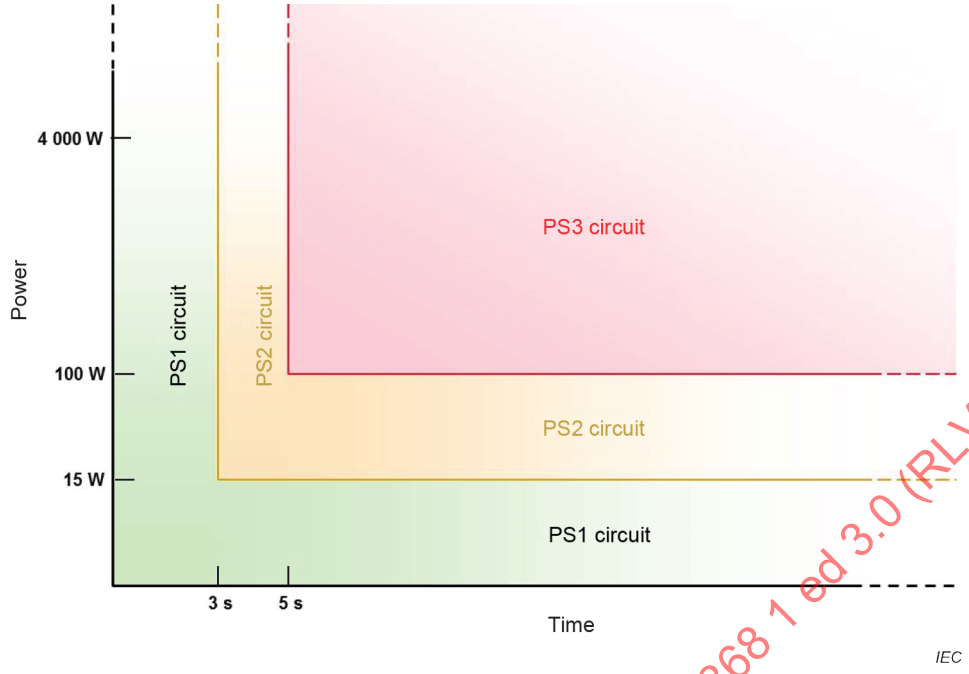


Figure 36 – Illustration of power source classification

6.2.3 Classification of potential ignition sources

6.2.3.1 Arcing PIS

An **arcing PIS** is a location with the following characteristics:

– an open circuit voltage (measured after 3 s) across an open conductor or opening electrical contact exceeding 50 V (peak) AC or DC; and

– the product of the peak of the open circuit voltage (V_p) and the measured RMS current (I_{rms}) exceeds 15 (that is, $V_p \times I_{rms} > 15$) for any of the following:

- a contact, such as a switch or connector;
- a termination, such as one made by a crimp, spring or solder termination;
- opening of a conductor, such as a printed wiring board trace, as a consequence of a **single fault condition**. This condition does not apply if electronic protection circuits or additional constructional measures are used to reduce the likelihood that such a fault becomes an **arcing PIS**.

An **arcing PIS** is considered not to exist in a PS1 because of the limits of the power source.

NOTE 1 An open conductor in an electric circuit includes those interruptions that occur in conductive patterns on printed boards.

Reliable or redundant connections are not considered to be an **arcing PIS**.

Redundant connections are any kind of two or more connections in parallel, where in the event of the failure of one connection, the remaining connections are still capable of handling the full power.

Reliable connections are connections that are considered not to open.

NOTE 2 Connections that could be considered reliable are:

– holes of solder pads on a printed board that are through-metallized;

– tubular rivets/eyelets that are additionally soldered;

– machine-made or tool-made crimp or wire-wrap connections.

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NOTE 3 Other means to avoid the occurrence of an **arcing PIS** can be used.

NOTE 4 Connection failure due to thermal fatigue phenomena could be prevented by selection of components with a coefficient of thermal expansion similar to that of the printed board material, taking into account the location of the component with respect to the fibre direction of the board material.

6.2.3.2 Resistive PIS

A **resistive PIS** is any part in a PS2 or PS3 circuit that:

– dissipates more than 15 W measured after 30 s under **normal operating conditions**; or

NOTE During the first 30 s there is no limit.

– under **single fault conditions**:

- dissipates more than 100 W measured for 30 s, disregarding the first 3 s, immediately after the introduction of the fault if electronic circuits, regulators or PTC devices are used; or
- dissipates more than 15 W measured 30 s after the introduction of the fault.

A **resistive PIS** is considered not to exist in a PS1 because of the limits of the power source.

6.3 Safeguards against fire under normal operating conditions and abnormal operating conditions

6.3.1 Requirements

Under **normal operating conditions** and **abnormal operating conditions**, the following **basic safeguards** are required:

– ignition shall not occur; and

– no part of the equipment shall attain a temperature value greater than 90 % of the spontaneous ignition temperature limit, in Celsius, of the part as defined by ISO 871. When the spontaneous ignition temperature of the material is not known, the temperature shall be limited to 300 °C; and

NOTE This document currently does not contain requirements for flammable dust or liquids other than for **insulating liquids**.

– **combustible materials** for components and other parts (including **electrical enclosures**, **mechanical enclosures** and decorative parts) not inside a **fire enclosure** shall comply with:

- **HB75 class material** if the thinnest significant thickness of this material is < 3 mm; or
- **HB40 class material** if the thinnest significant thickness of this material is ≥ 3 mm; or
- **HBF class foamed material**; or
- shall pass the Glow-Wire test at 550 °C according to IEC 60695-2-11.

These requirements do not apply to:

- parts with a volume of less than 1 750 mm^3;
- parts with a mass of **combustible material** of less than 4 g;
- supplies, **consumable materials**, media and recording materials;
- parts that are required to have particular properties in order to perform intended functions, such as synthetic rubber rollers, ink tubes and material requiring optical characteristics; and
- gears, cams, belts, bearings and other parts that would contribute negligible fuel to a fire, including, labels, mounting feet, key caps, knobs and the like.

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6.3.2 Compliance criteria

*Compliance is checked by inspection of the data sheets and by test under **normal operating conditions** according to Clause B.2 and under **abnormal operating conditions** according to Clause B.3. The temperatures of materials are measured continuously until thermal equilibrium has been attained.*

NOTE See B.1.5 for details on thermal equilibrium.

*Temperature limiting **basic safeguards** that comply with the applicable requirements of this document or the applicable safety device standard shall remain in the circuit being evaluated.*

6.4 Safeguards against fire under single fault conditions

6.4.1 General

This subclause defines the possible **safeguard** methods that can be used to reduce the likelihood of ignition or spread of fire under **single fault conditions**.

There are two methods of providing protection. Either method may be applied to different parts of the same equipment.

– **Reduce the likelihood of ignition:** Equipment is so designed that under **single fault conditions** no part shall have sustained flaming. This method can be used for any circuit in which the available steady state power to the circuit does not exceed 4 000 W. The appropriate requirements and tests are detailed in 6.4.2 and 6.4.3.

  - **Pluggable equipment type A** is considered not to exceed the steady state value of 4 000 W.
  - **Pluggable equipment type B** and **permanently connected equipment** are considered not to exceed the steady state value of 4 000 W if the product of the nominal **mains** voltage and the **protective current rating** of the installation overcurrent protective device ($V_{mains} \times I_{max}$) does not exceed 4 000 W.

– **Control fire spread:** Selection and application of **supplementary safeguards** for components, wiring, materials and constructional measures that reduce the spread of fire and, where necessary, by the use of a second **supplementary safeguard** such as a **fire enclosure**. This method can be used for any type of equipment. The appropriate requirements are detailed in 6.4.4, 6.4.5 and 6.4.6.

6.4.2 Reduction of the likelihood of ignition under single fault conditions in PS1 circuits

No **supplementary safeguards** are needed for protection against PS1. A PS1 is not considered to be capable of providing enough energy to result in materials reaching ignition temperatures.

6.4.3 Reduction of the likelihood of ignition under single fault conditions in PS2 circuits and PS3 circuits

6.4.3.1 Requirements

The likelihood of ignition under **single fault conditions** in PS2 circuits and PS3 circuits where the available power does not exceed 4 000 W (see 6.4.1) shall be reduced by using the following **supplementary safeguards** as applicable:

NOTE For PS3 circuits where the available power exceeds 4 000 W, see 6.4.6.

– an **arcing PIS** or a **resistive PIS** shall be separated as specified in 6.4.7 with the **accessible** outer surface of the equipment considered to be covered with a **combustible material**;

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– protective devices acting as a **safeguard** shall comply with G.3.1 to G.3.4 or the relevant IEC component standards;

– motors and transformers shall comply with G.5.3, G.5.4 or the relevant IEC component standard;

– varistors shall comply with G.8.2; and

– components associated with the **mains** shall comply with the relevant IEC component standards and the requirements of other parts of this document.

In addition, the tests of 6.4.3.2 apply.

EXAMPLES Components associated with the **mains** include the supply cord, appliance couplers, EMC filtering components, switches, etc.

6.4.3.2 Test method

The conditions of Clause B.4, that are possible causes for ignition, are applied in turn. A consequential fault may either interrupt or short-circuit a component. In case of doubt, the test shall be repeated two more times with replacement components in order to check that sustained flaming does not occur.

*The equipment is operated under **single fault conditions** and the temperatures of materials are monitored continuously until thermal equilibrium has been attained.*

*If a conductor opens during a simulated **single fault condition**, the conductor shall be bridged and the simulated **single fault condition** shall be continued. In all other cases, where an applied **single fault condition** results in interruption of the current before steady state has been reached, the temperatures are measured immediately after the interruption.*

NOTE 1 See B.1.5 for details on thermal equilibrium.

NOTE 2 Temperature rise can be observed after interruption of the current due to thermal inertia.

*If the temperature is limited by a fuse under a **single fault condition:***

– *a fuse complying with the IEC 60127 series shall open within 1 s; or*

– *a fuse not complying with the IEC 60127 series shall open within 1 s for three consecutive times; or*

– *the fuse shall comply with the following test.*

*The fuse is short-circuited and the current that would have passed through the fuse under the relevant **single fault condition** is measured.*

If the fuse current remains less than 2,1 times the current rating of the fuse, the temperatures are measured after a steady state has been attained.

If the current either immediately reaches 2,1 times the current rating of the fuse or more, or reaches this value after a period of time equal to the maximum pre-arcing time for the relevant current through the fuse under consideration, both the fuse and the short-circuit link are removed after an additional time corresponding to the maximum pre-arcing time of the fuse under consideration and the temperatures are measured immediately thereafter.

If the fuse resistance influences the current of the relevant circuit, the maximum resistance value of the fuse shall be taken into account when establishing the value of the current.

*Printed board conductors are tested by applying the relevant **single fault conditions** of B.4.4.*

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6.4.3.3 Compliance criteria

Compliance is checked by inspection, tests and measurements. See B.4.8 for compliance criteria.

6.4.4 Control of fire spread in PS1 circuits

No **supplementary safeguards** are needed for protection against PS1. A PS1 is not considered to be capable of providing enough energy to result in materials reaching ignition temperatures.

6.4.5 Control of fire spread in PS2 circuits

6.4.5.1 General

For the purposes of reducing the likelihood of fire spread in PS2 circuits to nearby **combustible materials**, circuits that meet the requirements of Annex Q are considered to be PS2 circuits.

6.4.5.2 Requirements

A **supplementary safeguard** is required to control the spread of fire from any possible **PIS** to other parts of the equipment as given below.

Conductors and devices that constitute a **PIS** shall comply with the following:

– printed boards shall be made of **V-1 class material** or **VTM-1 class material**; and
– wire insulation and tubing shall comply with 6.5.1.

Motors shall comply with G.5.4.

Transformers shall comply with G.5.3.

All other components in a PS2 circuit shall comply with one of the following:

– be mounted on **V-1 class material** or **VTM-1 class material;** or
– be made of **V-2 class material**, **VTM-2 class material** or **HF-2 class foamed material**; or
– comply with the requirements of Clause S.1; or
– have a size of less than 1 750 mm^3; or
– have a mass of **combustible material** of less than 4 g; or
– be separated from a **PIS** by the requirements of 6.4.7; or
– comply with the flammability requirements of the relevant IEC component standard; or
– be in a sealed **enclosure** of 0,06 m^3 or less, consisting totally of non-**combustible material** and having no ventilation openings; or
– the component shall not ignite during **single fault conditions** as specified in 6.4.3.2.

If the following materials and parts are not separated from a **PIS** according to the requirements of 6.4.7, then the materials and parts shall not ignite during **single fault conditions** as specified in 6.4.3.2:

– supplies, **consumable materials**, media and recording materials; and
– parts that are required to have particular properties in order to perform intended functions, such as synthetic rubber rollers, ink tubes and material requiring optical characteristics.

6.4.5.3 Compliance criteria

Compliance is checked by testing or by inspection of the equipment and material data sheets.

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6.4.6 Control of fire spread in a PS3 circuit

Fire spread in PS3 circuits shall be controlled by applying all of the following **supplementary safeguards**:

– conductors and devices within a PS3 circuit shall meet the requirements of 6.4.5;

– devices subject to arcing or changing contact resistance (for example, pluggable connectors) shall comply with one of the following:

- have materials made of **V-1 class material**, or
- comply with the flammability requirements of the relevant IEC component standard, or
- comply with the requirements of Clause S.1, or
- be mounted on material made of **V-1 class material** or **VTM-1 class material** and be of a volume not exceeding 1 750 mm^3 or have a mass of **combustible material** of less than 4 g; and

– by providing a **fire enclosure** as specified in 6.4.8.

Within the **fire enclosure**, **combustible materials** that do not comply with the flammability requirements for PS2 or PS3 circuits shall comply with the flammability test of Clause S.1 or be made of **V-2 class material**, **VTM-2 class material** or **HF-2 class foamed material**. These requirements do not apply to:

– parts with a volume of less than 1 750 mm^3;

– parts with a mass of **combustible material** of less than 4 g;

– supplies, **consumable materials**, media and recording materials;

– parts that are required to have particular properties in order to perform intended functions, such as synthetic rubber rollers, ink tubes and material requiring optical characteristics;

– gears, cams, belts, bearings and other parts that would contribute negligible fuel to a fire, including, labels, mounting feet, key caps, knobs and the like; and

– tubing for air or fluid systems, containers for powders or liquids and foamed plastic parts, provided that they are of **HB75 class material** if the thinnest significant thickness of the material is < 3 mm, or **HB40 class material** if the thinnest significant thickness of the material is ≥ 3 mm, or **HBF class foamed material** or pass the glow-wire test at 550 °C according to IEC 60695-2-11.

A **fire enclosure** is not necessary for the following components and materials:

– wire insulation and tubing complying with 6.5.1;

– components, including connectors, complying with the requirements of 6.4.8.2.1, and that fill an opening in a **fire enclosure**;

– plugs and connectors forming part of a power supply cord or interconnecting cable complying with 6.4.9, G.4.1 and Clause G.7;

– motors complying with G.5.4; and

– transformers complying with G.5.3.

Compliance is checked by inspection of the material data sheets or by test, or both.

6.4.7 Separation of combustible materials from a PIS

6.4.7.1 General

When required, the minimum separation requirements between a **PIS** and **combustible materials**, in order to reduce the likelihood of sustained flaming or spread of fire, may be achieved by either separation by distance (6.4.7.2) or separation by a fire barrier (6.4.7.3).

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Additional requirements for a **fire enclosure** or a fire barrier of **combustible material** located within 13 mm of an **arcing PIS** or 5 mm of a **resistive PIS** are given in 6.4.8.4.

6.4.7.2 Separation by distance

Combustible material, except the material on which the **PIS** is mounted, shall be separated from an **arcing PIS** or a **resistive PIS** according to Figure 37 and Figure 38.

Base material of printed boards, on which an **arcing PIS** is located, shall be made of **V-1 class material**, **VTM-1 class material** or **HF-1 class foamed material**.

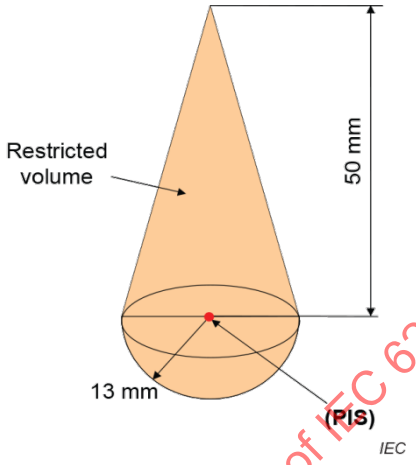
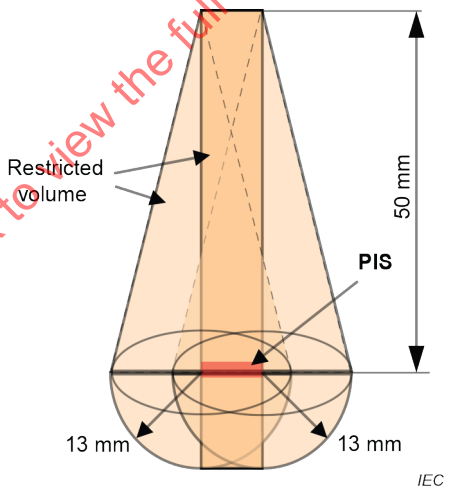


Figure 37 – Minimum separation requirements from a PIS



NOTE This figure can be used for:

– an **arcing PIS** that consists of tracks or areas on printed boards;

– the **resistive PIS** areas of components. Measurements are made from the nearest power dissipating element of the component involved. If in practice it is not readily possible to define the power dissipating part, then the outer surface of the component is used.

Figure 38 – Extended separation requirements from a PIS

When the distance between a **PIS** and **combustible materials** is less than specified in Figure 37 and Figure 38 as applicable, the **combustible materials** shall:

– have a volume of less than 1 750 mm^3;

– have a mass of **combustible material** of less than 4 g; or

– comply with:

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- the flammability requirements of the relevant IEC component standard; or
- be made of **V-1 class material**, **VTM-1 class material** or **HF-1 class foamed material**, or comply with IEC 60695-11-5. Severities are identified in Clause S.2.

6.4.7.3 Separation by a fire barrier

Combustible material shall be separated from an **arcing PIS** or a **resistive PIS** by a fire barrier as defined in 6.4.8.2.1 (see Figure 39).

Printed boards are not considered to be a fire barrier against an **arcing PIS** located on the same board. Printed boards complying with 6.4.8 may be considered to be a fire barrier against an **arcing PIS** located on a different board.

Printed boards can be considered to be a fire barrier against a **resistive PIS** provided that the following conditions are met:

– the printed board shall:
  - comply with the flammability test of Clause S.1 as used in the application; or
  - be made of **V-1 class material**, **VTM-1 class material** or **HF-1 class foamed material**;

– within the restricted volume, components shall meet the flammability requirements of the relevant component standard and no other materials rated less than **V-1 class material** shall be mounted on the same side of a printed board as the **resistive PIS**; and

– within the restricted volume, the printed board shall have no PS2 conductors or PS3 conductors (except for the conductors that supply the circuit under consideration). This applies to any side of the printed board as well as the inner layer of the printed board.

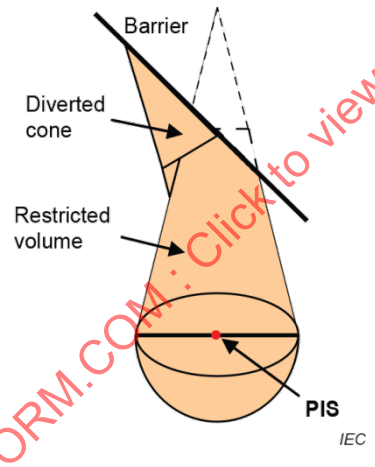


Figure 39a – Illustration showing an angled barrier

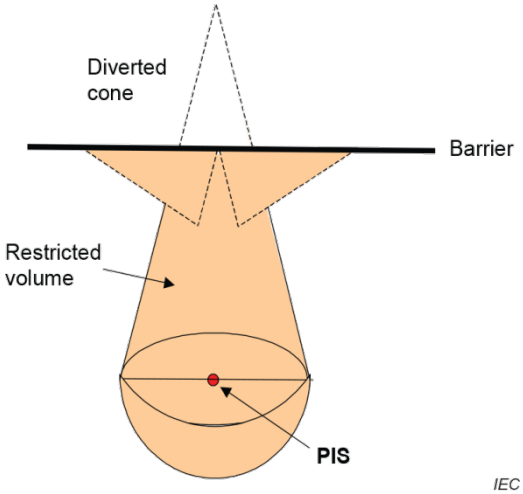


Figure 39b – Illustration showing a horizontal barrier

NOTE 1 The volume of the flame is nearly constant; consequently the shape of the flame is dependent upon the position and the shape of the barrier. Different shapes of barriers might give different flame shapes and result in a different restricted area and separation requirements.

NOTE 2 Dimensions are identical to Figure 37 and Figure 38 but, except as given in 6.4.8.4, the distance of the barrier from the **PIS** is not significant.

Figure 39 – Deflected separation requirements from a PIS when a fire barrier is used

6.4.7.4 Compliance criteria

Compliance is checked by inspection or measurement or both.

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6.4.8 Fire enclosures and fire barriers

6.4.8.1 General

The **safeguard** function of the **fire enclosure** and the fire barrier is to impede the spread of fire through the **enclosure** or barrier.

The **fire enclosure** may be the overall **enclosure**, or it may be within the overall **enclosure**. The **fire enclosure** need not have an exclusive function, but may provide other functions in addition to that of a **fire enclosure**.

6.4.8.2 Fire enclosure and fire barrier material properties

6.4.8.2.1 Requirements for a fire barrier

A fire barrier shall comply with the requirements of Clause S.1.

These requirements do not apply provided that the material is:

– made of non-**combustible material** (for example, metal, glass, ceramic, etc.); or
– made of **V-1 class material** or **VTM-1 class material**.

6.4.8.2.2 Requirements for a fire enclosure

For circuits where the available power does not exceed 4 000 W (see 6.4.1), a **fire enclosure** shall:

– comply with the requirements of Clause S.1; or
– be made of non-**combustible material** (for example, metal, glass, ceramic, etc.); or
– be made of **V-1 class material**.

For circuits where the available power exceeds 4 000 W, a **fire enclosure** shall:

– comply with the requirements of Clause S.5; or
– be made of non-**combustible material** (for example, metal, glass, ceramic, etc.); or
– be made of **5VA class material** or **5VB class material**.

Material for components that fill an opening in a **fire enclosure** or that is intended to be mounted in such opening shall:

– comply with the flammability requirements of the relevant IEC component standard; or
– be made of **V-1 class material**; or
– comply with Clause S.1.

6.4.8.2.3 Compliance criteria

Compliance is checked by inspection of applicable data sheets or test.

*The **material flammability class** is checked for the thinnest significant thickness used.*

6.4.8.3 Constructional requirements for a fire enclosure and a fire barrier

6.4.8.3.1 Fire enclosure and fire barrier openings

Openings in a **fire enclosure** or in a fire barrier shall be of such dimensions that fire and products of combustion passing through the openings are not likely to ignite material on the outside of the **enclosure** or on the side of a fire barrier opposite to the **PIS**.

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The openings to which these properties apply are relative to the site or location of the **PIS** and of **combustible materials**. The locations of openings relative to the flame property are shown in Figure 41 and Figure 42.

Regardless of the equipment orientation, the flame orientation property of the **PIS** is always vertical. Where the equipment has two or more **normal operating condition** orientations, opening properties apply to each possible orientation.

Requirements for the **fire enclosure** of a **secondary lithium battery** are specified in M.4.3.

Determination of top openings, side openings and bottom openings shall be done in accordance with Figure 40, taking into account all possible orientations of use (see also 4.1.6).

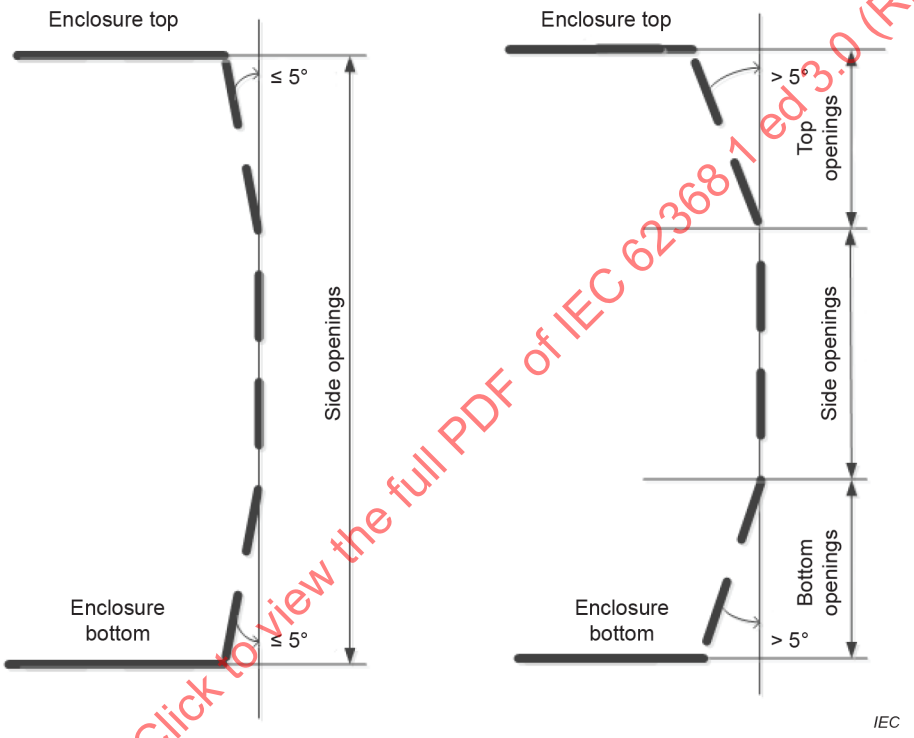


Figure 40 – Determination of top, bottom and side openings

6.4.8.3.2 Fire barrier dimensions

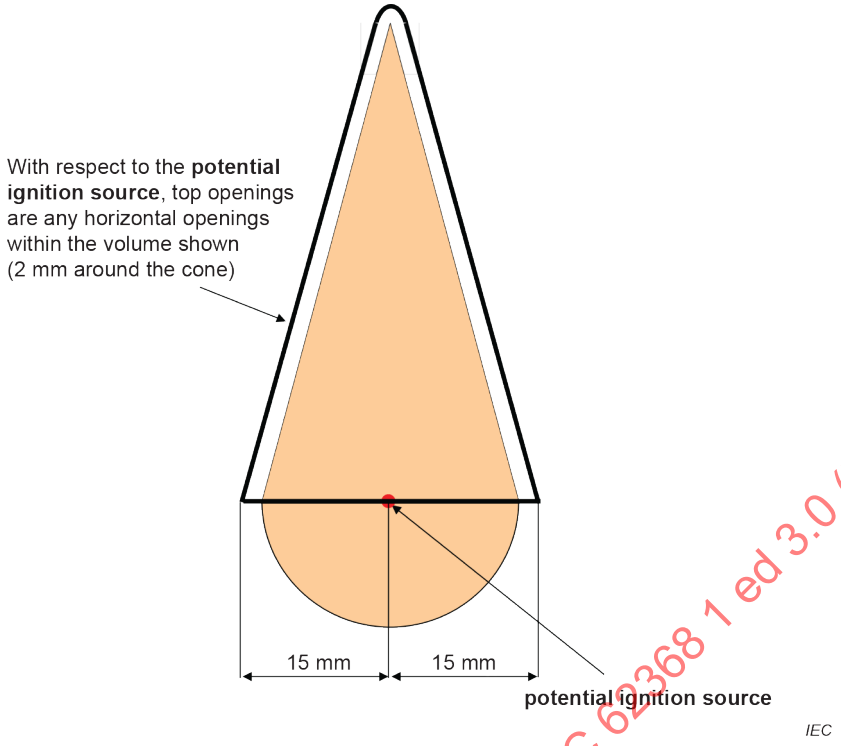
The edges of the fire barriers shall extend beyond the restricted volume (see Figure 39).

6.4.8.3.3 Top openings and top opening properties

Top opening properties of a **fire enclosure** shall apply to openings on a horizontal surface or any surface with an inclination of more than 5 degrees from vertical (see Figure 40) above a **PIS** located in a PS3 circuit as shown in Figure 41. Top opening properties of a fire barrier shall apply to openings above a **PIS** as shown in Figure 41.

Top openings that fall within the volume defined in Figure 41 shall comply with Clause S.2.

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NOTE Dimensions of the cone are identical to Figure 37 and Figure 38.

Figure 41 – Top openings

No test is required provided that the openings do not exceed:

– *5 mm in any dimension; or*

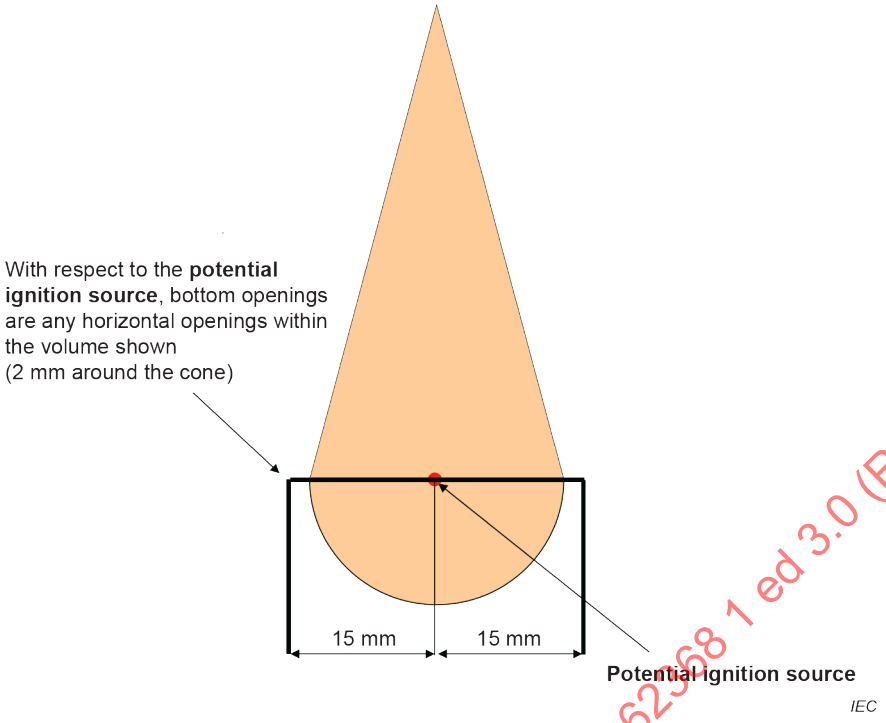
– *1 mm in width regardless of length.*

6.4.8.3.4 Bottom openings and bottom opening properties

Bottom opening properties of a **fire enclosure** and a fire barrier shall apply to openings on a horizontal surface or any other surface with an inclination of more than 5 degrees from the vertical (see Figure 40) below a **PIS** located in a PS3 circuit as shown in Figure 42. Openings on other surfaces below the **PIS** shall be considered side openings and 6.4.8.3.5 applies.

Bottom openings are those openings below a **PIS** and within 30 mm diameter cylinder extending indefinitely below the **PIS**.

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NOTE Dimensions of the cone are identical to Figure 37 and Figure 38.

Figure 42 – Bottom openings

Bottom openings shall comply with Clause S.3.

No test is necessary provided that one of the following conditions is met:

a) the bottom openings do not exceed:
   - 3 mm in any dimension; or
   - 1 mm in width regardless of length.

b) under components and parts meeting the requirements for **V-1 class material**, or **HF-1 class foamed material** or under components that pass the needle-flame test of IEC 60695-11-5 using a 30 s flame application, bottom openings shall not exceed:
   - 6 mm in any dimension; or
   - 2 mm in width regardless of length.

c) comply with a baffle plate construction as illustrated in Figure 43.

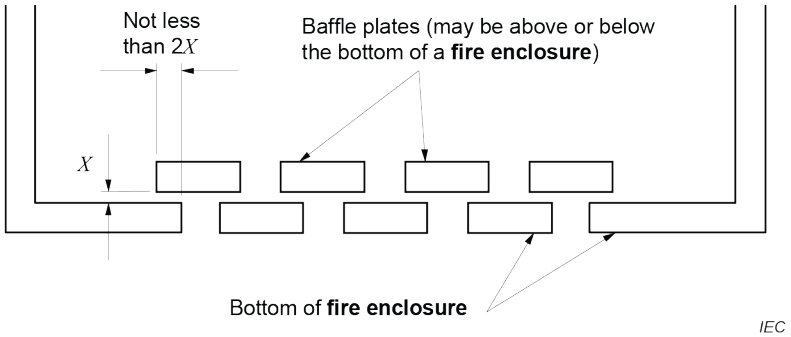


Figure 43 – Baffle plate construction

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Fixed equipment intended to be floor standing on a non-combustible surface does not require a **fire enclosure** bottom. Such equipment shall be marked in accordance with Clause F.5, except that element 3 is optional.

The elements of the **instructional safeguard** shall be as follows:

– element 1a: not available
– element 2: “RISK OF FIRE” or equivalent text
– element 3: optional
– element 4: “Install only on concrete or other non-combustible surface” or equivalent text

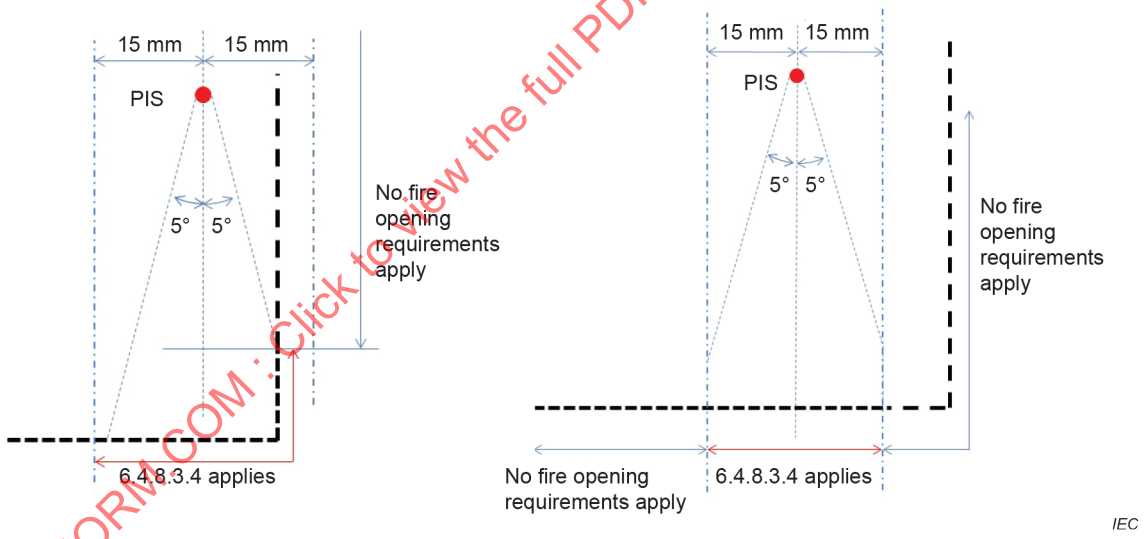
6.4.8.3.5 Side openings and side opening properties

Side opening properties of a **fire enclosure** and a fire barrier shall apply to openings that are on a vertical (± 5 degrees) side surface.

Where a portion of the side of a **fire enclosure** falls within the area indicated by the 5 degree angle in Figure 44, the limitations in 6.4.8.3.4 on sizes of openings in bottoms of **fire enclosures** also apply to this portion of the side.

*Compliance is checked by inspection and measurement. Except for that portion of the side of a **fire enclosure** that is subject to the requirements of 6.4.8.3.5 (see above paragraph), there are no other considerations for side openings.*

NOTE Limitations affecting the size of side openings are contained in other clauses of this document.



The **PIS** can be either a point, a component or a trace on a printed board.

Figure 44 – PIS trajectory downwards

6.4.8.3.6 Integrity of a fire enclosure

If part of a **fire enclosure** consists of a door or cover that can be opened by an **ordinary person**, the door or cover shall comply with requirements a), b), or c):

a) the door or cover shall be interlocked and comply with the **safety interlock** requirements in Annex K.

b) a door or cover, intended to be routinely opened by the **ordinary person**, shall comply with both of the following conditions:

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- it shall not be removable from other parts of the **fire enclosure** by the **ordinary person**; and
- it shall be provided with a means to keep it closed during **normal operating conditions**.

c) a door or cover intended only for occasional use by the **ordinary person**, such as for the installation of accessories, may be removable if an **instructional safeguard** is provided for correct removal and reinstallation of the door or cover.

6.4.8.3.7 Compliance criteria

Compliance is checked by inspection of applicable data sheets and, where necessary, by test.

6.4.8.4 Separation of a PIS from a fire enclosure and a fire barrier

A **fire enclosure** or fire barrier made of **combustible material** shall:

- have a minimum distance of 13 mm to an **arcing PIS**; and
- have a minimum distance of 5 mm to a **resistive PIS**.

Smaller distances are allowed provided that the part of the **fire enclosure** or fire barrier within the required separation distance complies with one of the following:

- the **fire enclosure** or fire barrier meets the needle-flame test according to IEC 60695-11-5. Severities are identified in Clause S.2. After the test, the **fire enclosure** or fire barrier material shall not have formed any holes that are bigger than allowed in 6.4.8.3.3 or 6.4.8.3.4 as appropriate; or
- the **fire enclosure** is made of **V-0 class material**; or
- the fire barrier is made of **V-0 class material** or **VTM-0 class material**.

6.4.9 Flammability of an insulating liquid

An **insulating liquid**:

- shall have an auto ignition temperature not less than 300 °C as determined in accordance with ISO 871 or similar national standard (for example ASTM E659-84); and
- shall not flash; or shall have a flashpoint higher than 135 °C determined in accordance with ISO 2719 using Pensky-Martens closed cup method (or a national standard, for example ASTM D93); or by the Small Scale closed cup method in accordance with ISO 3679 (or national standards, for example ASTM D3828 and ASTM D3278).

If transformer oil, silicon oil, mineral oil or other similar oil is used as **insulating liquid**, the oil shall comply with the flash point, fire point or flammability requirements of the applicable IEC standard. See Table 34 for a list of the IEC standards.

The temperature of components in contact with the **insulating liquid** shall not exceed the flashpoint of the **insulating liquid**.

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Table 34 – List of applicable IEC standards regarding insulating liquids

IEC 60296	*Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear*
IEC 60836	*Specifications for unused silicone insulating liquids for electrotechnical purposes*
IEC 61039	*Classification of insulating liquids*
IEC 61099	*Insulating liquids – Specifications for unused synthetic organic esters for electrical purposes*
IEC 60076-14	*Power transformers – Part 14: Liquid-immersed power transformers using high-temperature insulation materials*
IEC TS 62332-1	*Electrical insulation systems (EIS) – Thermal evaluation of combined liquid and solid components – Part 1: General requirements*

Compliance is checked by the available data or by inspection and tests as applicable.

6.5 Internal and external wiring

6.5.1 General requirements

In PS2 circuits or PS3 circuits, the insulation on internal or external wiring shall pass the test methods described below, or the equivalent.

For conductors with a cross-sectional area of 0,5 mm^2 or greater, the test methods in IEC 60332-1-2 and IEC 60332-1-3 shall be used.

For conductors with a cross-sectional area of less than 0,5 mm^2, the test methods in IEC 60332-2-2 shall be used.

For both internal and external wiring, the test method described in IEC TS 60695-11-21 may be used instead of the test methods in IEC 60332-1-2, IEC 60332-1-3 or IEC 60332-2-2.

NOTE Wire complying with UL 2556 VW-1 is considered to comply with these requirements.

The insulated conductor or cable shall be acceptable if it complies with the recommended performance requirements of the applicable IEC 60332 standards or with the requirements of IEC TS 60695-11-21.

6.5.2 Requirements for interconnection to building wiring.

Equipment intended to provide power over the wiring system to remote equipment shall limit the output current to a value that does not cause damage to the wiring system, due to overheating, under any external load condition. The maximum continuous current from the equipment shall not exceed a current limit that is suitable for the minimum wire gauge specified in the equipment installation instructions.

NOTE This wiring is not usually controlled by the equipment installation instructions, since the wiring is often installed independent of the equipment installation.

PS2 circuits or PS3 circuits that provide power and that are intended to be compatible with LPS to **external circuits** (see Annex Q) shall have their output power limited to values that reduce the likelihood of ignition within building wiring.

External paired conductor cable circuits, such as those described in Table 13, ID numbers 1 and 2 having a minimum wire diameter of 0,4 mm, shall have the current limited to 1,3 A.

EXAMPLE Time/current characteristics of type gD and type gN fuses specified in IEC 60269-2 comply with the above limit. Type gD or type gN fuses rated 1 A, would meet the 1,3 A current limit.

Compliance is checked by test, inspection and where necessary by the requirements of Annex Q.

6.5.3 Internal wiring for socket-outlets

Internal wiring for socket-outlets or appliance outlets providing **mains** power to other equipment shall have a nominal cross-sectional area at least as specified in Table G.7, including the condition of footnote [a].

Compliance is checked by inspection.

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6.6 Safeguards against fire due to the connection of additional equipment

The power delivered to connected equipment or accessories shall be limited to PS2 or shall comply with Clause Q.1, unless it is likely that the connected equipment or accessory also complies with this document.

This requirement does not apply to the audio output of audio amplifiers.

EXAMPLE Connected equipment or accessories that are likely to comply with this document include a scanner, a mouse, a keyboard, a DVD drive, a CD ROM drive or a joystick.

Compliance is checked by inspection or measurement.

7 Injury caused by hazardous substances

7.1 General

To reduce the likelihood of injury due to exposure to **hazardous substances**, equipment shall be provided with the **safeguards** specified in Clause 7.

NOTE 1 These **safeguards** are not intended to be the only means to reduce the likelihood of such injury.

NOTE 2 The classification of other possible **hazardous substances** not addressed in Clause 7 is not covered by this document. In many regions of the world different legislation applies, such as Restriction of Hazardous Substances Directive (RoHS) and Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH).

7.2 Reduction of exposure to hazardous substances

The exposure to **hazardous substances** shall be reduced. Reduction of exposure to **hazardous substances** shall be controlled by using containment of the **hazardous substances**. Containers shall be sufficiently robust and shall not be damaged or degraded by the contents over the lifetime of the product.

Compliance is checked by:

– *the examination of the effects the chemical has on the material of the container; and*

– *any relevant tests of Annex T according to 4.4.3, following which there shall be no leakage from the container.*

7.3 Ozone exposure

For equipment that produces ozone, the installation and operating instructions shall indicate that precaution shall be taken to ensure that the concentration of ozone is limited to a safe value.

NOTE 1 Currently, the typical long term exposure limit for ozone is considered to be $0,1 \times 10^{-6}$ ($0,2\ mg/m^3$) calculated as an 8 h time-weighted average concentration. Time-weighted average is the average level of exposure over a given time period.

NOTE 2 Ozone is heavier than air.

Compliance is checked by inspection of instructions or accompanying documents.

7.4 Use of personal safeguards or personal protective equipment (PPE)

Where **safeguards**, such as containment of a chemical, are not practical, a **personal safeguard** and its use shall be specified in the instructions that are provided with the equipment.

Compliance is checked by inspection of instructions or accompanying documents.

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7.5 Use of instructional safeguards and instructions

Where a **hazardous substance** is capable of causing an injury, **instructional safeguards** as specified in ISO 7010 and instructions shall be applied to the equipment in accordance with Clause F.5.

Compliance is checked by inspection of instructions or accompanying documents.

7.6 Batteries and their protection circuits

Batteries and their protection circuits shall comply with Annex M.

8 Mechanically-caused injury

8.1 General

To reduce the likelihood of injury due to exposure to mechanical hazards, equipment shall be provided with the **safeguards** specified in Clause 8.

NOTE 1 In some cases, the person is the source of the kinetic energy.

NOTE 2 Where not specifically mentioned in Clause 8, the words “products” and “equipment” also cover carts, stands and carriers used with these products or equipment.

8.2 Mechanical energy source classifications

8.2.1 General classification

Various categories of mechanical energy sources are given in Table 35.

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Table 35 – Classification for various categories of mechanical energy sources

Line	Category	MS1	MS2	MS3
1	Sharp edges and corners	Does not cause pain or injury [b]	Does not cause injury [b] but may be painful	May cause injury [c]
2	Moving parts	Does not cause pain or injury [b]	Does not cause injury [b] but may be painful	May cause injury [c]
3a	Plastic fan blades [a] See Figure 46	$\frac{N}{15\,000} + \frac{K}{2\,400} \leq 1$	$\frac{N}{44\,000} + \frac{K}{7\,200} \leq 1$	> MS2
3b	Other fan blades [a] See Figure 45	$\frac{N}{15\,000} + \frac{K}{2\,400} \leq 1$	$\frac{N}{22\,000} + \frac{K}{3\,600} \leq 1$	> MS2
4	Loosening, exploding or imploding parts	NA	NA	See [d]
5	Equipment mass [f]	≤ 7 kg	≤ 25 kg	> 25 kg
6	Wall/ceiling or other structure mount [f]	Equipment mass ≤ 1 kg mounted ≤ 2 m [e]	Equipment mass > 1 kg mounted ≤ 2 m [e]	All equipment mounted > 2 m

[a] The K factor is determined from the formula $K = 6 \times 10^{-7}$ ($m\ r^2\ N^2$), where m is the mass (kg) of the moving part of the fan assembly (blade, shaft and rotor), r is the radius (mm) of the fan blade from centre line of the motor (shaft) to the tip of the outer area likely to be contacted, N is the rotational speed (rpm) of the fan blade.

In the end product, the fan maximum operational voltage can be different than the **rated voltage** of the fan and this difference should be taken into account.

[b] The phrase “Does not cause injury” means that, according to experience and/or basic safety standards, a doctor or hospital emergency attention is not needed.

[c] The phrase “May cause injury” means that, according to experience and/or basic safety standards, a doctor or hospital emergency attention may be needed.

[d] The following equipment constructions are examples considered MS3:

– CRTs having a maximum face dimension exceeding 160 mm; and

– lamps in which the pressure exceeds 0,2 MPa when cold or 0,4 MPa when operating.

[e] This classification can only be used if the manufacturer’s instructions state that the equipment is only suitable for mounting at heights ≤ 2 m.

[f] Mass of supplies, **consumable materials**, media or the like that may be contained in the equipment shall be included in the calculation of the equipment mass. The additional mass of such items is determined by the manufacturer.

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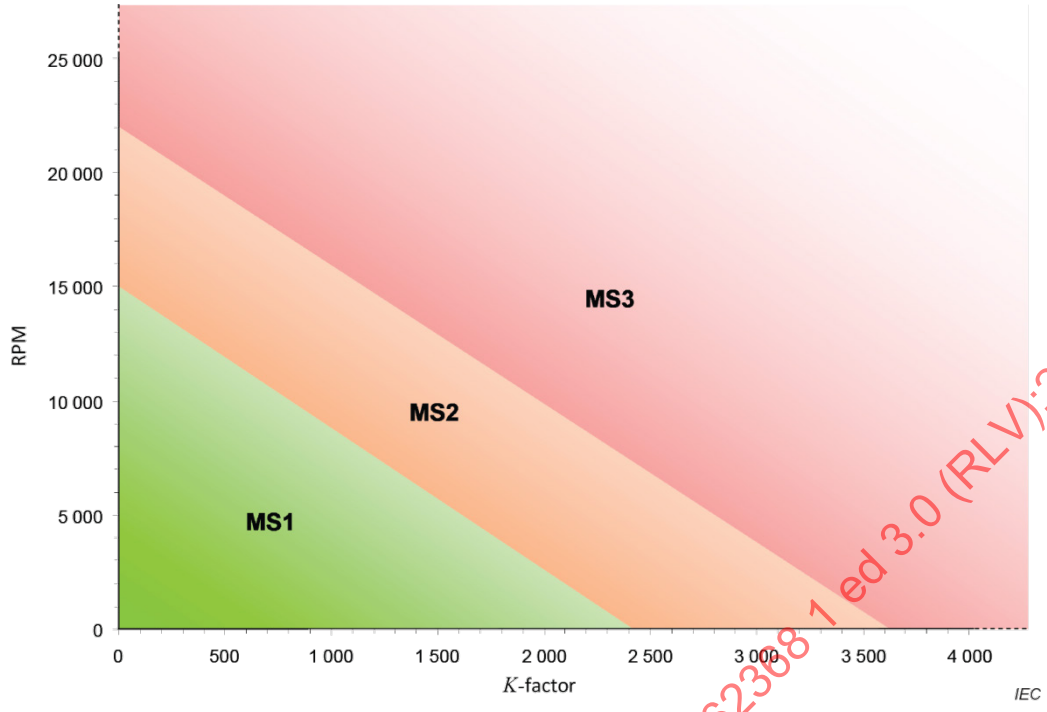


Figure 45 – Limits for moving fan blades made of non-plastic materials

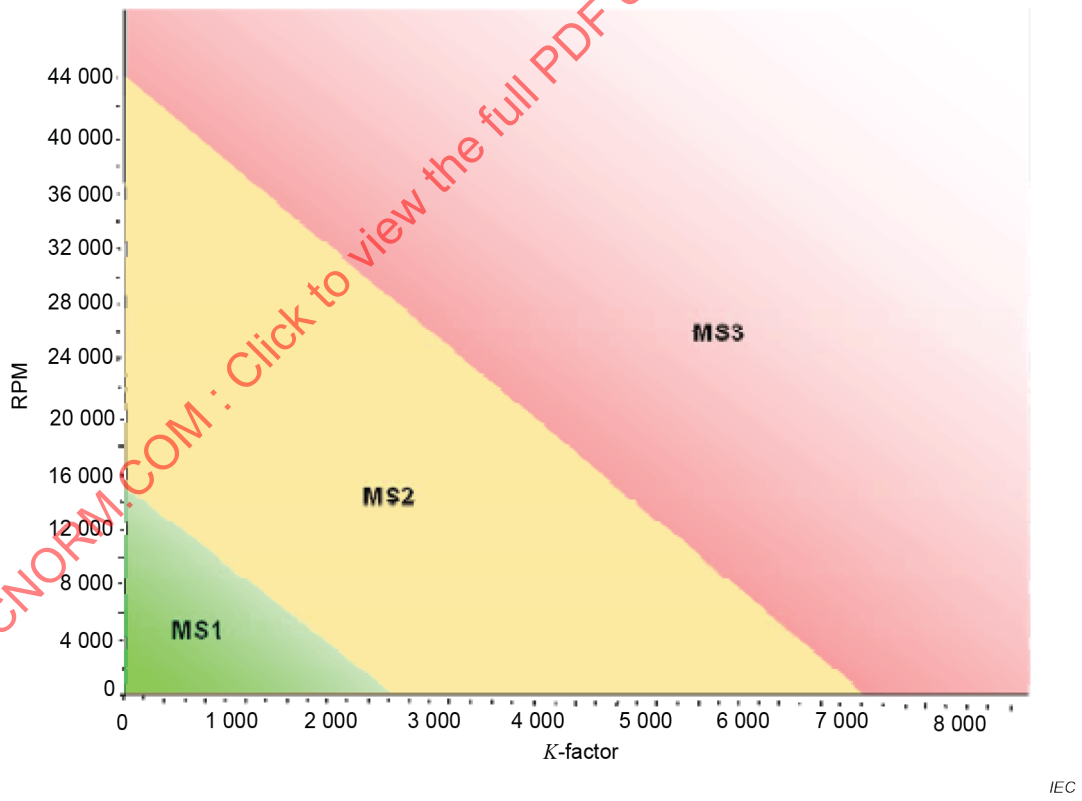


Figure 46 – Limits for moving fan blades made of plastic materials

8.2.2 MS1

MS1 is a class 1 mechanical energy source with levels not exceeding MS1 limits under **normal operating conditions** and **abnormal operating conditions** and not exceeding MS2 under **single fault conditions**.

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8.2.3 MS2

MS2 is a class 2 mechanical energy source with levels not exceeding MS2 limits under **normal operating conditions**, **abnormal operating conditions**, and **single fault conditions**, but is not MS1.

8.2.4 MS3

MS3 is a class 3 mechanical energy source with levels exceeding MS2 limits under **normal operating conditions**, **abnormal operating conditions** or **single fault conditions**, or any mechanical energy source declared to be treated as MS3 by the manufacturer.

8.3 Safeguards against mechanical energy sources

Except as given below, **safeguard** requirements for parts **accessible** to **ordinary persons**, **instructed persons** and **skilled persons** are given in 4.3.

An **instructional safeguard** shall be provided for MS2 that is not obvious to an **instructed person** or for MS3 that is not obvious to a **skilled person**.

Other MS3 parts not actively being serviced shall be located or guarded so that unintentional contact with such parts during service operations is an unlikely result in the **skilled person** involuntary recoiling from class 2 or class 3 energy sources being serviced.

8.4 Safeguards against parts with sharp edges and corners

8.4.1 Requirements

Safeguards that reduce the likelihood of injury by parts with sharp edges and corners in **accessible** areas of the equipment are specified below.

Classification of the energy sources shall be done according to Table 35, line 1.

Where a sharp edge or corner classified as MS2 or MS3 is required to be **accessible** for the function of the equipment:

– any potential exposure shall not be life threatening; and
– the sharp edge or corner shall be obvious to an **ordinary person** or an **instructed person** when exposed; and
– the sharp edge shall be guarded as much as practicable; and
– an **instructional safeguard** shall be provided to reduce the risk of unintentional contact in accordance with Clause F.5, except that element 3 is optional.

The elements of the **instructional safeguard** shall be as follows:

– element 1a:  , IEC 60417-6043 (2011-01)
– element 2: “Sharp edges” or equivalent text
– element 3: optional
– element 4: “Do not touch” or equivalent text

8.4.2 Compliance criteria

*Where a sharp edge or corner is required to be **accessible** for the function of the equipment, compliance is checked by inspection.*

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*Where a sharp edge or corner is not required to be **accessible** for the function of the equipment compliance is checked by the relevant tests of Annex V. During and after the application of the force, the sharp edge or corner shall not be **accessible**.*

8.5 Safeguards against moving parts

8.5.1 Requirements

Safeguards that reduce the likelihood of injury caused by moving parts of the equipment (for example, pinch points, meshing gears and parts that may start moving due to unexpected resetting of a control device) are specified below.

Plastic fan blades are classified according to Table 35, line 3a. Other fan blades are classified according to Table 35, line 3b. Other moving parts are classified according to Table 35, line 2.

NOTE 1 The ability of a part to cause injury is not solely dependent upon the kinetic energy it possesses. Consequently, the classification used in this document can only be based on typical experience and engineering judgement.

NOTE 2 Examples of factors influencing the energy transfer to a body part include shape of the surface that strikes the body part, elasticity, velocity and the mass of equipment and body part.

If a **safety interlock** is used as **safeguard**, the energy of the moving part shall be reduced to MS1 before the part is **accessible**.

Unless otherwise specified, where the likelihood exists that fingers, jewellery, clothing, hair, etc., can come into contact with moving MS2 or MS3 parts, an **equipment safeguard** shall be provided to prevent entry of body parts or entanglement of such items.

If a moving MS2 part is required to be **accessible** for the function of the equipment to an **ordinary person**, the moving part shall be guarded as much as practicable and an **instructional safeguard** as given in 8.5.2 shall be used.

If a moving MS3 part is required to be **accessible** for the function of the equipment to an **ordinary person** or an **instructed person**:

– any exposure shall not be life threatening; and

– the moving part shall be obvious when exposed; and

– the moving part shall be guarded as much as practicable; and

– an **instructional safeguard** as given in 8.5.2 shall be used; and

– a manually activated stopping device shall be clearly visible and placed in a prominent position within 750 mm of the MS3 part.

  Components of the manually activated stopping device shall be of an electromechanical type. A manually activated stopping device may consist of:

  - a switch complying with IEC 61058-1 and that meets the requirements of Annex K and that is provided with a latching type mechanism meeting the requirements of IEC 60947-5-5, or
  - an emergency stop device in accordance with IEC 60947-5-5.

  Restarting of the mechanical system shall only be possible by initiating a start control procedure after the manually activated stopping device has been manually reset.

Moving MS3 parts:

– that are only **accessible** to a **skilled person**; and

– where the MS3 moving part is not obvious (for example, a device having intermittent movement),

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shall have an **instructional safeguard** as given in 8.5.2. Unless the moving part is arranged, located, enclosed or guarded in such a way that the possibility of contact with the moving parts is unlikely, a stopping device shall be placed in a clearly visible and prominent position within 750 mm of the MS3 part.

8.5.2 Instructional safeguard requirements

An **instructional safeguard** shall be provided to reduce the likelihood of unintentional contact with a moving part in accordance with Clause F.5, except that element 3 is optional.

The elements of the **instructional safeguard** shall be as follows:

– element 1a:  IEC 60417-6056 (2011-05) for moving fan blades; or

 IEC 60417-6057 (2011-05) for other moving parts

– element 2: "Moving parts" or "Moving fan blade" as applicable, or equivalent text

– element 3: optional

– element 4: "Keep body parts away from moving parts" or "Keep body parts away from fan blades" or "Keep body parts out of the motion path" as applicable, or equivalent text

During **ordinary person** servicing conditions, where it is necessary to defeat or bypass the **equipment safeguard** preventing access to a moving part classified as MS2, an **instructional safeguard** shall be provided to:

– disconnect the power source prior to defeating or bypassing the **equipment safeguard**; and

– restore the **equipment safeguard** before restoring power.

8.5.3 Compliance criteria

The accessibility of moving parts shall be checked by inspection and, if necessary, be evaluated according to the relevant parts of Annex V.

8.5.4 Special categories of equipment containing moving parts

8.5.4.1 General

Clause 8.5.4 applies to large self-contained equipment installed in **restricted access areas** (for example, a data centre), typically of such a size that a person may enter completely, or may insert a complete limb or head into areas containing hazardous moving parts and where a person is expected to enter the area to service or operate the equipment.

Equipment covered by this paragraph are automated information mass storage and retrieval systems that use integral hazardous moving parts for the handling of recorded media (for example, tape cartridges, tape cassettes, optical discs, etc.) and similar functions and large printers.

8.5.4.2 Equipment containing work cells with MS3 parts

8.5.4.2.1 Protection of persons in the work cell

During **normal operating conditions**, no MS3 moving parts shall be **accessible** at the outer **enclosure** of a **work cell.**

The equipment shall be provided with **safeguards** to reduce the risk of injury due to MS3 moving parts in the **work cell**. Other class 3 energy sources within a **work cell** shall not be

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accessible under **normal operating conditions**, **abnormal operating conditions** and **single fault conditions**.

EXAMPLES **Safeguards** include interlocks, barriers and awareness signals, together with designated procedures and training.

NOTE 1 Some authorities may require installation of fire detection and extinguishing systems in **work cells**.

Access to a **work cell** or any of its compartments shall be protected by either of the following methods:

– Method 1 – **Safety interlock** method. No key or **tool** is needed to gain entry to the **work cell**. **Safety interlocks** meeting the requirements of Annex K shall be provided to prevent access to the **work cell** while power is available to the MS3 moving parts in that compartment. Power to the MS3 moving parts shall not be restored until the doors are closed and latched. Opening of the interlocked access door into any compartment of a **work cell** containing MS3 moving parts, or an access door between a compartment containing MS3 moving parts and one that has been disabled, shall automatically initiate disconnection of the supply to such parts, and to reduce to a class 2 energy source within 2 s for an **instructed person** or a **skilled person**. If reduction of the energy source class takes longer than 2 s, then an **instructional safeguard** shall be provided in accordance with Clause F.5.

– Method 2 – Key or **tool** method. A key or **tool** shall be required to gain and control access to the **work cell**, and access to the **work cell** shall be prevented while power is available to the MS3 moving parts in that **work cell**. The operating and servicing instructions, as appropriate, shall specify that the key or **tool** must be carried by the person while in the **work cell**. When the **work cell** can be entered completely closing of the door without the key or **tool** shall not result in the equipment being restarted automatically.

  NOTE 2 The key or **tool** may be used as the means to remove power before access to the **work cell** or compartment.

Except as permitted in 8.5.4.2.2, it shall not be possible to start or restart the system until all relevant access doors are closed and latched.

Where it is possible to enter a **work cell** completely, an automatically activated mechanical interlock shall be provided so that the door cannot be closed inadvertently if this closure would allow the equipment to be restarted. It shall be possible to open any door from inside the **work cell** without the use of a key or **tool**. The means of opening the door from inside the **work cell** shall be readily identifiable and visible, whether the door is open or closed, irrespective of the operating status of the equipment.

Compliance is checked by inspection.

During servicing of the equipment, there may be a need to energize the equipment to allow for alignment, etc. In such cases, under **single fault conditions** or **abnormal operating conditions**, adequate means shall be provided to limit the movement of the parts so that they do not become MS3, such as by extended travel or by having parts detach and be ejected from the moving assembly. Such means shall be capable of limiting these moving parts to less than MS3 under rated load, maximum speed conditions and at maximum extension.

*Compliance is checked by inspection, and, if necessary, by the tests of B.3 and B.4. The **enclosure** or compartment separation barriers shall contain any part that may become detached during the test.*

8.5.4.2.2 Access Protection Override

8.5.4.2.2.1 General

If it is necessary for a **skilled person** to override a protective mechanisim such as a **safety interlock** for access to a **work cell** or compartment, an override system complying with

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Clause K.4 shall be provided. In addition, when an override system is used, an emergency stop system shall be provided in accordance with 8.5.4.2.3, and shall comply with the operational endurance requirements of 8.5.4.2.4.

Compliance is checked by inspection.

8.5.4.2.2.2 Visual indicator

A set of two or more bright flashing indicators complying with IEC 60073 shall operate under the following conditions:

a) for a **work cell** or compartment that can be entered completely to indicate the equipment is being restored to normal operation and motion is pending; or

b) for any equipment when the interlock is overridden and drive power is available to MS3 moving parts.

The indicators shall be readily visible at any point within the **work cell** or relevant compartment and at the point of entry. For condition a), the indicators shall operate for a minimum of 10 s prior to movement of a MS3 moving part along the most significant axis. If condition a) can occur while condition b) is in effect, there shall be a change of light sequencing such that the change in status will be obvious to persons in or at the point of entry to the **work cell**.

NOTE The most significant axis is the one with the longest travel distance. This is usually the horizontal (X) axis.

Compliance is checked by inspection and test.

8.5.4.2.3 Emergency stop system

This subclause only applies if a **safety interlock** override is provided as specified in 8.5.4.2.2.

An emergency stop system shall override all other controls, remove drive power from MS3 moving parts and employ automatic braking, if necessary, to cause all these moving parts to stop within a reasonable time period such that a level 3 hazard cannot be contacted.

Components of the emergency stop system shall be of an electromechanical type. An emergency stop control may consist of:

– a switch complying with IEC 61058-1 and that meets the requirements of Annex K and that is provided with a latching type mechanism meeting the requirements of IEC 60947-5-5, or equivalent; or

– an emergency stop device in accordance with IEC 60947-5-5.

NOTE In the United Kingdom, an emergency stop system complying with the requirements of IEC 60204-1 and ISO 13850 is required where there is a risk of personal injury.

Alternatively, the safety function of the emergency stop system shall have a Safety Integrity Level (SIL) per IEC 62061, or a Performance Level (PL) per ISO 13849-1 that is consistent with the results of a risk assessment of the **work cell**.

Restarting of the mechanical system shall only be possible by initiating a start control procedure after the emergency stop control has been manually reset.

For equipment where a person may completely enter the **work cell**, the emergency stop system shall include a minimum of two emergency stop controls, one outside the **work cell** and one within the **work cell**. The system start up procedure shall include a non-hazardous method to ensure no person is present in the **work cell**. If it can be shown, after application of the single fault tests specified in 8.5.4.2.4 to the movement control circuitry or other sensing

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means, that such tests do not by-pass the non-hazardous start up procedure, the emergency stopping distance test of this subclause is not required.

For equipment where a person may only partially enter a **work cell** or compartment, a minimum of one emergency stop control shall be provided outside of the **work cell**. The emergency stop system shall be operable by the person needing to have access to the **work cell**.

An emergency stop control provided outside the **work cell** shall be readily visible and shall be located on the equipment such that the person operating it can see if the **work cell** is occupied. The installation instructions shall require that space be provided around the control so that an **instructed person** or **skilled person** can easily reach and activate it.

An emergency stop control provided inside the **work cell** shall be readily accessible from anywhere inside the **work cell** and shall be provided with lighting to permit easy identification. It shall consist of a red palm or mushroom head button or be provided with an indirect arrangement, such as an easily identifiable red safety cable, that activates the emergency stop system.

Compliance is checked by inspection and, if necessary, by the following tests.

While the mechanical system is operating at its maximum kinetic energy (carrying maximum load capacity at maximum speed), the emergency stop system is to be activated and the distance to stop measured. The results of the distance measurements shall show that after activation of the emergency stop system, any subsequent motion in any direction would be unlikely to present a risk of injury.

The maximum stopping distance from the point of activation, along the most significant axis, shall be 1 m or less. In addition, if there is an end point along the most significant axis beyond which the MS3 moving part does not operate, there shall be at least 150 mm of empty space available between this end point and the nearest fixed mechanical part, intended to provide sufficient space for a person not to be harmed. The requirements of B.3.8 apply.

8.5.4.2.4 Endurance requirements

Except as referenced in 8.5.4.2.3, this subclause only applies when a **safety interlock** override is provided as specified in 8.5.4.2.2, or if any **instructed person** or **skilled person accessible** cable contains ES3 voltages.

Movable cable assemblies are tested to ensure that no mechanical damage occurs that could result in any of the following:

– a malfunction of the **safety interlock** system;
– compromise any compartment separation barriers or **mechanical enclosures**;
– expose a person to other hazards.

If the voltage in these cables and movement control circuitry are ES3, mechanical endurance tests shall be applied to ensure that no electric shock hazard results.

For cables that carry only voltages meeting the requirements for ES1, if it can be shown that single open-circuit or short-circuit fault testing of these cables and movement control circuitry would not result in a hazard, they are exempt from the mechanical endurance tests.

Compliance is checked by inspection and, when necessary, by the following mechanical endurance tests.

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The mechanical system, including the means (for example, limit switches) that limit movement during normal operation, are subjected to 100 000 cycles of operation at rated load and maximum speed through the maximum length or rotation of travel permitted by the design.

After the cycling:

– *a mechanical function check (for example, MS3 moving parts to operate electromechanical switches; end of travel mechanical stop, etc.) and a visual inspection, are conducted. Mechanical stops and electromechanical switches shall perform as intended. There shall be no evidence of loss of mechanical integrity. All safety-related functions (including emergency stop systems, and the like, as applicable) shall operate normally; and*

– *the assembly cables that control the MS3 moving parts, other than those containing only ES1, are examined for damage that exposes conductors carrying greater than ES1. No conductor shall be broken and no individual strands shall have penetrated the insulation. If damage cannot be determined by inspection, the cable assembly shall pass an electric strength test of 1 000 V, in accordance with 5.4, applied between the conductors carrying greater than ES1 and foil wrapped around the body of the cable.*

8.5.4.3 Equipment having an electromechanical device for destruction of media

8.5.4.3.1 General requirements

Equipment safeguards to protect persons, including children, for equipment intended to mechanically destroy various media by means of moving parts that draw the media into the equipment are specified below. The media destruction device within this equipment is classed as MS3.

EXAMPLES Equipment that includes household use and home-office use document shredding and similar media destruction devices, as determined by the nature of their power source.

For equipment for use in locations where children are not likely to be present, see Clause F.4.

NOTE This equipment design typically applies to commercial or industrial equipment expected to be installed in locations where only adults are normally present.

Equipment shall be provided with **safeguards** so that MS3 moving parts are not **accessible** to the appropriate jointed test probe of Annex V and the wedge probe of Figure V.4. Requirements for **safety interlocks** are according to 4.4.5, except that where a moving part cannot be reduced to the appropriate energy class within 2 s, the **safety interlock** shall continue to prevent access.

8.5.4.3.2 Instructional safeguards against moving parts

For equipment installed where children may be present, an **instructional safeguard** shall be provided in accordance with Clause F.5, except that element 3 is optional.

The elements of the **instructional safeguard** shall be as follows:

– element 1a:  , IEC 60417-6057 (2011-05)

– element 2: optional

– element 3: optional

– element 4: “This equipment is not intended for use by children” and “Avoid touching the media feed opening with the hands, clothing or hair” and “Unplug this equipment when not in use for an extended period of time” or equivalent text

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8.5.4.3.3 Disconnection from the supply

An isolating switch complying with Annex L shall be provided to disconnect power to MS3 moving parts. A switch with an “OFF” position, that removes all power from the MS3 moving part is acceptable. The switch shall be located where it is easily **accessible** to the user whose body part or clothes may be caught.

The ”ON" and "OFF" positions of a two-position switch shall be marked in accordance with F.3.5.2.

For a multi-position switch, the "OFF" position of the switch shall be marked in accordance with F.3.5.2, and the other positions shall be marked with appropriate words or symbols.

8.5.4.3.4 Test method

The media destruction device is tested with the wedge probe of Figure V.4 applied in any direction relative to the opening:

– *with a force up to 45 N for a strip-cut type device; and*

– *with a force up to 90 N for a cross-cut type device.*

NOTE Media destruction devices are typically identified as either strip-cut type or cross-cut type. A strip-cut media destruction device shreds the media into long strips using a motor-based shredding mechanism. A cross-cut media destruction device shreds the media two or more ways into tiny particles, typically using a more powerful motor and more complex shredding mechanism.

*Any **enclosure** or guard that can be removed or opened by an **ordinary person** or an **instructed person** shall be removed or opened prior to application of the probes.*

8.5.4.3.5 Compliance criteria

Compliance is checked in accordance with V.1.2 and V.1.5. The wedge probe shall not contact any moving part.

*Where the equipment is provided with a **safety interlock**, compliance is checked according to 4.4.5, except where a moving part cannot be reduced to the appropriate energy class within 2 s, the **safety interlock** shall continue to prevent access.*

8.5.5 High pressure lamps

8.5.5.1 General

The containment mechanism for high pressure lamps that are considered MS3 according to Line 4 of Table 35 shall have adequate strength to contain an **explosion** of the lamp so as to reduce the likelihood of injury to an **ordinary person** or **instructed person** during normal use, or lamp assembly replacement, as appropriate.

8.5.5.2 Test method

For the protection against the effects of a high pressure lamp failure, the following test is performed as follows:

– *lamp assemblies considered MS3 parts during field replacement are tested separate from the equipment;*

– *lamp assemblies only considered MS3 parts during operation, may be tested separately, or as normally installed in the equipment, or both.*

*An **explosion** of the lamp is stimulated by mechanical impact, electronic pulse generator or similar method. The lamp shall operate for at least 5 min to obtain operational temperature and pressure. To evaluate the rupture results for potential debris area and particle size, the equipment or lamp assembly is placed on a horizontal surface, and a dark sticky mat (or*

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another adequate method) of adequate size to capture the particles is placed near the exhaust vent of the equipment. The equipment opening shall be oriented to maximize potential for particles to be expelled from the product horizontally across the dark sticky mat. After the rupture, the glass particles generated are measured using a magnified glass piece with a 0,1 mm resolution. The test shall be conducted to simulate the worst case operating position specified in the instructions.

NOTE It is easier for the inspection of potential glass debris if the sticky mat has a dark blue colour.

An example of an electronic pulse generator method is given in Figure D.3.

The charge is increased in steps of 5 J until the lamp ruptures are repeatable.

8.5.5.3 Compliance criteria

Compliance is checked by physical inspection or, if necessary, by the tests of 8.5.5.2.

When tested in accordance with 8.5.5.2, inspect the dark sticky mat for glass particles, and:

– *glass particles less than 0,8 mm in the longest axis shall not be found beyond 1 m of the* ***enclosure*** *opening; and*
– *glass particles equal to or greater than 0,8 mm in the longest axis shall not be found.*

For ***professional equipment****, where it is unlikely that the particles will be within reach of an* ***ordinary person****, the value of 0,8 mm may be replaced with 5 mm.*

8.6 Stability of equipment

8.6.1 Requirements

Classification of products for the purposes of assessing equipment stability is to be done according to Table 35, line 5.

In case units are fixed together, the MS class is determined by the total weight of the units. If units are intended to be separated for relocation, the MS class is determined by the individual weight.

Individual units that are designed to be mechanically fixed together on site and are not used individually, or **stationary equipment**, shall be assessed by inspection after installation according to the manufacturer's instructions and, if necessary, tested according to 8.6.2.2.

Equipment shall comply with the requirements and tests given in 8.6.2, 8.6.3, 8.6.4 and 8.6.5 according to Table 36. Where an "x" is given, it means that the test is applicable.

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Table 36 – Overview of requirements and tests

Equipment type		Type of test				
		Static stability	Downward force	Relocation	Glass slide [b]	Horizontal force
		8.6.2.2	8.6.2.3	8.6.3	8.6.4	8.6.5
MS1	All equipment	No stability requirements				
MS2	Floor standing			x		
	Non-floor standing	x				
	Controls or display [a]	x			x	
	Fixed equipment	No stability requirements				
MS3	Floor standing	x	x	x		
	Non-floor standing	x				
	Controls or display [a]	x			x	x
	Fixed equipment	No stability requirements				

[a] Equipment with front mounted **accessible** user controls and equipment having displays with moving images likely to be used in the home or similar installation environments where the equipment may be **accessible** to children.

[b] The glass slide test is not applicable to floor standing equipment, even though the equipment may have controls or a display.

Where thermoplastic materials have an influence on the stability of the equipment, the relevant stability tests shall be conducted after the stress relief test in Clause T.8 when the equipment has cooled to room temperature.

MS2 and MS3 television sets shall have an **instructional safeguard** in accordance with Clause F.5, except that the **instructional safeguard** may be included in the installation instructions or equivalent document accompanying the equipment.

The elements of the **instructional safeguard** shall be as follows:

– element 1a: not available
– element 2: “Stability Hazard” or equivalent word
– element 3: “The television set may fall, causing serious personal injury or death” or equivalent text
– element 4: the text below or equivalent text

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A television set may fall, causing serious personal injury or death. Many injuries, particularly to children, can be avoided by taking simple precautions such as:

– ALWAYS use cabinets or stands or mounting methods recommended by the manufacturer of the television set.

– ALWAYS use furniture that can safely support the television set.

– ALWAYS ensure the television set is not overhanging the edge of the supporting furniture.

– ALWAYS educate children about the dangers of climbing on furniture to reach the television set or its controls.

– ALWAYS route cords and cables connected to your television so they cannot be tripped over, pulled or grabbed.

– NEVER place a television set in an unstable location.

– NEVER place the television set on tall furniture (for example, cupboards or bookcases) without anchoring both the furniture and the television set to a suitable support.

– NEVER place the television set on cloth or other materials that may be located between the television set and supporting furniture.

– NEVER place items that might tempt children to climb, such as toys and remote controls, on the top of the television or furniture on which the television is placed.

If the existing television set is going to be retained and relocated, the same considerations as above should be applied.

8.6.2 Static stability

8.6.2.1 Test setup

The equipment shall be blocked, if necessary, by means of a stop of the smallest dimensions possible to keep it from sliding or rolling during the test. During the tests, containers, if any, are to contain the amount of substance within their rated capacity that will result in the most disadvantageous condition.

*All doors, drawers, casters, adjustable feet and other appurtenances that are **accessible** to an **ordinary person**, are arranged in any combination that results in the least stability. Equipment provided with multi-positional features shall be tested in the least favourable position based on the equipment construction. However, if the casters are intended only to transport the unit, and if the installation instructions require adjustable feet to be lowered after installation, then the adjustable feet (and not the casters) are used in this test.*

*Where equipment is subject to periodic maintenance or routinely serviced or repaired at its intended use location, the doors, drawers, etc. or any other adjustment means **accessible** to an **instructed person** or **skilled person** shall be arranged in any combination specified by the servicing instructions that results in the least stability.*

The tests of 8.6.2.2 and 8.6.2.3 shall be performed as indicated in Table 36.

8.6.2.2 Static stability test

The equipment shall be subjected to one of the following tests:

– *The equipment is tilted in all directions such that the base of the equipment is at an angle up to and including 10°; or*

– *The equipment is placed on a plane at an angle of 10° from the horizontal and rotated slowly through an angle of 360° about its normal vertical axis; or*

– *The equipment is placed on a horizontal non-skid surface and subjected to a force equal to:*

  - *50 % of the weight of the unit vertical downwards, but not more than 100 N. If, during the test, the supporting surface prevents the equipment from overturning, the test shall be repeated such that the supporting surface is not used to pass the test; and*

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- *13 % of the weight in all horizontal directions but not more than 250 N,*

that is applied to the worst case positions on the equipment by means of a suitable test apparatus having a flat surface of approximately 125 mm by 200 mm, in such a way as to produce the maximum overturning moment. The test may be applied at any height not exceeding 1,5 m from the base of the equipment. The test force shall be discontinued if the equipment remains stable after being tilted 10° from vertical.

8.6.2.3 Downward force test

Equipment shall not tip over when a constant downward force of 800 N is applied at the point of leverage for a maximum moment to any point of any surface within 10° of horizontal of at least 125 mm by at least 200 mm, at any height up to 1 m from the base of the equipment. The 800 N force is applied by means of a suitable test apparatus having a flat surface of approximately 125 mm by 200 mm. The downward force is applied with the complete flat surface of the test apparatus in contact with the equipment, however the test apparatus need not be in full contact with uneven surfaces (for example, corrugated or curved surfaces).

Equipment having a shape or a flexibility of the surface that is not likely to be used as a step or a ladder are exempt from the test.

EXAMPLE Products in combination with a cart or stand or products with protrusion or recess where the construction is obviously not to be used as a step or ladder.

8.6.2.4 Compliance criteria

During the tests, the equipment shall not tip over.

8.6.3 Relocation stability

8.6.3.1 Requirements

Equipment shall be stable when it is being relocated. Equipment shall:

– be equipped with wheels having a minimum diameter of 100 mm; or

– comply with the test of 8.6.3.2.

8.6.3.2 Test method and compliance criteria

The equipment is tilted to an angle of 10° from its normal upright position in any direction. If the equipment is such that when it is tilted through an angle of 10° when standing on a horizontal plane, a part of the equipment not normally in contact with the supporting surface would touch the horizontal plane, the equipment is placed on the edge of the horizontal support during the test so that the contact is not made. Alternatively, the equipment may be placed on a plane and is rotated through an angle of 360° about its normal vertical axis while tilted at 10°.

Equipment expected to be moved or relocated by ***ordinary persons*** *shall have:*

– *all doors and drawers not having a positive means of retention and that can be opened inadvertently; and*

– *casters, adjustable feet and the like*

arranged in any combination that results in the least stability.

Equipment expected to be moved or relocated by an ***instructed person*** *or a* ***skilled person****, shall have all doors, drawers, etc., positioned in accordance with the manufacturer's instructions.*

A unit provided with multi-positional features shall be tested in the least favourable position based on the equipment construction.

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The equipment shall not tip over during the test.

8.6.4 Glass slide test

The equipment is placed on a clean, dry, glass covered horizontal surface so that only the supporting feet are in contact with the glass. The glass-covered surface is then tilted in the most unfavourable direction through an angle of 10°.

During the test, the equipment shall not slide or tip over.

8.6.5 Horizontal force test and compliance criteria

The equipment is to be placed on a horizontal non-skid surface with all doors, drawers, casters, adjustable feet and other movable parts arranged in any combination that results in the least stable condition. The equipment shall be blocked, if necessary, by means of a stop of the smallest dimensions possible, to keep it from sliding or rolling when subjected to one of the following tests:

- *an external horizontal force of 20 % of the weight of the equipment or 250 N, whichever is less, is applied to that point on the equipment that will result in the least stability. The force shall not be applied more than 1,5 m above the supporting surface; or*
- *the equipment shall be moved through any angle of tilt up to and including 15° from the vertical; or*
- *the equipment is placed on a plane and is rotated through an angle of 360° about its normal vertical axis while tilted at an angle of 15°.*

During the test, the equipment shall not tip over.

8.7 Equipment mounted to a wall, ceiling or other structure

8.7.1 Requirements

Classification of equipment for the purposes of assessing mounting means for attachment to a wall, ceiling or other fixed structure (for example, a pole or tower) is done according to Table 35, line 6.

For MS2 or MS3 equipment:

- If the manufacturer defines specific mounting means, the combination of the mounting means and the equipment shall comply with 8.7.2, Test 1. The hardware used to fix the mounting means to the equipment shall either be provided with the equipment, or described in detail in the user instructions (for example, length of screws, diameter of the screws, etc.).
- If the manufacturer does not define specific mounting means, but the equipment is provided with any part (for example, a hook or threaded hole) which facilitates attaching such mounting means to the equipment, such parts shall comply with 8.7.2, Test 2, as appropriate. The user instruction shall advise on the safe use of such parts (for example, screw size including thread size and length, number of screws, etc.).
- If the equipment is provided with threaded parts for attachment of the mounting means, the threaded parts without the mounting means shall additionally comply with 8.7.2, Test 3.

NOTE The tests are meant to test the fixing of the mounting means to the equipment and not to test the fixing to the wall, ceiling or other structure.

8.7.2 Test methods

If the construction involves thermoplastic materials that have an influence on the strength of the mounting system, the tests shall be performed after the stress relief test of Clause T.8.

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Test 1

The equipment is mounted in accordance with the manufacturer's instructions and the mounting means positioned, when possible, to represent the most severe stress on the supports.

A force in addition to the weight of the equipment is applied downwards through the centre of gravity of the equipment, for 1 min. The additional force shall be:

- *three times the weight of the equipment; or*
- *the weight of the equipment plus 880 N,*

whichever is less.

Afterwards, for equipment mounted to a wall or another structure, a horizontal force of 50 N is applied laterally for 1 min.

Test 2

The test force shall be equivalent to the least of the following divided by the number of attachment points in the mounting system:

- *four times the weight of the equipment; or*
- *two times the weight of the equipment plus 880 N.*

Each individual representative point in the mounting system, one at a time, shall be subjected to the following six test forces:

- *a shear force perpendicular to its centre axis for 1 min. The force shall be applied in four directions, one direction at a time, separated by 90°.*
- *an inward directed push force parallel to its centre axis for 1 min.*
- *an outward directed pull force parallel to its centre axis for 1 min.*

Test 3

If the mounting system design relies upon threaded parts, each threaded part, one at a time, shall be subjected to the following test.

The screw is tightened with a torque according to Table 37 and then loosened, for a total of 5 times. The torque shall be applied gradually.

If a corresponding screw fastener is supplied by the manufacturer, it shall be used for the test. If no corresponding screw fastener is supplied by the manufacturer, even though a screw type may be recommended in the user instructions, any screw with the same diameter shall be used for the test.

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Table 37 – Torque to be applied to screws

Nominal diameter of screw mm		Torque Nm
	up to and including 2,8	0,4
over 2,8	up to and including 3,0	0,5
over 3,0	up to and including 3,2	0,6
over 3,2	up to and including 3,6	0,8
over 3,6	up to and including 4,1	1,2
over 4,1	up to and including 4,7	1,8
over 4,7	up to and including 5,3	2,0
over 5,3	up to and including 6,0	2,5

8.7.3 Compliance criteria

Compliance is checked by inspection and by the tests of 8.7.2, as applicable. The equipment or its associated mounting means shall not become dislodged and shall remain mechanically intact and secure during the test. Threaded parts shall remain mechanically intact.

8.8 Handle strength

8.8.1 General

A part of the equipment used for lifting or carrying the equipment, regardless of its shape or location or whether the part is intended for lifting or carrying by hand or via mechanical means, is considered to be a handle and shall have adequate strength.

The equipment is classified according to Table 35, line 5.

If equipment having handles is designed, or provided with instructions, for lifting or carrying multiple units together, the class is determined taking into account the weight that may be carried.

Compliance is checked by inspection or by available data, or, where necessary, by the test of 8.8.2. As a result of the test, the handle, its securing means, or that portion of the ***enclosure*** *to which it is secured, shall not break, crack, or detach from the equipment.*

8.8.2 Test method

A weight shall be uniformly applied over a 75 mm width at the centre of the handle, without clamping.

The weight shall be the equipment weight plus an additional weight as specified below:

– *for MS1 equipment with two or more handles, a weight that exerts a force of three times the weight of the equipment;*

NOTE No tests apply to MS1 equipment having only one handle.

– *for MS2 equipment, a weight that exerts a force of three times the weight of the equipment;*

– *for MS3 equipment with a mass 50 kg or less, a weight that exerts a force of two times the weight of the equipment or 75 kg, whichever is greater; and*

– *for MS3 equipment with a mass greater than 50 kg, a weight that exerts a force of the weight of the equipment or 100 kg, whichever is greater.*

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The additional weight shall be started at zero and gradually increased so that the test value is attained in 5 s to 10 s and maintained for 60 s. When more than one handle is provided, the force shall be distributed between the handles. The distribution of the forces shall be determined by measuring the percentage of the equipment's weight sustained by each handle with the equipment in the intended carrying position. When MS2 equipment is furnished with more than one handle, and it can be considered capable of being carried by only one handle, each handle shall be capable of sustaining the total force.

8.9 Wheels or casters attachment requirements

8.9.1 General

The equipment is classified according to Table 35, line 5. When equipment is intended to be used with carts, stands and similar carriers provided with wheels or casters, the classification is applied using the combined mass.

The likelihood of MS3 equipment, including carts, stands and similar carriers that support the equipment, from tipping over during movement shall be reduced.

8.9.2 Test method

*Wheels or casters on MS3 equipment, or their supporting cart, stand or similar carrier, intended to be moved as part of its **normal operating conditions**, shall be capable of withstanding a pull of 20 N. The pull force is to be applied by a weight, or a steady pull, to the wheel or caster for a period of 1 min in any direction made possible by the construction.*

During the test, the wheels or casters shall not be damaged or pull free from its securing means.

8.10 Carts, stands, and similar carriers

8.10.1 General

The equipment shall be stable with the cart, stand or similar carrier. The classifications of Table 35, line 5 are applied using the combined mass of both the equipment and the carts or stands specified with the equipment.

All carts and stands specified for use with the equipment shall be subjected to the applicable tests described in the following subclauses. A cart, stand or carrier shall be subjected to the applicable tests alone and again with the equipment specified by the manufacturer placed on the cart or stand.

MS3 equipment, including their supporting carts, stands and similar carriers that support the equipment, that are not moved as part of its **normal operating conditions**, shall comply with the horizontal force test of 8.6.5.

MS2 or MS3 equipment more than 1 m in height, including equipment mounted on their specified cart, stand or carrier, shall comply with the relocation stability test in 8.6.3 except that the tip angle becomes 15°. If equipment is provided with wheels or casters that allow the equipment to only move in limited directions, the test is only applied in those directions (for example, an electronic white board).

8.10.2 Marking and instructions

A cart, stand or similar carrier that is specified by the manufacturer for use with specific equipment, but is packaged and marketed separately from the equipment, shall be provided with an **instructional safeguard** in accordance with Clause F.5.

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The elements of the **instructional safeguard** shall be as follows:

– element 1a: not available
– element 2: “Caution” or equivalent text
– element 4: “This (cart, stand, or carrier) is intended for use only with (manufacturer's name), (model number or series), (equipment name).” or equivalent text
– element 3: “Use with other equipment may result in instability causing injury” or equivalent text

The elements shall be in the order 2, 4, and 3.

The **instructional safeguard** shall be affixed to the cart, stand or carrier, or included in the installation instructions or equivalent document accompanying the equipment.

Equipment only intended and shipped for use with a specific cart, stand or similar carrier, shall be provided with an **instructional safeguard** in accordance with Clause F.5 and be comprised of:

– element 1a: not available
– element 2: “Caution” or equivalent word or text
– element 4: “This (equipment name) is for use only with (manufacturer's name), (model number or series), (cart, stand, or carrier)” or equivalent text
– element 3: “Use with other (carts, stands, or carriers) may result in instability causing injury” or equivalent text

The elements shall be in the order 2, 4, and 3.

The **instructional safeguard** shall be affixed to the equipment or included in the installation instructions or equivalent document accompanying the equipment.

8.10.3 Cart, stand or carrier loading test and compliance criteria

*A cart, stand or carrier shall be constructed so that permanent deformation or damage that is capable of resulting in injury to a person, does not occur when it is subjected to a force of 220 N applied for 1 min to any grippable or leverage point **accessible** to a child.*

To determine compliance, the force is applied through the end of a 30 mm diameter circular cylinder. The force is to be applied to a shelf drawer, dowel rung support, or equivalent part that is within 750 mm from the floor and will support some or all of a child's weight. The force is to be applied for 1 min with the cart or stand at room temperature. The part shall not collapse or break so as to expose sharp edges or produce pinch points that are capable of resulting in injury.

In addition, a cart, stand or other carrier shall be constructed so that permanent deformation or damage that is capable of resulting in injury to persons does not occur when each supporting surface is individually loaded with:

– *the manufacturer’s intended load plus 440 N for the surface intended to support a display with moving images; or*
– *four times the manufacturer's intended load or 100 N, whichever is greater but not to exceed 440 N, is applied to all applicable surfaces.*

A dedicated storage area intended to accommodate specific accessories such as media tapes, discs, etc. shall be fully loaded to the rated load.

The weight is to be applied for 1 min on each supporting surface, with the other supporting surfaces unloaded.

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8.10.4 Cart, stand or carrier impact test

When tested as described below, a cart, stand or carrier shall not produce a risk of injury to persons.

A single impact is to be applied to any part of the cart or stand and the test method is to be as described in Clause T.6. However, a cart, stand or carrier made of glass shall instead be tested according to 4.4.3.6.

8.10.5 Mechanical stability

A cart, stand or carrier, including floor standing types, shall be subjected to the applicable tests described in 8.6.3 and 8.6.5 by itself, and where applicable in combination with its intended MS2 or MS3 equipment.

For the purposes of these tests, the weight shall be considered as the total weight of the equipment plus the weight of the cart, stand or carrier. The equipment shall be installed according to the manufacturer's instructions and the horizontal force shall be applied to either the cart, stand or carrier or intended equipment to produce a maximum overturning moment on the equipment at a point up to a maximum height of 1,5 m above the floor level.

If during the tests of 8.6.3 and 8.6.5 the equipment starts to slide or tip relative to the cart, stand or carrier, only the horizontal force test shall be repeated by reducing the force to 13 % of the weight of the equipment alone, or 100 N, whichever is less.

The equipment and cart or stand shall not tip over.

8.10.6 Thermoplastic temperature stability

An equipment, cart, stand or carrier using thermoplastic materials in its construction shall withstand the test of Clause T.8 without any shrinkage, warpage, or other distortion of the thermoplastic materials that results in the equipment failing to comply with 8.10.3, 8.10.4 and 8.10.5.

8.11 Mounting means for slide-rail mounted equipment (SRME)

8.11.1 General

This subclause specifies requirements for horizontally mounted slide-rails to reduce the likelihood of injury by retaining the SRME in a stable position and not allowing the slide-rails to buckle, the means of attachment to break, or the SRME to slide past the end of the slide-rails.

The requirements below apply to the mounting means of MS2 and MS3 SRME that is:

– installed in a rack and that is intended to be extended on slide-rails away from the rack for installation, use or service; and

– SRME that extends the full width of the rack; and

– having a top installation position more than 1 m in height from the supporting surface.

The requirements do not apply to:

– equipment subassemblies; or

– other equipment fixed in place in the rack; or

– equipment that is not intended to be serviced while extended on slide-rails.

The mechanical mounting means for the SRME are referred to as slide-rails. The SRME may be the actual product configured in its worst case mechanical loading, or a representative **enclosure** with weights to simulate worst case loading.

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NOTE 1 Slide-rails include bearing slides, friction slides or other equivalent mounting means.

NOTE 2 Subassemblies of the end product (for example, removable modules, component drawers, pull out paper/heater trays in copiers/printers) are not considered to be SRME.

8.11.2 Requirements

Classification of products for the purposes of assessing equipment stability is to be done according to Table 35, line 5.

NOTE For assessing equipment stability, see 8.6.

Slide-rails shall retain the SRME and have end stops that prevent the SRME from unintentionally sliding off the mounting means.

The slide-rails shall be installed in a representative rack with the SRME, or in an equivalent setup in accordance with the manufacturer's instructions.

Slide rails with a single extended position shall comply with the downward force test of 8.11.3.1 in the extended position.

Slide rails having a service position and an installation position shall comply with the downward force test of 8.11.3.1 in the service position.

All slide rails shall comply with the tests of 8.11.3.2 and 8.11.3.3 in both the service position and the installation position.

Following each test, the slide-rails and the SRME may be replaced before conducting the next test.

A multi position slide rail shall not extend automatically to any of the extended positions. The SRME shall only be able to go to the service position when pulled out. A latch or other means shall be provided to stop the SRME in the service position. Any service position and installation position shall be explained. An **instructional safeguard** shall be provided for the installer. The elements of the **instructional safeguard** shall be as follows:

– element 1a: not available
– element 2: Stability hazard
– element 3: "The rack may tip over causing serious personal injury"
– element 4: the text below or equivalent text

Before extending the rack to the installation position, read the installation instructions. Do not put any load on the slide-rail mounted equipment in the installation position. Do not leave the slide-rail mounted equipment in the installation position.

8.11.3 Mechanical strength test

8.11.3.1 Downward force test

With the SRME in its extended position, a force in addition to the weight of the SRME is to be applied downwards through the centre of gravity for 1 min.

The additional force applied to the SRME shall be equal to the greater of the following two values, with a maximum of 800 N:

– *50 % of the SRME weight plus a force of 330 N; or*

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– *50 % of the SRME weight, plus an additional weight, where the additional weight is equal to the SRME weight or a force of 530 N, whichever is less.*

NOTE This additional force is intended to take into account other items or devices that are stacked on top of the installed SRME while in the extended position during installation of other SRME.

For slide-rail mounted shelves, the shelf shall be tested with a weight of 125 % of the maximum weight that is intended to be placed on the shelf.

A marking shall be provided on the shelf to indicate the maximum weight that can be added to the shelf.

8.11.3.2 Lateral push force test

A 250 N static push force is applied laterally, in both directions at or near the end of the SRME with the slide rails in their fully extended (service) position for a period of 1 min. The applied weight need not be in full contact with uneven surfaces (for example, corrugated or curved surfaces) but shall be concentrated within 30 mm of the end of the SRME.

8.11.3.3 Integrity of slide rail end stops

To test the integrity of the end stops, a 250 N static pull force is applied at the front of the fully extended rail on the SRME for a period of 1 min, in an attempt to cause the SRME to come off the slide-rail. The SRME is then returned to the (installed) use position and then placed back in the fully extended position. The test is performed 10 times.

8.11.4 Compliance criteria

Compliance is checked by inspection and available manufacturer's data. If data is not available, then the tests according to 8.11.3 are conducted.

Following each test, the SRME and its associated slide-rails shall remain secure for one complete cycle of travel on its slide-rails. If the mounting means is not able to perform one complete cycle without binding, a force of 100 N shall be applied horizontally to the front of the SRME at its centre point with the intent to completely retract the SRME into the rack.

The mounting means shall not bend or buckle to any extent that could introduce an injury. End stops shall retain the SRME in a safe position and shall not allow the SRME to slide past the end of the slide-rails.

8.12 Telescoping or rod antennas

A telescoping or rod antenna shall be provided with a minimum 6,0 mm diameter button or ball on the end. An antenna end piece and the sections of a telescoping antenna shall be secured in such a manner as to prevent removal.

Compliance is checked by inspection and the test of Clause T.11.

9 Thermal burn injury

9.1 General

To reduce the likelihood of painful effects and injury due to thermal burns, **accessible** parts shall be classified and when necessary provided with the **safeguards** specified in Clause 9.

NOTE Electric burns due to radio frequency (RF) energy sources are a special case in this document. They are controlled by limiting accessibility above a specified frequency. These limits and conditions are defined in the notes [d] and [e] defined in Table 4.

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9.2 Thermal energy source classifications

9.2.1 TS1

TS1 is a class1 thermal energy source with temperature levels:

– not exceeding TS1 limits under **normal operating conditions**; and
– not exceeding TS2 limits under:
  - **abnormal operating conditions**; or
  - **single fault conditions**.

9.2.2 TS2

TS2 is a class 2 thermal energy source where:

– the temperature exceeds the TS1 limits; and
– under **normal operating conditions**, **abnormal operating conditions** or **single fault conditions** the temperature does not exceed the TS2 limits.

Where the malfunction of the equipment is evident, no limits apply.

9.2.3 TS3

TS3 is a class 3 thermal energy source where the temperature exceeds the TS2 limits in Table 38 under **normal operating conditions** or under **abnormal operating conditions**, or under **single fault conditions**.

9.3 Touch temperature limits

9.3.1 Requirements

Except as noted below, touch temperatures of **accessible** parts shall comply with Table 38.

An **accessible** part that, while in contact with the body, is likely to drop in temperature upon touch can be evaluated under the limits of Annex A in IEC Guide 117:2010. An appropriate and reproducible test methodology is determined by the manufacturer with due regard to the test method in IEC Guide 117.

9.3.2 Test method and compliance criteria

The temperature tests are run with the room ambient conditions as defined in B.1.5 and B.2.3, except that the room ambient temperature shall be 25 °C ± 5 °C.

If the test is performed at a temperature between 20 °C and 25 °C, the results are adjusted to reflect a value of 25 °C.

NOTE 1 For an explanation of why the test is done at 25 °C without adjusting results for higher ambient temperatures, see IEC TR 62368-2.

*The equipment shall be operated in a manner the manufacturer determines likely to result in elevated thermal conditions of **accessible** surfaces and parts.*

NOTE 2 This may not be the condition of maximum input current or wattage but the condition that delivers the highest thermal level to the part in question.

*Compliance is checked by measuring the steady state temperature of **accessible** surfaces.*

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Table 38 – Touch temperature limits for accessible parts

	Accessible parts [b]	Maximum temperature (T_{max}) °C			
		Metal [d]	Glass, porcelain and vitreous material	Plastic and rubber	Wood
TS1	Devices worn on the body (in direct contact with the skin) in normal use (> 8 h) [e]	43 to 48	43 to 48	43 to 48	43 to 48
	Handles, knobs, grips, etc., and surfaces either held or touched in normal use (> 1 min and < 8 h) [a]	48	48	48	48
	Handles, knobs, grips, etc., and surfaces held for short periods of time or touched occasionally (> 10 s and < 1 min)	51	56	60	60
	Handle, knobs, grips etc., and surfaces touched occasionally for very short periods (> 1 s and < 10 s) [f]	60	71	77	107
	Surfaces that need not be touched to operate the equipment (< 1 s)	70	85	94	140
TS2	Handles, knobs, grips, etc., and surfaces held in normal use (> 1 min) [a]	58	58	58	58
	Handles, knobs, grips, etc., and surfaces held for short periods of time or touched occasionally (> 10 s and < 1 min)	61	66	70	70
	Handle, knobs, grips etc., and surfaces touched occasionally for very short periods (> 1 s and < 10 s) [f]	70	81	87	117
	Surfaces that need not be touched to operate the equipment (< 1 s)	80 (100) [c]	95 (100) [c]	104	150
TS3	Higher than the TS2 limits				

[a] Examples of these surfaces include a telephone handset, a mobile phone or another handheld device, and the palm rest surface of a notebook computer. Limits for > 1 s and < 10 s may be used for local hotspots where touching can be easily avoided by changing the way the device is held.

[b] Where necessary, time of contact shall be determined by the manufacturer and shall be consistent with the intended use in accordance with the equipment instructions.

[c] The values in parentheses may be used for the following areas and surfaces:

– an area on the surface of the equipment that has no dimension exceeding 50 mm, and that is not likely to be touched in normal use; or

– heatsinks and metallic parts directly covering heatsinks, except those on surfaces incorporating switches or controls handled during normal use.

For these areas and parts, an **instructional safeguard** in accordance with Clause F.5 shall be provided on or near the hot part.

Under **abnormal operating conditions** and **single fault conditions**, for other areas and surfaces of the equipment, an **equipment basic safeguard** is required.

[d] For metal parts that are covered with plastic or rubber material of at least 0,3 mm thick, the covering is considered suitable for use as a **safeguard** and the temperature limit of plastic and rubber is allowed.

[e] Examples include portable lightweight devices such as watches, headsets, personal music players and sports monitoring equipment. For larger devices or devices in direct contact with vital areas of the face (e.g. the airways), lower limits may apply. For contact durations less than 8 hours based on its intended normal use, apply limits between 48 °C/1 min and 43 °C/8 h. Calculations shall be rounded down to the nearest whole number. An example is a headset with a limited **battery** charge of 2 h.

[f] Examples include surfaces that need to be touched for disconnection.

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9.4 Safeguards against thermal energy sources

Except as given below, **safeguard** requirements for parts **accessible** to **ordinary persons**, **instructed persons** and **skilled persons** are given in 4.3.

For protection of an **ordinary person** against TS2, an **instructional safeguard** in accordance with 9.5.2 may be used as the **basic safeguard**.

Accessible parts (internal and external) classified as TS2 or TS3 that require heat for the intended function (for example, a document laminator, thermal print head, fuser heater, etc.) shall comply with all of the following:

– the part does not need to be touched to operate the equipment (for example, a part also serving a handle, knob, or grip function);
– it is unlikely that an **ordinary person** will touch the part intentionally under **normal operating conditions**;
– unintentional contact with the part is unlikely by an **ordinary person** during maintenance not involving the part;
– the part is provided with an **instructional safeguard** on or near the part in accordance with 9.5.2; and
– it is unlikely that the part will be touched by children.

For protection of a **skilled person**, parts and surfaces classed TS3 shall be provided with an **equipment safeguard** or provided with an **instructional safeguard** so that unintentional contact with such parts and surfaces during service operations is unlikely to cause the **skilled person** to recoil into other class 3 energy sources (see Figure 19).

9.5 Requirements for safeguards

9.5.1 Equipment safeguard

An **equipment safeguard** shall limit the transfer of thermal energy (source temperature) under **normal operating conditions**, **abnormal operating conditions** and **single fault conditions** or limit accessibility to a thermal energy source to a touch temperature as classified in Table 38.

Temperature limits are applied only for those **abnormal operating conditions** or **single fault conditions** where the equipment continues to operate as intended and, hence, the **abnormal operating condition** or **single fault condition** is not obvious. If a malfunction is evident, then the limits are not applicable.

9.5.2 Instructional safeguard

An **instructional safeguard** shall be provided in accordance with Clause F.5, except that element 3 is optional.

The elements of the **instructional safeguard** shall be as follows:

– element 1a:  , IEC 60417-5041 (2002-10)
– element 2: “CAUTION” and “Hot surface” or equivalent word or text
– element 3: optional
– element 4: “Do not touch” or equivalent text

9.6 Requirements for wireless power transmitters

9.6.1 General

Wireless power transmitters for near field wireless power transfer can warm up foreign metallic objects that may be placed close to or on such a transmitter. To avoid a burn due to high temperatures of the foreign metallic objects, the transmitter is tested as specified in 9.6.3.

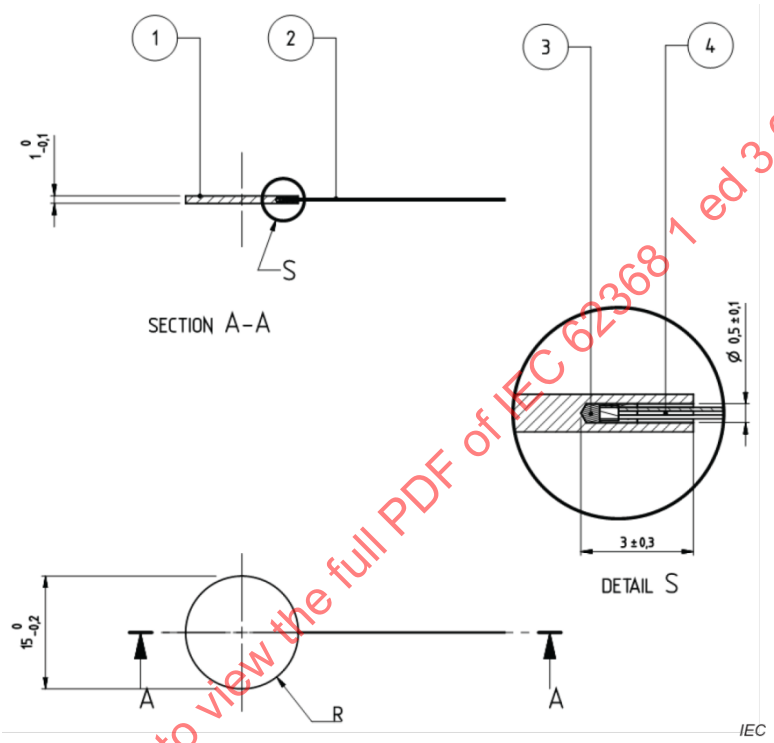
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9.6.2 Specification of the foreign objects

The following foreign objects are used:

– a steel disc, see Figure 47;
– an aluminium ring, see Figure 48; and
– an aluminium foil, see Figure 49.

Dimensions in millimetres

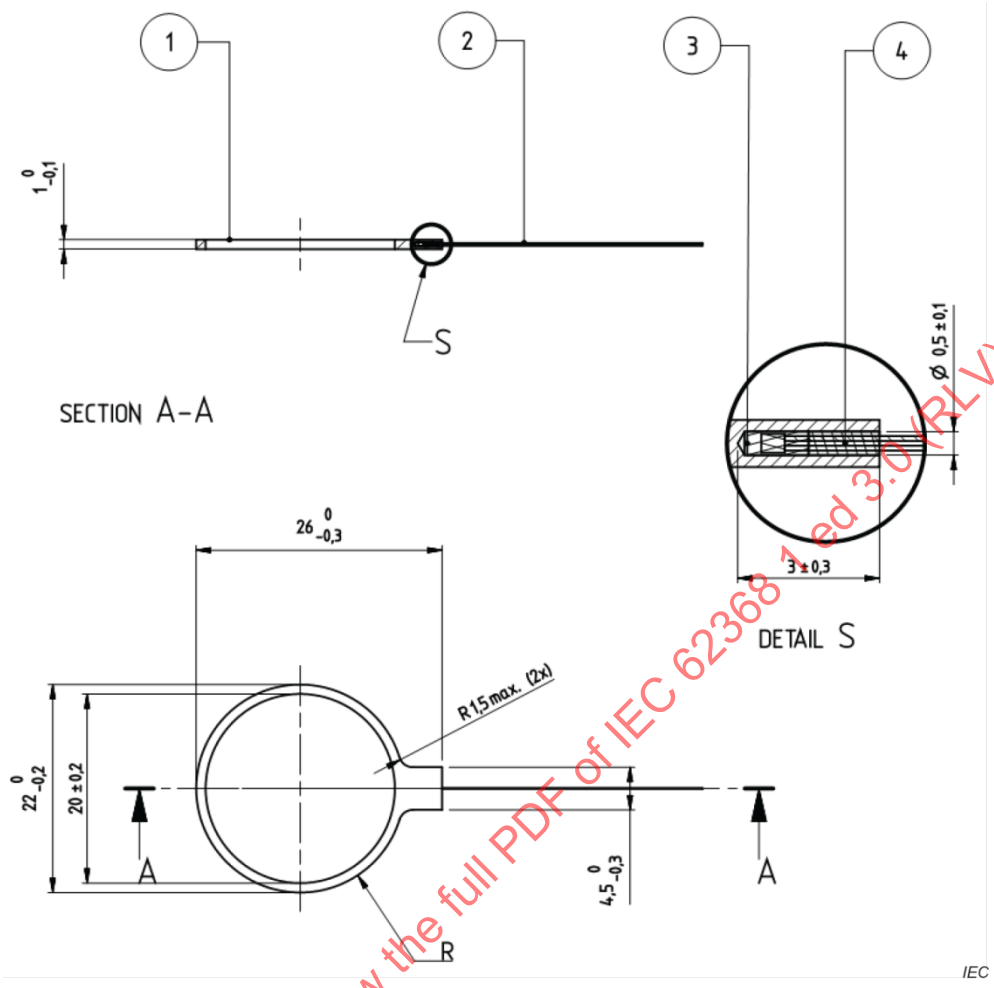


No	Name	Remarks
1	Disc	Steel 1,1011/ RFe 160
2	Thermocouple	Any suitable type
3	Heatsink compound	Heat transport
4	Silicon tubing	Strain relief

Figure 47 – Steel disc

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Dimensions in millimetres

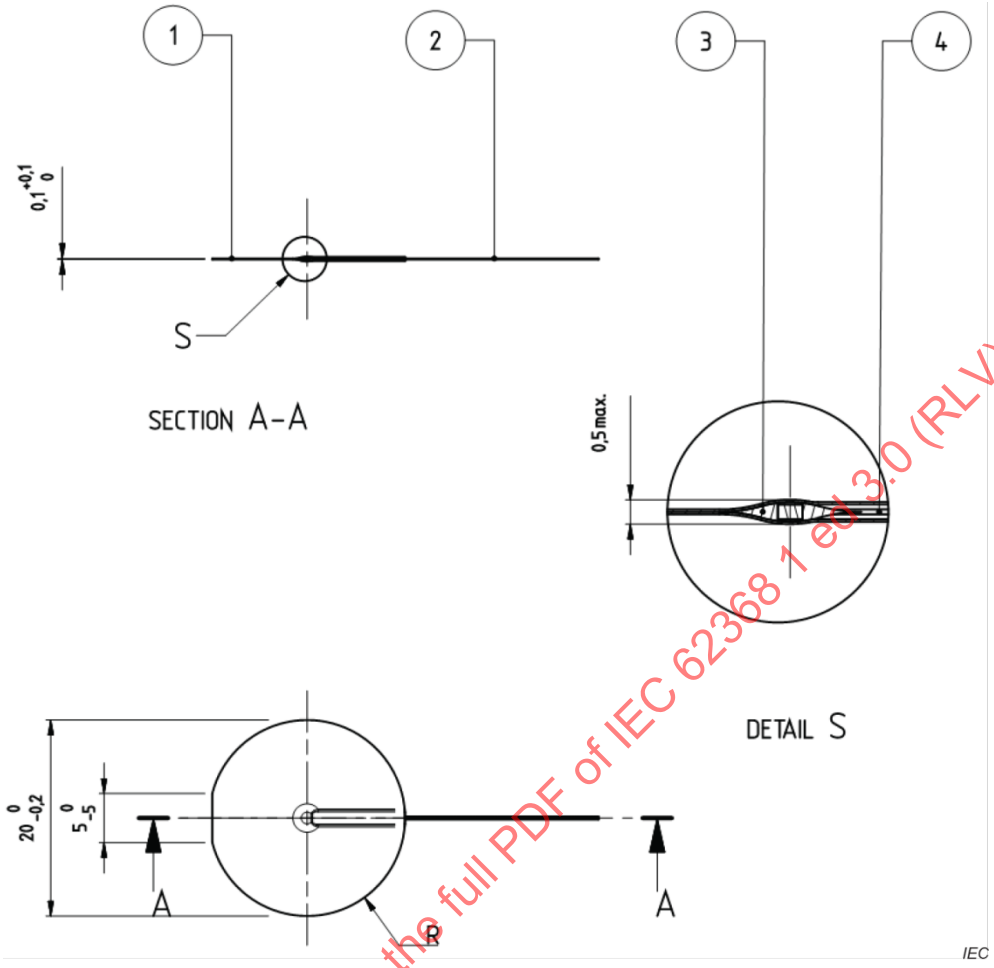


No	Name	Remarks
1	Ring	Aluminium (for example AlSilMg1Mn 100 Hv)
2	Thermocouple	Any suitable type
3	Heatsink compound	Heat transport
4	Silicon tubing	Strain relief

Figure 48 – Aluminium ring

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Dimensions in millimetres



No	Name	Remarks
1	Foil	Al 99,5 %
2	Thermocouple	Any suitable type
3	Heatsink compound	Heat transport
4	Silicon tubing	Strain relief (or use of glue layer on the foil)

Figure 49 – Aluminium foil

9.6.3 Test method and compliance criteria

*The **wireless power transmitter** is placed in a room under the temperature conditions as specified in 9.3.2.*

The test is performed once with each of the foreign objects specified in 9.6.2 placed in direct contact with the transmitter. Each test has four cycles:

- *one without a receiver present and with the foreign object in direct contact with the transmitter; and*
- *one with a receiver placed in direct contact with the foreign object; and*
- *one with a receiver placed at a distance of 2 mm from the foreign object; and*
- *one with a receiver placed at a distance of 5 mm from the foreign object.*

The transmitter is operated to transmit its maximum power.

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NOTE The test is not meant to test the temperature of the receiver, therefore any compatible receiver that can draw the maximum power from the **wireless power transmitter** can be used and the temperature of the receiver does not have to be monitored.

During each cycle, the foreign object can be moved on the transmitter in order to find the location where the highest temperature occurs.

During the tests, the temperature of the foreign object shall not exceed 70 °C.

10 Radiation

10.1 General

To reduce the likelihood of painful effects and injury due to optical energy(visible, IR, UV), X-ray, and acoustic energy, equipment shall be provided with the **safeguards** specified in this clause.

10.2 Radiation energy source classifications

10.2.1 General classification

Radiation energy source classifications are given in Table 39.

Table 39 – Radiation energy source classifications

Source		RS1	RS2	RS3
Lasers	optical fibre communication systems (OFCS)	According to IEC 60825-2		
	free space optical communication systems for transmission of information	According to IEC 60825-12		
	Other lasers, except those used in image projectors	According to IEC 60825-1 [a]		
Lamps and lamp systems (including LEDs), except those used in image projectors		According to IEC 62471:2006 [b]		
Image projectors (beamers)	Image projectors with lasers	According to IEC 60825-1 [a] or IEC 62471-5:2015 if applicable		
	Image projectors with lamps or LEDs	According to IEC 62471-5:2015		
X-Ray		≤ 36 pA/kg at 50 mm [c]	≤ 185 pA/kg at 100 mm [d]	> RS2
PMP Acoustic Maximum sound pressure [e]	sound output	≤ 85 dB(A)	≤ 100 dB(A)	> RS2
	analogue output	≤ 27 mV	≤ 150 mV	> RS2
	digital output	≤ –25 dBFS	≤ –10 dBFS	> RS2
PMP Acoustic Maximum dose exposure [e]	sound output	100 % CSD = ≤ 80 dB(A) / 40 h	≤ 100 dB(A)	> RS2
	analogue output	≤ 15 mV	≤ 150 mV	> RS2
	digital output	≤ –30 dBFS	≤ –10 dBFS	> RS2

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[a] Additional considerations for laser products designed to function as conventional lamps (such as laser image projector), see Note 2 of 10.3.

NOTE 1 For example, in IEC 60825-1:2014, Class 1, Class 1C, Class 1M, Class 2, Class 2M, Class 3R, Class 3B and Class 4 are defined. These are not classifications of radiation energy source itself.

[b] To classify the risk group, **abnormal operating conditions** and **single fault conditions** shall be taken into account.

In general, the radiation of the following low power application of a lamp is classified as Exempt Group. Also, classification according to IEC 62471 (all parts) is not required for:

– indicating lights;

– infra-red devices such as used in home entertainment devices;

– infra-red devices for data transmission such as used between computers and computer peripherals;

– optocouplers;

– UV radiation from general purpose incandescent and fluorescent lamps, with ordinary glass envelopes; and

– other similar low power devices.

NOTE 2 If optical radiation is broadband visible and IR-A radiation and the luminance of the source does not exceed 10^4 cd/m^2, it is expected that the radiation does not exceed the exposure limits given in 4.3 of IEC 62471:2006 (see 4.1 of IEC 62471:2006).

For UV-C limits (wavelengths between 180 nm and 200 nm), the value of IEC 62471 for 200 nm is used.

[c] 36 pA/kg equals 5 μSv/h or 0,5 mR/h. This value is consistent with International Commission on Radiation Protection (ICRP) Publication 60.

[d] 185 pA/kg equals 25 μSv/h or 2,5 mR/h.

Measurement is made with any part of the cabinet, case, and chassis removed per maintenance instructions (CRT exposed) at the maximum test voltage applicable and under the conditions as specified below.

NOTE 3 In the member countries of CENELEC, the amount of ionizing radiation is regulated by European Council Directive 96/29/Euratom of 13 May 1996. This Directive requires that at any point 100 mm from the surface of the equipment, the dose-rate shall not exceed 1 μSv/h (0,1 mR/h) taking account of the background level. For complete requirements refer to the above Directive.

NOTE 4 In the USA, the measuring conditions in the U.S. Code of Federal Regulations Title 21 Part 1020 are as given below (for complete requirements, refer to the above regulations).

Measurements are made with the EUT connected to the following source of supply:

– 130 V if the **rated voltage** is between 110 V and 120 V; or

– 110 % of the **rated voltage**, if the **rated voltage** is not between 110 V and 120 V.

During the measurements:

– all user and service **accessible** controls are adjusted to combinations that produce maximum X-radiation emissions; and

– **abnormal operating conditions** of any component or circuit malfunction causing an increase of X-radiation emissions are to be simulated.

NOTE 5 In Canada, the measuring conditions in the Consolidated Regulations of Canada, c.1370 are as given below (for complete requirements refer to the above regulations).

Measurements are made with the EUT connected to the following source of supply:

– 127 V if the **rated voltage** is between 110 V and 120 V; or

– 110 % of the **rated voltage**, if the **rated voltage** is not between 110 V and 120 V.

During the measurements all user and service **accessible** controls are adjusted to combinations that produce maximum X-radiation emissions.

[e] Fault testing measurements are not required for listening devices and personal music players.

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10.2.2 RS1

For X-radiation sources, RS1 is a class 1 radiation energy source that does not exceed RS1 limits under:

– **normal operating conditions**; and

– **abnormal operating conditions** that do not lead to a **single fault condition**; and

– **single fault conditions**.

For acoustic radiation sources, RS1 is a class 1 radiation energy source that does not exceed RS1 limits under:

– **normal operating conditions**; and
– **abnormal operating conditions**.

10.2.3 RS2

RS2 is a class 2 radiation energy source that does not exceed RS2 limits under:

– **normal operating conditions**; and
– **abnormal operating conditions**; and
– **single fault conditions**, except for acoustic radiation sources, and

is not RS1.

10.2.4 RS3

RS3 is a class 3 radiation energy source that exceeds RS2 limits under:

– **normal operating conditions**; or
– **abnormal operating conditions**; or
– **single fault conditions**.

10.3 Safeguards against laser radiation

Equipment containing laser(s) shall comply with the requirements as indicated in Table 39.

When applying the IEC 60825 series, the requirements of this document shall be considered, in particular those for:

– the robustness of a **safeguard** (see 4.4.3);
– operating conditions (see Annex B); and
– **safety interlocks** (see Annex K).

Laser equipment intended for use by an **ordinary person** or an **instructed person** shall not be Class 3B or Class 4.

NOTE 1 National and regional legislation regarding occupational safety and health (OSH) and regarding the general public, for example for consumer products, may contain additional or different requirements.

NOTE 2 For laser products designed to function as conventional lamps (such as laser image projector), see 4.4 of IEC 60825-1:2014. For additional consideration for such equipment, see 10.4.

Compliance is checked by evaluation of available data sheets, by inspection and, if necessary, by measurement.

NOTE 3 For guidance on measuring techniques, see the IEC 60825 series.

10.4 Safeguards against optical radiation from lamps and lamp systems (including LED types)

10.4.1 General requirements

Equipment emitting optical radiation shall comply with the requirements as indicated in Table 39.

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Electronic light effect equipment does not have to comply with the requirements of 10.4. However, IEC TR 62471-2 should be considered and proper installation instructions shall be provided.

For lamps used in other equipment, the following applies:

NOTE 1 National legislation regarding occupational safety and health (OSH) may contain additional or different requirements.

Radiation not needed to be **accessible** for the correct functioning of the equipment shall not exceed the level specified in Table 40. When the **accessible** radiation level for the correct functioning of the equipment needs to exceed the levels in Table 40, the equipment shall be provided with an **instructional safeguard** in accordance with 10.4.3.

Table 40 – Allowable radiation level according to IEC 62471 (all parts) for each hazard type

Hazard type	Allowed radiation level
Ultraviolet hazard 200 nm to 400 nm	Exempt Group
Retinal blue light hazard 300 nm to 700 nm	Exempt Group or Risk Group 1
Retinal thermal hazard 380 nm to 1400 nm	Exempt Group or Risk Group 1
Cornea/lens infrared hazard 780 nm to 3 000 nm	Exempt Group
Retinal thermal hazard, weak visual stimulus 780 nm to 1 400 nm	Exempt Group

Lamps and lamp systems intended for use by an **ordinary person** or an **instructed person** shall not emit Risk Group 3 energy.

The risk group, based on the classification according to IEC 62471 series, shall be marked on the equipment. If the size or design of the product makes marking impractical, the marking shall be included in the packaging and included in the user instructions. If the **accessible** radiation level does not exceed the level specified in Table 40, marking is not required.

If a **safety interlock** is used for reducing the radiation level, it shall reduce the radiation to the allowable radiation levels specified in Table 40.

When equipment emits optical radiation in more than one hazard type, see also 10.4.3.

The following information should be provided in the user manual for safe operation and installation. This information shall also be provided for safe operation by a **skilled person** who may be exposed to Risk Group 3 energy levels.

– Adequate instructions for proper assembly, installation, maintenance and safe use, including clear warnings concerning precautions to avoid possible exposure to hazardous optical radiation; and

– Advice on safe operating procedures and warnings concerning **reasonably foreseeable misuse**, malfunctions and hazardous failure modes. Where servicing and maintenance procedures are detailed, they should, wherever possible, include explicit instructions on safe procedures to be followed; and

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– The marking on the equipment should be reproduced in the user manual. A yellow background is not required in the user manual.

NOTE 2 See IEC TR 62471-2 for more information including the terms and definitions used in this subclause.

10.4.2 Requirements for enclosures

The **enclosure** protecting against optical radiation not needed to be **accessible** for the correct functioning of the equipment and that exceeds the level specified in Table 40 shall comply with 4.4.3 and is considered to be a **reinforced safeguard**.

Materials that comprise a **safeguard** and are exposed to UV radiation from a lamp in the equipment shall be sufficiently resistant to degradation to the extent that the **safeguard** function remains effective for the equipment lifetime. Metal, glass and ceramic materials are considered to be resistant to degradation.

10.4.3 Instructional safeguard

For image projectors, the **instructional safeguard** shall comply with the requirements of 6.5.4 and 6.5.5 of IEC 62471-5:2015 for Risk Group 2 and Risk Group 3, respectively.

For image projectors with lamps, the cautionary statement defined in IEC 62471-5:2015 shall be used as an **instructional safeguard**.

For all other equipment with lamps, an **instructional safeguard** in accordance with Clause F.5 shall be used. The elements of the **instructional safeguard** shall be as follows:

– element 1a: the UV radiation symbol  , IEC 60417-6040:2010-08 for ultraviolet hazard; or

the visible radiation symbol  , IEC 60417-6041:2010-08 for retinal blue light hazard and Retinal thermal hazard; or

the IR radiation symbol  , IEC 60417-6151:2012-02 for cornea/lens infrared hazard and retinal thermal hazard, weak visual stimulus

– element 2: According to Table 41 or equivalent text

– element 3 and 4: According to Table 42 or equivalent text

The elements 1a and 2 shall be black on a yellow background.

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Table 41 – Hazard-related risk group marking of equipment

Hazard	Exempt Group	Risk Group 1	Risk Group 2	Risk Group 3
Ultraviolet hazard 200 nm to 400 nm	Not required	NOTICE UV emitted from this product	CAUTION UV emitted from this product.	WARNING UV emitted from this product.
Retinal blue light hazard 300 nm to 700 nm	Not required	Not required	CAUTION Possibly hazardous optical radiation emitted from this product	WARNING Possibly hazardous optical radiation emitted from this product
Retinal thermal hazard 380 nm to 1400 nm	Not required	Not required	CAUTION Possibly hazardous optical radiation emitted from this product	WARNING Possibly hazardous optical radiation emitted from this product
Cornea/lens infrared hazard 780 nm to 3 000 nm	Not required	NOTICE IR emitted from this product	CAUTION IR emitted from this product	WARNING IR emitted from this product.
Retinal thermal hazard, weak visual stimulus 780 nm to 1 400 nm	Not required	CAUTION IR emitted from this product	CAUTION IR emitted from this product.	WARNING IR emitted from this product.

Table 42 – Explanation of marking information and guidance on control measures

Hazard	Exempt Group	Risk Group 1	Risk Group 2	Risk Group 3
Ultraviolet hazard 200 nm to 400 nm	Not required	Minimize exposure to eyes or skin. Use appropriate shielding.	Eye or skin irritation may result from exposure. Use appropriate shielding.	Avoid eye and skin exposure to unshielded product.
Retinal blue light hazard 300 nm to 700 nm	Not required	Not required	Do not stare at operating lamp. May be harmful to the eyes.	Do not look at operating lamp. Eye injury may result.
Retinal thermal hazard 380 nm to 1400 nm	Not required	Not required	Do not stare at operating lamp. May be harmful to the eyes.	Do not look at operating lamp. Eye injury may result.
Cornea/lens infrared hazard 780 nm to 3 000 nm	Not required	Use appropriate shielding or eye protection.	Avoid eye exposure.Use appropriate shielding or eye protection.	Avoid eye exposure. Use appropriate shielding or eye protection.
Retinal thermal hazard, weak visual stimulus 780 nm to 1 400 nm	Not required	Do not stare at operating lamp.	Do not stare at operating lamp.	Do not look at operating lamp.

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When equipment emits optical radiation in more than one hazard spectral region, the equipment shall be classified for the most restrictive case. If the optical radiation in any spectral region requires a marking per Table 41 or Table 42, all relevant warnings shall be included. For example, for a lamp assigned to Risk Group 3 on the basis of a retinal IR hazard and emitting UV to the level of Risk Group 2, the legend of the marking shall indicate Risk Group 3, with the appropriate ‘Warning’ text; and show the ‘Caution’ text for Risk Group 2 for the UV, but shall not mention Risk Group 2 explicitly, as illustrated in Figure 50.

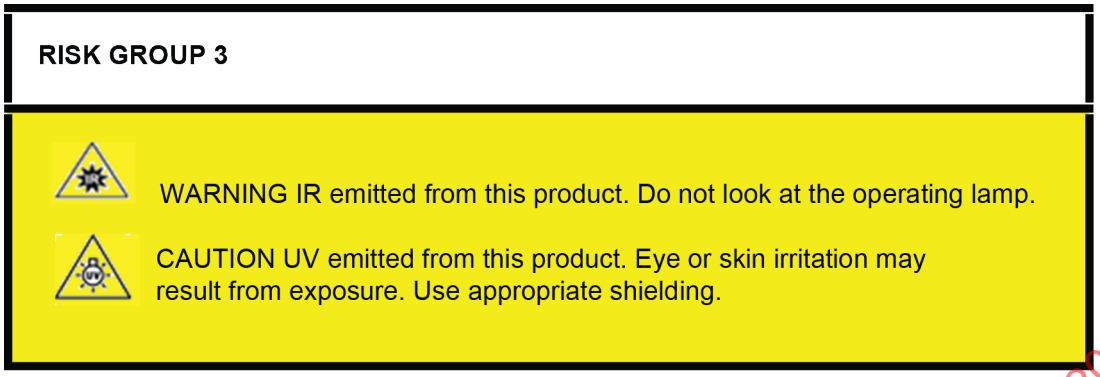


Figure 50 – Example of a warning label for a lamp with multiple hazard spectral regions

10.4.4 Compliance criteria

Compliance is checked by evaluation of available data sheets, by inspection and, if necessary, by measurement.

NOTE For guidance on measuring techniques, see the relevant part of the IEC 62471 series.

Compliance against material degradation from UV radiation is checked by the relevant tests in Annex C.

10.5 Safeguards against X-radiation

10.5.1 Requirements

Equipment X-radiation that exits the equipment shall not exceed RS1 under **normal operating conditions**, **abnormal operating conditions**, and **single fault conditions**.

An **equipment safeguard** is required between RS2 or RS3 and all persons.

Doors and covers acting as a **safeguard** that, when open, would allow access to RS2 or RS3 for a **skilled person** shall be provided with an **instructional safeguard** in accordance with Clause F.5.

10.5.2 Compliance criteria

Compliance is checked by inspection and, where necessary, by the test of 10.5.3.

10.5.3 Test method

Equipment that is likely to produce ionizing radiation is checked by measuring the amount of radiation. Account is taken of the background level.

The amount of radiation is determined by means of a radiation monitor of the ionizing chamber type with an effective area of 1 000 mm^2 or by measuring equipment of other types giving equivalent results.

*Measurements are made with the EUT operating at the most unfavourable supply voltage (see B.2.3) and with controls for an **ordinary person** and an **instructed person**, and controls for a **skilled person** that are not locked in a reliable manner, adjusted so as to give maximum radiation whilst maintaining the equipment operative for normal use.*

NOTE 1 Soldered joints and fixing by application of paint, epoxy, or similar materials are considered reliable locking means.

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*Moreover, the measurement shall be made under any **abnormal operating condition** and **single fault conditions** that can cause an increase of the high-voltage, provided an intelligible picture is maintained for 5 min, at the end of which the measurement is made and averaged over 5 min.*

During the measurements, an intelligible picture is to be maintained.

A picture is considered to be intelligible if the following conditions are met:

- *a scanning amplitude of at least 70 % of the usable screen for both width and height;*
- *a minimum luminance of 50 cd/m^2 with locked blank raster provided by a test generator;*
- *not more than 12 flashovers in a 1 h period; and*
- *a horizontal resolution corresponding to at least 1,5 MHz in the centre with a similar vertical degradation.*

NOTE 2 In the USA and Canada, an intelligible picture is in synchronization while covering 60 % of the viewable screen area.

10.6 Safeguards against acoustic energy sources

10.6.1 General

Safeguard requirements for protection against long-term exposure to excessive sound pressure levels from personal music players closely coupled to the ear are specified below. Requirements for earphones and headphones intended for use with personal music players are also covered.

A personal music player (PMP) is a portable equipment intended for use by an **ordinary person**, that:

- is designed to allow the user to listen to audio or audiovisual content / material; and
- uses a listening device, such as headphones or earphones that can be worn in or on or around the ears; and
- has a player that can be body worn (of a size suitable to be carried in a clothing pocket) and is intended for the user to walk around with while in continuous use (for example, on a street, in a subway, at an airport, etc.).

EXAMPLES Portable CD players, MP3 audio players, mobile phones with MP3 type features, PDAs or similar equipment.

Personal music players shall comply with the requirements of either 10.6.2 or 10.6.3.

NOTE 1 Protection against acoustic energy sources from telecom applications is referenced to ITU-T P.360.

NOTE 2 It is the intention of the Committee to allow the alternative methods for now, but to only use the dose measurement method as given in 10.6.3 in future. Therefore, manufacturers are encouraged to implement 10.6.3 as soon as possible.

Listening devices sold separately shall comply with the requirements of 10.6.6.

These requirements are valid for music or video mode only.

For equipment that is clearly designed or intended primarily for use by children, additional limits of the relevant toy standards may apply.

NOTE 3 In Europe, the relevant requirements are given in EN 71-1:2011, 4.20 and the related tests methods and measurement distances apply.

The requirements do not apply to:

- **professional equipment**;

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– hearing aid equipment and other devices for assistive listening; and

– the following type of analogue personal music players:

  • long distance radio receiver (for example, a multiband radio receiver or world band radio receiver, an AM radio receiver), and

  • cassette player/recorder; and

  NOTE 2 This exemption has been allowed because this technology is falling out of use and it is expected that within a few years it will no longer exist. This exemption will not be extended to other technologies.

– a player while connected to an external amplifier that does not allow the user to walk around while in use.

10.6.2 Classification

10.6.2.1 RS1 limits

RS1 is a class 1 acoustic energy source that does not exceed the following:

– for equipment provided as a package (player with its listening device), and with a proprietary connector between the player and its listening device, or where the combination of player and listening device is known by other means such as setting or automatic detection, the $L_{\mathrm{Aeq},T}$ acoustic output shall be lower or equal to the relevant RS1 sound output value of Table 39 when playing the fixed "programme simulation noise" described in EN 50332-1.

– for equipment provided with a standardized connector (for example, a 3,5 mm phone jack) that allows connection to a listening device for general use, the unweighted RMS output voltage shall be lower or equal to the relevant RS1 analogue output value of Table 39 when playing the fixed "programme simulation noise" described in EN 50332-1.

– for equipment provided with a digital output, the output signal shall be lower or equal to the relevant RS1 digital output value of Table 39 when playing the fixed "programme simulation noise" described in EN 50332-1.

NOTE 1 Unless otherwise specified, wherever the term acoustic output is used in 10.6.2, $L_{\mathrm{Aeq},T}$ is the A-weighted equivalent sound pressure level over a 30 s period.

If the player is able to analyse a song, and where the average sound pressure (long term $L_{\mathrm{Aeq},T}$) measured over the duration of the song is lower than the average produced by the programme simulation noise, the output is considered RS1 as long as the average sound pressure of the song does not exceed the basic limit of 85 dB(A). In this case, T becomes the duration of the song.

NOTE 2 Classical music typically has an average sound pressure (long term $L_{\mathrm{Aeq},T}$) which is much lower than the average programme simulation noise.

For example, if the player is set with the programme simulation noise to 85 dB(A), but the average sound pressure of the song is only 65 dB(A), the output is considered to be RS1 as long as the average sound level of the song is not above the basic limit of 85 dB(A).

10.6.2.2 RS2 limits

RS2 is a class 2 acoustic energy source that does not exceed the following:

– for equipment provided as a package (player with its listening device), and with a proprietary connector between the player and its listening device, or where the combination of player and listening device is known by other means such as setting or automatic detection, the $L_{\mathrm{Aeq},T}$ acoustic output shall be lower or equal to the relevant RS2 sound output value of Table 39 when playing the fixed "programme simulation noise" described in EN 50332-1.

– for equipment provided with a standardized connector (for example, a 3,5 mm phone jack) that allows connection to a listening device for general use, the unweighted RMS output voltage shall be lower or equal to the relevant RS2 analogue output value of Table 39 when playing the fixed "programme simulation noise" described in EN 50332-1.

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– for equipment provided with a digital output, the output signal shall be lower or equal to the relevant RS2 digital output value of Table 39 when playing the fixed “programme simulation noise” described in EN 50332-1.

10.6.2.3 RS3 limits

RS3 is a class 3 acoustic energy source that exceeds RS2 limits.

10.6.3 Requirements for dose-based systems

10.6.3.1 General requirements

Personal music players shall give the warnings as provided below when tested according to EN 50332-3.

The manufacturer may offer optional settings to allow the users to modify when and how they wish to receive the notifications and warnings to promote a better user experience without defeating the **safeguards**. This allows the users to be informed in a method that best meets their physical capabilities and device usage needs. If such optional settings are offered, an administrator (for example, parental restrictions, business/educational administrators, etc.) shall be able to lock any optional settings into a specific configuration.

The personal music player shall be supplied with easy to understand explanation of the dose management system and how to use it. The user should be made aware that other sources may significantly contribute to the **sound exposure** (for example work, transportation, concerts, clubs, cinema, car races, etc.).

10.6.3.2 Dose-based warning and automatic decrease

When a dose of 100 % CSD is reached (RS2), and at least at every 100 % further increase of CSD, the device shall warn the user and require an acknowledgement. In case the user does not acknowledge, the output level shall automatically decrease to RS1.

NOTE 100 % CSD is based on 80 dB(A) for 40 h.

The warning shall at least clearly indicate that listening above 100 % CSD leads to the risk of hearing damage or loss.

10.6.3.3 Exposure-based warning and requirements

The purpose of the dose-based only requirement is to inform and educate users about safe listening practice.

In addition to dose-based requirements, a system shall therefore either:

– Limit the 30 s integrated exposure level (MEL30) to the relevant RS2 limit of Table 39. The limiter settling time shall be 20 s or faster. The measurement of such limiting functionality is, after allowing the 20 s settling time of the PMP limiter, conducted according to EN 50332-1 or EN 50332-2 as applicable.
– Warn the user in case **momentary exposure level (MEL)** equals or exceeds 100 dB(A). The warning may be given visually or audibly. If the warning is given visually, it shall remain visible for at least 5 s. If the warning is given audibly, it shall interrupt the programme clearly and unmistakingly for at least 1 s.

10.6.4 Measurement methods

All volume controls shall be turned to maximum during tests.

Measurements shall be made in accordance with EN 50332-1 or EN 50332-2 as applicable.

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10.6.5 Protection of persons

Except as given below, protection requirements for parts **accessible** to **ordinary persons**, **instructed persons** and **skilled persons** are given in 4.3.

NOTE 1 Volume control is not considered a **safeguard.**

An **equipment safeguard** shall prevent exposure of an **ordinary person** to an RS2 source unless all of the following are met:

– an **instructional safeguard** is provided as given below; and

– the **instructional safeguard** is acknowledged by the user. The output level shall not be higher than RS1 until the acknowledgment is made. The acknowledgement does not need to be repeated more than once every 20 h of cumulative listening time.

NOTE 2 The 20 h listening time is the accumulative listening time, independent of how often and how long the personal music player has been switched off.

The output level shall automatically return to an output level not exceeding RS1 when the power is switched off.

A **skilled person** shall not unintentionally be exposed to RS3.

When required, an **instructional safeguard** in accordance with Clause F.5 shall be used, except that the **instructional safeguard** shall be placed on the equipment, on the packaging, or in the instruction manual. Alternatively, the **instructional safeguard** may be given through the equipment display during use. The elements of the **instructional safeguard** shall be as follows:

– element 1a: the symbol  , IEC 60417-6044 (2011-01)

– element 2: “High sound pressure” or equivalent wording

– element 3: “Hearing damage risk” or equivalent wording

– element 4: “Do not listen at high volume levels for long periods.” or equivalent wording

10.6.6 Requirements for listening devices (headphones, earphones, etc.)

10.6.6.1 Corded listening devices with analogue input

With 94 dB(A) L_{Aeq} acoustic pressure output of the listening device, and with the volume and sound settings in the listening device (for example, built-in volume level control, additional sound feature like equalization, etc.) set to the combination of positions that maximize the measured acoustic output, the input voltage of the listening device when playing the fixed “programme simulation noise” as described in EN 50332-1 shall be ≥ 75 mV.

NOTE The values of 94 dB(A) and 75 mV correspond with 85 dB(A) and 27 mV or 100 dB(A) and 150 mV.

10.6.6.2 Corded listening devices with digital input

With any playing device playing the fixed “programme simulation noise” described in EN 50332-1, and with the volume and sound settings in the listening device (for example, built-in volume level control, additional sound feature like equalization, etc.) set to the combination of positions that maximize the measured acoustic output, the $L_{Aeq,T}$ acoustic output of the listening device shall be ≤ 100 dB(A) with an input signal of –10 dBFS.

10.6.6.3 Cordless listening devices

In cordless mode,

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– with any playing and transmitting device playing the fixed programme simulation noise described in EN 50332-1; and

– respecting the cordless transmission standards, where an air interface standard exists that specifies the equivalent acoustic level; and

– with volume and sound settings in the receiving device (for example, built-in volume level control, additional sound feature like equalization, etc.) set to the combination of positions that maximize the measured acoustic output for the above mentioned programme simulation noise,

– the $L_{\mathrm{Aeq},T}$ acoustic output of the listening device shall be ≤ 100 dB(A) with an input signal of –10 dBFS.

10.6.6.4 Measurement method

Measurements shall be made in accordance with EN 50332-2 as applicable.

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Annex A
(informative)

Examples of equipment within the scope of this document

Some examples of equipment within the scope of this document are:

Generic product type	Specific example of generic type
Banking equipment	Monetary processing machines including automated teller (cash dispensing) machines (ATM)
Consumer electronic equipment (including professional audio, video and musical instrument equipment)	Receiving equipment and amplifiers for sound and/or vision, supply equipment intended to supply other equipment covered by the scope of this document, electronic musical instruments, and electronic accessories such as rhythm generators, tone generators, music tuners and the like for use with electronic or non-electronic musical instruments, audio and/or video educational equipment, video projectors, video cameras and video monitors, network surveillance cameras, video games, juke boxes, record and optical disc players, tape and optical disc recorders, antenna signal converters and amplifiers, antenna positioners, Citizen's Band equipment, equipment for imagery, electronic light effect equipment, intercommunication equipment using low voltage mains as the transmission medium, cable head-end receivers, multimedia equipment, electronic flash equipment
Data and text processing machines and associated equipment	Data preparation equipment, data processing equipment, data storage equipment, personal computers, tablets, smartphones, wearable devices, plotters, printers (including 3D printers), scanners, text processing equipment, visual display units
Data network equipment	Bridges, data circuit terminating equipment, data terminal equipment, routers
Electrical and electronic retail equipment	Cash registers, point of sale terminals including associated electronic scales
Electrical and electronic office machines	Calculators, copying machines, dictation equipment, document shredding machines, duplicators, erasers, micrographic office equipment, motor-operated files, paper trimmers (punchers, cutting machines, separators), paper jogging machines, pencil sharpeners, staplers, typewriters
Other information technology equipment	Photoprinting equipment, public information terminals, electronic kiosks, multimedia equipment
Postage equipment	Mail processing machines, postage machines
Telecommunication network infrastructure equipment	Billing equipment, multiplexers, network powering equipment, network terminating equipment, radio base stations, repeaters, transmission equipment, telecommunication switching equipment
Telecommunication terminal equipment	Facsimile equipment, key telephone systems, modems, PABXs, pagers, telephone answering machines, telephone sets (wired and wireless)

This list is not intended to be all-inclusive, and equipment that is not listed is not necessarily excluded from the scope.

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Annex B
(normative)

Normal operating condition tests, abnormal operating condition tests and single fault condition tests

B.1 General

B.1.1 Test applicability

This annex specifies various tests and test conditions applicable to the equipment.

If it is evident that a particular test is not applicable, or not necessary after inspection of available data, the test shall not be made. Tests in this document shall be conducted only if safety is involved.

In order to establish whether or not a test is applicable, the circuits and construction shall be carefully investigated to take into account the consequences of possible faults. The consequence of a fault may or may not require the use of a **safeguard** to reduce the likelihood of injury or fire.

B.1.2 Type of test

Except where otherwise stated, tests specified are **type tests**.

B.1.3 Test samples

Unless otherwise specified, the sample under test shall be representative of the actual equipment or shall be the actual equipment.

As an alternative to conducting tests on the complete equipment, tests may be conducted separately on circuits, components or sub-assemblies outside the equipment, provided that inspection of the equipment and circuit arrangements ensure that such testing will indicate that the assembled equipment would conform to the requirements of this document. If any such test indicates the likelihood of non-conformance in the complete equipment, the test shall be repeated in the equipment.

If a test could be destructive, a model may be used to represent the condition to be evaluated.

B.1.4 Compliance by inspection of relevant data

Where in this document compliance of materials, components or subassemblies is checked by inspection or by testing of properties, compliance may be confirmed by reviewing any relevant data or previous test results that are available instead of carrying out the specified **type tests**.

B.1.5 Temperature measurement conditions

The test measurement set-up shall reproduce the most severe equipment installation conditions. Where a maximum temperature (T_{max}) is specified for compliance with tests, it is based on the assumption that the room ambient air temperature will be 25 °C when the equipment is operating. However, the manufacturer may specify a different maximum ambient air temperature.

Unless otherwise specified, it is not necessary to maintain the ambient temperature (T_{amb}) at a specific value during tests, but it shall be monitored and recorded.

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With reference to those tests that are to be continued until steady state temperatures are attained, steady state is considered to exist if the temperature rise does not exceed 3 K in 30 min. If the measured temperature is at least 10 % less than the specified temperature limit, steady state is considered to exist if the temperature rise does not exceed 1 K in 5 min.

Unless a particular method is specified, temperatures of windings shall be determined either by the thermocouple method or by any other method giving the average temperature of the winding wires such as the resistance method.

B.2 Normal operating conditions

B.2.1 General

Except where specific test conditions are stated elsewhere and where it is clear that there is a significant impact on the results of the test, the tests shall be conducted under the most unfavourable **normal operating conditions** taking into account the following parameters:

– supply voltage;

– supply frequency;

– environmental conditions (for example, the manufacturer's rated maximum ambient temperature);

– physical location of equipment and position of movable parts, as specified by the manufacturer;

– operating mode, including external loading due to interconnected equipment; and

– adjustment of a control.

For audio amplifiers and equipment containing an audio amplifier, additional test conditions apply, see Annex E.

B.2.2 Supply frequency

In determining the most unfavourable supply frequency for a test, different frequencies within the **rated frequency** range shall be taken into account (for example, 50 Hz and 60 Hz) but consideration of the tolerance on a **rated frequency** (for example, 50 Hz ± 0,5 Hz) is not necessary.

B.2.3 Supply voltage

In determining the most unfavourable supply voltage for a test, the following variables shall be taken into account:

– multiple **rated voltages**;

– extremes of **rated voltage ranges**; and

– tolerance on **rated voltage** as declared by the manufacturer.

Unless the manufacturer declares a wider tolerance, the minimum tolerance shall be taken as +10 % and −10 % for AC **mains** and +20 % and −15 % for DC **mains**. Equipment intended by the manufacturer to be restricted to connection to a conditioned power supply system (for example, a UPS) may be provided with a narrower tolerance if the equipment is also provided with instructions specifying such restriction.

B.2.4 Normal operating voltages

The following voltages shall be considered:

– normal operating voltages generated in the equipment, including repetitive peak voltages such as those associated with switch mode power supplies; and

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– normal operating voltages generated external to the equipment, including ringing signals received from **external circuits** as indicated in Table 13, ID numbers 1 and 2.

Externally generated **mains transient voltages** and **external circuit** transient voltages shall not be considered:

– when determining **working voltages**, because such transients have been taken into account in the procedures for determining minimum **clearances** (see 5.4.2); and

– when classifying circuits in the equipment as ES1, ES2 and ES3 (see 5.2).

B.2.5 Input test

In determination of the input current or input power, the following variables shall be considered:

– *loads due to optional features, offered or provided for by the manufacturer for inclusion in or with the EUT;*

– *loads due to other units of equipment intended by the manufacturer to draw power from the EUT;*

– *loads that could be connected to any standard supply outlet on the equipment that is **accessible** to an **ordinary person**, up to the value specified by the manufacturer;*

– *for equipment containing an audio amplifier, see Clause E.1;*

– *for equipment where the primary function is to display moving images, the following settings shall apply:*

- *the 'Three vertical bar signal' shall be used as defined in 3.2.1.3 of IEC 60107-1:1997; and*
- *user **accessible** picture controls shall be adjusted so as to obtain the maximum power consumption; and*
- *sound settings shall be as defined in Clause E.1 of this document.*

Artificial loads may be used to simulate such loads during testing.

In each case, the readings are taken when the input current or input power has stabilized. If the current or power varies during the normal operating cycle, the steady state current or power is taken as the mean indication of the value, measured on a recording RMS ammeter or power meter, during a representative period.

*The measured input current or input power under **normal operating conditions**, but at the **rated voltage** or at each end of each **rated voltage range**, shall not exceed the **rated current** or **rated power** by more than 10 %.*

Compliance is checked by measuring the input current or input power of the equipment under the following conditions:

– *where equipment has more than one **rated voltage**, the input current or input power is measured at each **rated voltage**; and*

– *where equipment has one or more **rated voltage ranges**, the input current or input power is measured at each end of each **rated voltage range**:*

- *where a single value of **rated current** or **rated power** is marked, it is compared with the higher value of input current or input power measured in the associated **rated voltage range**; and*
- *where two values of **rated current** or **rated power** are marked, separated by a hyphen, they are compared with the two values measured in the associated **rated voltage range**.*

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B.2.6 Operating temperature measurement conditions

B.2.6.1 General

Temperatures measured on the equipment shall conform to B.2.6.2 or B.2.6.3, as applicable, all temperatures being in degrees Celsius (°C); where:

T is the temperature of the given part measured under the prescribed test conditions;

T_{max} is the maximum temperature specified for compliance with the test;

T_{amb} is the ambient temperature during test;

T_{ma} is the maximum ambient temperature specified by the manufacturer, or 25 °C, whichever is greater.

B.2.6.2 Operating temperature dependent heating/cooling

For equipment where the amount of heating or cooling is designed to be dependent on temperature (for example, the equipment contains a fan that has a higher speed at a higher temperature), the temperature measurement is made at the least favourable ambient temperature within the manufacturer's specified operating range. In this case, T shall not exceed T_{max}.

NOTE 1 In order to find the highest value of T for each component, it can be useful to conduct several tests at different values of T_{amb}.

NOTE 2 The least favourable value of T_{amb} can be different for different components.

Alternatively, the temperature measurement may be made under ambient conditions with the heating/cooling device at its least effective setting or with the device defeated.

B.2.6.3 Operating temperature independent heating/cooling

For equipment where the amount of heating or cooling is not designed to be dependent on ambient temperature, the method in B.2.6.2 may be used. Alternatively, the test is performed at any value of T_{amb} within the manufacturer's specified operating range. In this case, T shall not exceed ($T_{max} + T_{amb} - T_{ma}$).

During the test, T_{amb} should not exceed T_{ma} unless agreed by all parties involved.

B.2.7 Battery charging and discharging under normal operating conditions

Under **normal operating conditions**, **battery** charging and discharging conditions shall comply with the requirements of Annex M as applicable.

B.3 Simulated abnormal operating conditions

B.3.1 General

When applying simulated **abnormal operating conditions**, parts, supplies, and media shall be in place if they are likely to have an effect on the outcome of the test.

Each **abnormal operating condition** shall be applied in turn, one at a time.

Faults that are the direct consequence of the **abnormal operating condition** are deemed to be a **single fault condition**.

The equipment, installation, instructions, and specifications shall be examined to determine those **abnormal operating conditions** that might reasonably be expected to occur.

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As a minimum, the following examples of **abnormal operating conditions** shall be considered, as applicable, in addition to those mentioned in B.3.2 to B.3.7:

– for paper handling equipment: a paper jam;

– for equipment with controls **accessible** to an **ordinary person**: adjustment of the controls, both individually and collectively, for worst-case operating conditions;

– for audio amplifiers with controls **accessible** to an **ordinary person**: adjustment of the controls, both individually and collectively, for worst-case operating conditions, without applying the conditions specified in Annex E;

– for equipment with moving parts **accessible** to an **ordinary person**: a moving parts jam;

– for equipment with media: incorrect media, incorrect size media, and incorrect media quantity;

– for equipment with replenishable liquids or liquid cartridges, or replenishable materials: liquids or materials spilled into the equipment; and

– for equipment that uses an **insulating liquid** described in 5.4.12.1: loss of liquid.

Before introducing any of the above **abnormal operating conditions**, the equipment shall be operating under **normal operating conditions**.

B.3.2 Covering of ventilation openings

The top, sides and the back of equipment, if such surfaces have ventilation openings, shall be covered one at a time with a card (thick, stiff paper or thin cardboard) with a minimum density of 200 g/m^2, with dimensions not less than each tested surface, covering all openings.

Openings on different surfaces on top of the equipment (if any) are covered simultaneously by separate pieces of card.

Openings on top of the equipment, on a surface inclined at an angle greater than 30° and smaller than 60° to the horizontal, from which an obstruction is free to slide, are excluded.

On the back and the sides of the equipment, the card is attached to the upper edge and allowed to hang freely.

Except as specified below, there are no requirements for blocking openings in the bottom of the equipment.

In addition, equipment with ventilation openings likely to be used on a soft support (like bedding, blankets etc.), shall comply with one of the following:

– Openings in the bottom, sides and back of the equipment are to be covered simultaneously. External surfaces shall not exceed the TS2 limits in Table 38.

– An **instructional safeguard** shall be provided in accordance with Clause F.5, except that element 3 is optional.

  The elements of the **instructional safeguard** shall be as follows:

  - element 1a: not available
  - element 2: “Do not cover ventilation openings” or equivalent wording
  - element 3: optional
  - element 4: “This equipment is not intended to be used on soft support (like beddings, blankets etc.).” or equivalent wording

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B.3.3 DC mains polarity test

If the connection to the DC **mains** is not polarized and the connection is **accessible** to an **ordinary person**, then the possible influence of polarity shall be taken into account when testing equipment designed for DC.

B.3.4 Setting of voltage selector

Equipment to be supplied from the **mains** and provided with a voltage setting device to be set by the **ordinary person** or an **instructed person**, is tested with the **mains** voltage setting device at the most unfavourable position.

B.3.5 Maximum load at output terminals

Output terminals of equipment supplying power to other equipment, except socket-outlets and appliance outlets directly connected to the **mains**, are connected to the most unfavourable load impedance, including short-circuit.

B.3.6 Reverse battery polarity

If it is possible for an **ordinary person** to insert replaceable **batteries** with reversed polarity, the equipment is tested in all possible configurations with one or more **batteries** reversed (see also Annex M).

B.3.7 Audio amplifier abnormal operating conditions

Abnormal operating conditions for audio amplifiers are specified in Clause E.3.

B.3.8 Compliance criteria during and after abnormal operating conditions

*During an **abnormal operating condition** that does not lead to a **single fault condition**, all **safeguards** shall remain effective. After restoration of **normal operating conditions**, all **safeguards** shall comply with applicable requirements.*

*If an **abnormal operating condition** leads to a consequential fault, the compliance criteria of B.4.8 apply.*

B.4 Simulated single fault conditions

B.4.1 General

When applying simulated **single fault conditions**, parts, supplies, and media shall be in place if they are likely to have an effect on the outcome of the test.

The introduction of any **single fault condition** shall be applied in turn one at a time. Faults, that are the direct consequence of the **single fault condition**, are deemed to be part of that **single fault condition**.

The equipment construction, circuit diagrams, component specifications, including **functional insulation** are examined to determine those **single fault conditions** that might reasonably be expected and that:

– might bypass a **safeguard**; or

– cause the operation of a **supplementary safeguard**; or

– otherwise affect the safety of the equipment.

The following **single fault conditions** shall be considered:

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– an **abnormal operating condition** that results in a **single fault condition** (for example, an **ordinary person** overloading external output terminals, or an **ordinary person** incorrectly setting a selector switch);
– a **basic safeguard** failure or a **supplementary safeguard** failure;
– except for integrated circuit current limiters complying with Clause G.9, a component failure simulated by short-circuiting any two leads and open-circuiting any one lead of the component one at a time; and
– when required by B.4.4, a failure of **functional insulation**.

B.4.2 Temperature controlling device

Except for temperature controlling **safeguards**, according G.3.1 to G.3.4, any single device or component of a circuit controlling the temperature during temperature measurement shall be open-circuited or short-circuited, whichever is more unfavourable.

Temperatures shall be measured according to B.1.5.

B.4.3 Motor tests

B.4.3.1 Blocked motor test

Motors are blocked or the rotor is locked in the end product if it is obvious that such an action will result in an increase in internal ambient temperature of the equipment (for example, locking the rotor of the fan motor to stop air flow).

B.4.3.2 Compliance criteria

Compliance is checked by inspection and examination of the available data or by testing according to G.5.4.

B.4.4 Functional insulation

B.4.4.1 Clearances for functional insulation

Unless the **clearance** for **functional insulation** complies with:

– the **clearance** for **basic insulation** as specified in 5.4.2; or
– for ES1 and PS1 circuits used in **pollution degree** 1 and **pollution degree** 2 environments, the **clearance** for **basic insulation** for printed wiring boards as specified in IEC 60664-1:2007, Table F.4; or
– the electric strength test of 5.4.9.1 for **basic insulation**,

a **clearance** for **functional insulation** shall be short-circuited.

B.4.4.2 Creepage distances for functional insulation

Unless the **creepage distance** for **functional insulation** complies with:

– the **creepage distance** for **basic insulation** as specified in 5.4.3; or
– for ES1 and PS1 circuits used in **pollution degree** 1 and **pollution degree** 2 environments, the **clearance** for **basic insulation** for printed wiring boards as specified in IEC 60664-1:2007, Table F.4; or
– the electric strength test of 5.4.9.1 for **basic insulation**,

a **creepage distance** for **functional insulation** shall be short-circuited.

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B.4.4.3 Functional insulation on coated printed boards

Unless the **functional insulation** complies with:

– the separation distance of Table G.13; or

– the electric strength test of 5.4.9.1 for **basic insulation**,

a **functional insulation** on a coated printed board shall be short-circuited.

B.4.5 Short-circuit and interruption of electrodes in tubes and semiconductors

Electrodes in electronic tubes and leads of semiconductor devices shall be short-circuited, or if applicable, interrupted. One lead at a time is interrupted or any two leads connected together in turn.

B.4.6 Short-circuit or disconnection of passive components

Resistors, capacitors, windings, loudspeakers, VDRs and other passive components shall be short-circuited or disconnected, whichever is more unfavourable.

These **single fault conditions** do not apply to:

– PTC thermistors complying with IEC 60730-1:2013, Clauses 15, 17, J.15 and J.17;

– a PTC providing IEC 60730-1 Type 2.AL action;

– resistors complying with the tests of 5.5.6;

– capacitors complying with IEC 60384-14 and assessed according to 5.5.2 of this document;

– isolating components (for example, optocouplers and transformers) complying with the relevant component requirements in Annex G for **reinforced insulation**; and

– other components that serve as a **safeguard** complying with the relevant requirements of Annex G or with the safety requirements of the relevant IEC component standard.

B.4.7 Continuous operation of components

*Motors, relay coils or the like, intended for **short–time operation** or **intermittent operation**, are operated continuously if this can occur during operation of the equipment.*

*For equipment rated for **short–time operation** or **intermittent operation**, the test is repeated until steady state conditions are reached, irrespective of the operating time. For this test, the **thermostats**, **temperature limiters** and **thermal cut-offs** are not short-circuited.*

*In circuits not directly connected to the **mains** and in circuits supplied by a DC power distribution system, electromechanical components normally energized intermittently, except for motors, a fault shall be simulated in the drive circuit to cause continuous energizing of the component.*

The duration of the test shall be as follows:

– *for equipment or components whose failure to operate is not evident to an **ordinary person**, as long as necessary to establish steady conditions or up to the interruption of the circuit due to other consequences of the simulated fault condition, whichever is the shorter; and*

– *for other equipment and components: 5 min or up to interruption of the circuit due to a failure of the component (for example, burn-out) or to other consequences of the simulated fault condition, whichever is shorter.*

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B.4.8 Compliance criteria during and after single fault conditions

*During and after a **single fault condition**, an **accessible** part shall not exceed the relevant energy class as specified in 5.3, 8.3, 9.4, 10.3, 10.4.1, 10.5.1 and 10.6.5 for the related person depending on the hazard involved. During and after **single fault conditions**, any flame inside the equipment shall extinguish within 10 s and no surrounding parts shall have ignited. Any part showing flames shall be regarded as a **PIS**.*

*After a **single fault condition** that might impact an insulation used as a **safeguard**, the insulation shall withstand the electric strength test of 5.4.9.1 for the relevant insulation.*

*During and after a **single fault condition**, the opening of a conductor on a printed board shall not be used as a **safeguard**, except for the following situations, in which case the fault condition shall be repeated 3 times:*

– *Conductors of a printed board of **V-1 class material** or **VTM-1 class material** may open under overload condition provided that the open circuit is not an **arcing PIS**. Conductors on a printed board material that has no **material flammability class** or is classed lower than **V-1 class material** shall not open.*

– *Under a **single fault condition**, the peeling of conductors on a printed board shall not result in the failure of any **supplementary safeguard** or **reinforced safeguard**.*

B.4.9 Battery charging and discharging under single fault conditions

*Under **single fault conditions**, **battery** charging and discharging conditions shall comply with the requirements of Annex M as applicable.*

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Annex C
(normative)

UV radiation

C.1 Protection of materials in equipment from UV radiation

C.1.1 General

This annex defines the test requirements and test procedures for materials that have **safeguard** properties and that are subject to UV radiation exposure.

C.1.2 Requirements

The following requirements apply to equipment, or parts of equipment, that are exposed to lamps that produce significant UV radiation in the spectrum 180 nm to 400 nm and to outdoor equipment exposed to sunlight.

NOTE 1 General-purpose incandescent and fluorescent lamps, with ordinary glass envelopes, are not considered to emit significant UV radiation.

NOTE 2 Filters and/or lenses usually act as a **safeguard** and can serve as part of the **enclosure**.

Table C.1 – Minimum property retention limits after UV exposure

Parts to be tested	Property	Standard for the test method	Minimum retention after test
Parts providing mechanical support	Tensile strength [a]	ISO 527 series	70 %
	or flexural strength [a] [b]	ISO 178	70 %
Parts providing impact resistance	Charpy impact [c] or	ISO 179-1	70 %
	Izod impact [c] or	ISO 180	70 %
	Tensile impact [c]	ISO 8256	70 %
All parts	**Material flammability class**	See Clause S.4 of this document	[d]

[a] Tensile strength and flexural strength tests are to be conducted on specimens no thicker than the actual thicknesses.

[b] The side of the sample exposed to UV radiation is to be in contact with the two loading points when using the three point loading method.

[c] Tests conducted on 3,0 mm thick specimens for Izod impact and tensile impact tests and 4,0 mm thick specimens for Charpy impact tests are considered representative of other thicknesses, down to 0,75 mm.

[d] The **material flammability class** may change as long as it does not fall below that specified in Clause 6 of this document.

C.1.3 Test method and compliance criteria

Compliance is checked by examination of the construction and of available data regarding the UV resistance characteristics of the parts exposed to UV radiation in the equipment. If such data is not available, the tests in Table C.1 are carried out on the parts.

Samples taken from the parts, or consisting of identical material, are prepared according to the standard for the test to be carried out. They are then conditioned according to Clause C.2. After conditioning, the samples shall show no signs of significant deterioration, such as crazing or cracking. They are then kept at room ambient conditions for not less than 16 h and not more than 96 h, after which they are tested according to the standard for the relevant test.

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In order to evaluate the percentage retention of properties after test, samples that have not been conditioned according to Clause C.2 are tested at the same time as the conditioned samples.

The retention shall be as specified in Table C.1.

C.2 UV light conditioning test

C.2.1 Test apparatus

Samples are exposed to UV light by using one of the following apparatus:

- *a twin enclosed carbon-arc (see C.2.3) with continuous exposure for a minimum of 720 h. The test apparatus shall operate with a black-panel temperature of 63 °C ± 3 °C in a relative humidity of (50 ± 5) %; or*
- *a xenon-arc (see C.2.4) with continuous exposure for a minimum of 1 000 h. The test apparatus shall operate with a 6 500 W, water-cooled xenon-arc lamp, a spectral irradiance of 0,35 W/m^2 at 340 nm, a black-panel temperature of 63 °C ± 3 °C in a relative humidity of (50 ± 5) %.*

C.2.2 Mounting of test samples

The samples are mounted vertically on the inside of the cylinder of the light exposure apparatus, with the widest portion of the samples facing the arcs. They are mounted so that they do not touch each other.

C.2.3 Carbon-arc light-exposure test

The apparatus described in ISO 4892-4, or equivalent, is used in accordance with the procedures given in ISO 4892-1 and ISO 4892-4 using a type 1 filter, with water spray.

C.2.4 Xenon-arc light-exposure test

The apparatus described in ISO 4892-2:2013, or equivalent, is used in accordance with the procedures given in ISO 4892-1 and ISO 4892-4 using cycle 1 of method A of Table 3, without water spray.

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Annex D
(normative)

Test generators

D.1 Impulse test generators

These circuits produce test pulses as referenced in Table D.1. In this table:

– the circuit 1 impulse is typical of voltages induced into telephone wires and coaxial cables in long outdoor cable runs due to lightning strikes to their earthing shield;

– the circuit 2 impulse is typical of earth potential rises due to either lightning strikes to power lines or power line faults; and

– the circuit 3 impulse is typical of voltages induced into antenna system wiring due to nearby lightning strikes to earth.

NOTE During the tests, use extreme care due to the high electric charge stored in the capacitor C_1.

The circuit in Figure D.1, using the component values in circuits 1 and 2 of Table D.1, is used to generate impulses, the C_1 capacitor being charged initially to a voltage U_c.

Circuit 1 of Table D.1 generates 10/700 µs impulses (10 µs virtual front time, 700 µs virtual time to half value) to simulate transients in **external circuits** as indicated in Table 13, ID numbers 1, 2, 3, 4 and 5.

Circuit 2 of Table D.1 generates 1,2/50 µs impulses (1,2 µs virtual front time, 50 µs virtual time to half value) to simulate transients in power distribution systems.

The impulse wave shapes are under open-circuit conditions and can be different under load conditions.

During the test, the peak voltage of the applied impulse shall not be less than the peak impulse test voltage (for example, see Table 14) and the pulse shape (for example, 1,2 µs virtual front time, 50 µs virtual time to half value for the 1,2/50 µs impulse) shall remain substantially the same as under open-circuit conditions. Components in parallel with the ***clearance*** *may be disconnected during this test.*

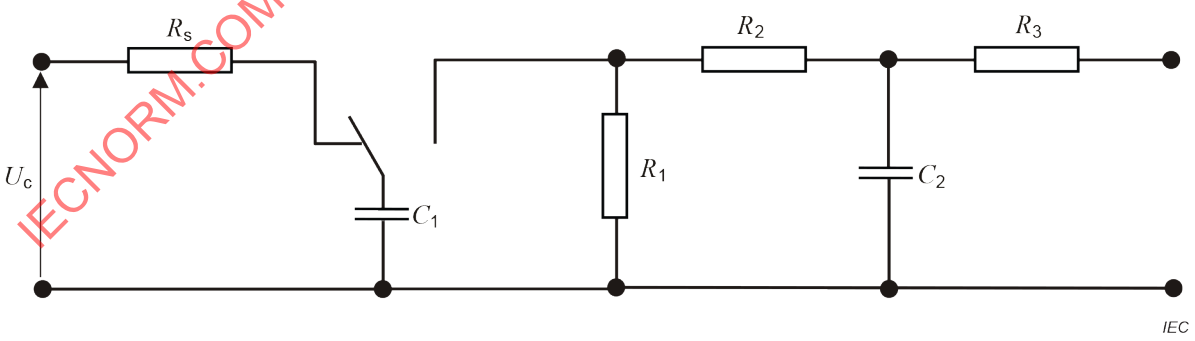


Figure D.1 – 1,2/50 µs and 10/700 µs voltage impulse generator

D.2 Antenna interface test generator

The circuit in Figure D.2 using the component values of circuit 3 in Table D.1, is used to generate impulses, the C_1 capacitor being charged initially to a voltage U_c.

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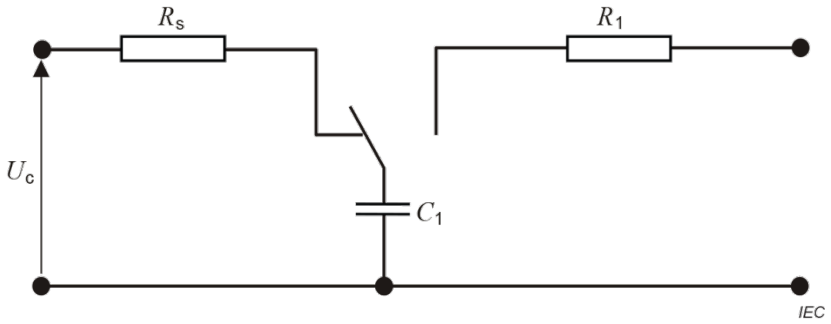
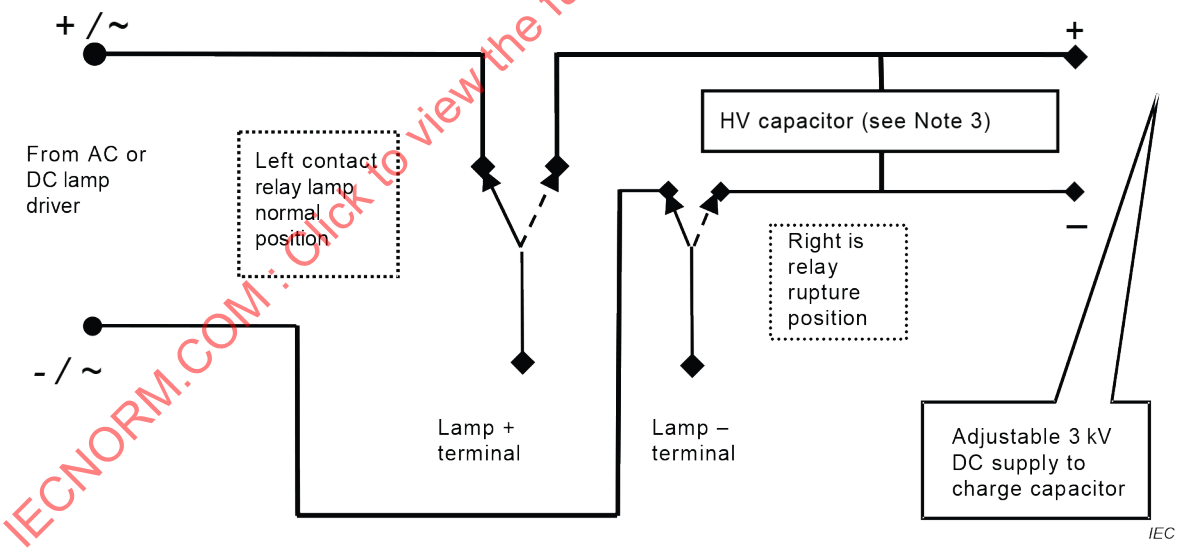


Figure D.2 – Antenna interface test generator circuit

Table D.1 – Component values for Figure D.1 and Figure D.2

	Test impulse	Figure	R_S	C_1	C_2	R_1	R_2	R_3
Circuit 1	10/700 µs	D.1	-	20 µF	0,2 µF	50 Ω	15 Ω	25 Ω
Circuit 2	1,2/50 µs	D.1	-	1 µF	30 nF	76 Ω	13 Ω	25 Ω
Circuit 3	-	D.2	15 MΩ	1 nF	-	1 kΩ	-	-
Alternative test generators may be used provided they give the same result. NOTE Circuits 1 and 2 are based on ITU-T Recommendation K.44.								

D.3 Electronic pulse generator



NOTE 1 The operating pressure of the lamp can be converted to energy (Joules). The operating energy level can typically be used as the starting point for the test charge.

NOTE 2 The relay is a 5 kV double pole defibrillator type, nitrogen filled. A defibrillator qualified relay is sufficient. See IEC 60601-2-4.

NOTE 3 The HV capacitor is rated 0,42 µF 5 kV.

Figure D.3 – Example of an electronic pulse generator

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Annex E
(normative)

Test conditions for equipment containing audio amplifiers

E.1 Electrical energy source classification for audio signals

When classifying audio signals as an electrical energy source (see Table E.1), the equipment shall be operated to deliver maximum **non-clipped output power** into its **rated load impedance**. The load is removed and the electrical energy source class is determined from the resulting open-circuit output voltage.

Tone controls are to be set at mid-range.

Table E.1 – Audio signal electrical energy source classes and safeguards

Class	Audio signal voltage V RMS	Examples of safeguards between energy source and ordinary person	Example of safeguards between energy source and instructed person
ES1	0 up to 71	No **safeguard** necessary	No **safeguard** necessary
ES2	Above 71 and up to 120	Insulated terminals [a] marked with ISO 7000, symbol  0434a (2004-01) or symbol  0434b (2004-01)	No **safeguard** necessary
		Instructional safeguard for uninsulated parts of terminals and bare wiring [b]	
ES3	Above 120	Connectors conforming to the requirements of IEC 61984 and marked with the symbol of IEC 60417-6042 (2010-11) 	

[a] Terminals that have no conductive parts **accessible** after wiring are installed according to instructions.

[b] An **instructional safeguard** indicating that touching uninsulated terminals or wiring may result in an unpleasant sensation.

E.2 Audio amplifier normal operating conditions

Equipment containing an audio amplifier shall be operated using a sine wave audio signal source at a frequency of 1 000 Hz. In the case where an amplifier is not intended for operation at 1 000 Hz, the **peak response frequency** shall be used.

The equipment shall be operated in such a way as to deliver 1/8 **non-clipped output power** to the **rated load impedance**. Alternatively, a band-limited pink noise signal may be used for operation after **non-clipped output power** is established using a sine wave. The noise bandwidth of the pink noise test signal shall be limited by a filter of a characteristic as shown in Figure E.1.

If visible clipping cannot be established, the maximum attainable power shall be considered as the **non-clipped output power**.

In addition, all of the following conditions shall be considered under **normal operating conditions**:

– The most unfavourable **rated load impedance** or the actual loudspeaker, when provided, is connected to the amplifier output.

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– All amplifier channels are operated simultaneously.
– Organs or similar instruments that have a tone-generator unit shall not be operated with the 1 000 Hz signal, but instead be operated with any combination of two bass pedal keys, if present, and ten manual keys depressed. All stops and tabs that can increase the output power shall be activated and the equipment shall be adjusted to deliver 1/8 of the maximum attainable output power.
– Where the intended amplifier function depends on phase difference between two channels, there shall be a phase difference of 90° between signals applied to the two channels.
– For equipment containing multi-channel amplifiers, where some channels cannot be operated independently, those channels shall be operated using the **rated load impedance** at the output power level that corresponds, by design, to 1/8 of the **non-clipped output power** of the adjustable amplifier channel(s).
– Where continuous operation is not possible, the amplifier shall be operated at the maximum output power level that allows continuous operation.

The temperature measurements shall be carried out with the equipment positioned in accordance with the instruction manual provided by the manufacturer, or, in the absence of instructions, the equipment shall be positioned 5 cm behind the front edge of an open-fronted wooden test box with 1 cm free space along the sides and top and 5 cm depth behind the equipment.

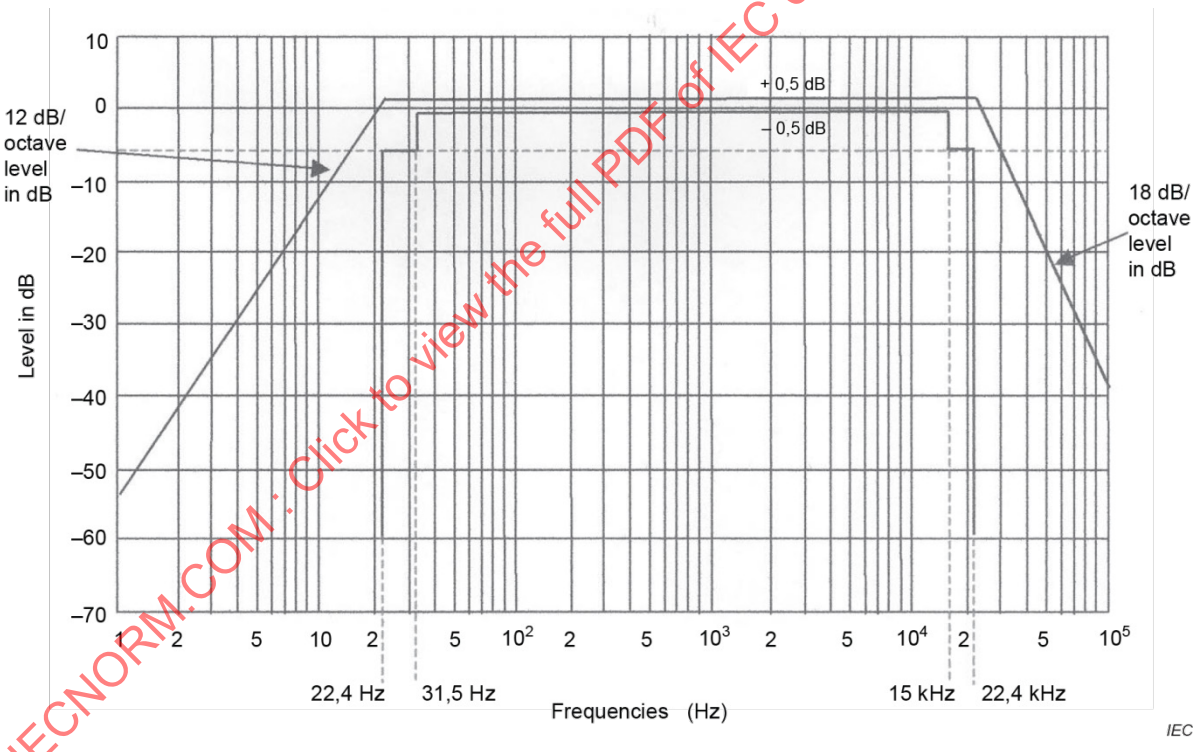


Figure E.1 – Band-pass filter for wide-band noise measurement

E.3 Audio amplifier abnormal operating conditions

Abnormal operating conditions shall be simulated by adjusting the controls to the most unfavourable output power from zero up to the maximum attainable output power into the most unfavourable **rated load impedance** connected to the output terminals. Short-circuit of the output terminals is also considered to be an **abnormal operating condition**.

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Annex F
(normative)

Equipment markings, instructions, and instructional safeguards

F.1 General

This annex specifies equipment markings, equipment instructions, and **instructional safeguards** necessary for equipment installation, operation, maintenance, and servicing in accordance with the requirements of this document.

Unless symbols are used, safety related equipment marking, instructions and **instructional safeguards** shall be in a language accepted in the respective countries.

This annex does not apply to markings on components. Markings on components are specified in the relevant component standard.

This annex may apply to sub-assemblies such as power supplies.

NOTE 1 Where the term marking is used in this document, it also applies to instructions and required elements of an **instructional safeguard**.

NOTE 2 See Table F.1 for examples of markings.

Care shall be taken so that additional markings and instructions not required by this document do not contradict the markings and instructions required by this document.

F.2 Letter symbols and graphical symbols

F.2.1 Letter symbols

Letter symbols for quantities and units shall be in accordance with IEC 60027-1.

F.2.2 Graphical symbols

Graphical symbols placed on the equipment for safety purposes, whether required by this document or not, shall be in accordance with IEC 60417, ISO 3864-2, ISO 7000 or ISO 7010, if available. In the absence of suitable symbols, the manufacturer may design specific graphical symbols.

F.2.3 Compliance criteria

Compliance is checked by inspection.

F.3 Equipment markings

F.3.1 Equipment marking locations

In general, equipment markings shall be located near or adjacent to the part or region that is the subject of the marking.

Unless otherwise specified, equipment markings required in F.3.2, F.3.3, F.3.6 and F.3.7 shall be on the exterior of the equipment, excluding the bottom. However, these markings may be in an area that is easily **accessible** by hand, for example:

– under a lid; or

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– on the exterior of the bottom of:
  - **direct plug-in equipment**, **hand-held equipment**, **transportable equipment**; or
  - **movable equipment** with a mass not exceeding 18 kg, provided that the location of the marking is given in the instructions.

Markings shall not be put on parts that can be removed without the use of a **tool**, unless they apply to that part.

For **permanently connected equipment**, installation instructions shall be provided either as markings on the equipment, or in the instructions, or in a separate installation instruction document.

For equipment intended to be mounted on a supporting structure (for example, a rack, panel, wall, ceiling, etc.) and where the external surface of the equipment becomes partially invisible after installation, markings may be on any surface, including the bottom, that becomes visible after removal of the equipment from the supporting structure.

Unless the meaning of the marking is obvious, the marking shall be explained in the instructions.

Compliance is checked by inspection.

F.3.2 Equipment identification markings

F.3.2.1 Manufacturer identification

The manufacturer or responsible vendor shall be identified by means of a marking on the equipment. Identification may be the manufacturer's name, the responsible vendor's name, trademark, or other equivalent identification.

Compliance is checked by inspection.

F.3.2.2 Model identification

The model number, model name, or equivalent shall be identified by means of a marking on the equipment.

Compliance is checked by inspection.

F.3.3 Equipment rating markings

F.3.3.1 Equipment with direct connection to mains

If a unit is provided with a means for direct connection to the **mains**, it shall be marked with an electrical rating, as specified in F.3.3.3 to F.3.3.6.

F.3.3.2 Equipment without direct connection to mains

If a unit is not provided with a means for direct connection to the **mains**, it need not be marked with any electrical rating. However, any **rated power** or **rated current** marking on the equipment shall comply with B.2.5.

F.3.3.3 Nature of the supply voltage

The nature of the supply voltage, DC, AC, or three-phase AC, shall be marked on the equipment and shall immediately follow the equipment voltage rating. If a symbol is used,

– the symbol ⁓, IEC 60417-5032 (2002-10) shall be used for AC;

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– the symbol ⎓, IEC 60417-5031 (2002-10) shall be used for DC;

– the symbol 3~, IEC 60417-5032-1 (2002-10) shall be used for three-phase AC;

– the symbol 3N~, IEC 60417-5032-2 (2002-10) shall be used for three-phase AC with a neutral conductor; or

– the symbol ⏦, IEC 60417-5033 (2002-10) shall be used for combined AC and DC.

Three-phase equipment may be identified with “3-phase” or “3Ø” or any other arrangement that clearly indicates the phase of the supply voltage of the equipment.

F.3.3.4 Rated voltage

The **rated voltage** of the equipment shall be marked on the equipment. The voltage rating marking shall be immediately followed by the nature of the supply marking.

The **rated voltage** may be:

– a single, nominal value; or

– a single nominal value and a tolerance percentage of the nominal value; or

– two or more nominal values separated by a solidus (/); or

– a range indicated by minimum and maximum values separated by a hyphen; or

– any other arrangement that clearly indicates the voltage of the equipment.

If the equipment has more than one nominal voltage, all such voltages may be marked on the equipment. However, the voltage for which the equipment is set shall be clearly indicated (see F.3.4). If the equipment is installed by a **skilled person**, this indication may be in the installation instructions or at any location on the equipment, including inside the equipment.

Three-phase equipment shall be marked with the phase-to-phase voltage, a symbol indicating power supply system in accordance with IEC 61293, a solidus (/), the phase-to-neutral voltage, the symbol for voltage (*V*) and the number of phases, in that order. Any other arrangement that clearly indicates the three-phase **rated voltage** of the equipment is also acceptable.

NOTE The solidus (/) represents the word “or” and the hyphen (-) represents the word “to”.

F.3.3.5 Rated frequency

The **rated frequency** of the equipment shall be marked on the equipment.

The **rated frequency** may be:

– a single, nominal value; or

– a single nominal value and a tolerance percentage of the nominal value; or

– two or more nominal values separated by a solidus (/); or

– a range indicated by minimum and maximum values separated by a hyphen; or

– any other arrangement that clearly indicates the **rated frequency** of the equipment.

F.3.3.6 Rated current or rated power

The **rated current** or **rated power** of the equipment shall be marked on the equipment.

For three-phase equipment, the **rated current** is the current of one phase and the **rated power** is the total power of the three phases.

NOTE 1 B.2.5 establishes criteria for the way in which **rated current** or **rated power** are measured.

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NOTE 2 The **rated current** or **rated power** need not be stated to more than one significant digit.

NOTE 3 In some countries, for markings on equipment, a period is used as the decimal designator.

If the equipment has a socket-outlet for providing **mains** power to other equipment, the **rated current** or **rated power** of the equipment shall include the assigned current or power of the socket-outlet.

See F.3.5.1 for marking requirements for a **mains** socket-outlet.

If the equipment has more than one **rated voltage**, the **rated current** or **rated power** for each **rated voltage** shall be marked on the equipment. The arrangement of the markings shall clearly indicate the **rated current** or **rated power** associated with each **rated voltage** of the equipment.

Equipment with a **rated voltage range** may be marked with either the maximum **rated current** or with the current range.

F.3.3.7 Equipment with multiple supply connections

If the equipment has multiple supply connections, each connection shall be marked with its **rated current** or **rated power**.

Where the multiple **mains** supplies are identical, they may have one marking indicating the number of supplies.

EXAMPLE "240 V ~ / 10 A × N" where N is the number of identical **mains** supply connections.

If the equipment has multiple supply connections, and if each connection has a different **rated voltage** than the other supply connections, each connection shall be marked with its **rated voltage**.

The overall system electrical rating need not be marked.

F.3.3.8 Compliance criteria

Compliance is checked by inspection.

F.3.4 Voltage setting device

If the equipment uses a voltage setting device that is operable by an **ordinary person** or an **instructed person**, the act of changing the voltage setting shall also change the indication of the voltage for which the equipment is set. The setting shall be readable when the equipment is ready for use.

If the equipment uses a voltage-setting device that is operable only by a **skilled person**, and if the act of changing the voltage setting does not also change the indication of the voltage rating, an **instructional safeguard** shall state that, when changing the voltage setting, the indication of the voltage setting shall also be changed.

Compliance is checked by inspection.

F.3.5 Markings on terminals and operating devices

F.3.5.1 Mains appliance outlet and socket-outlet markings

If a **mains** appliance outlet is provided on the equipment, the **rated voltage** and assigned current or power shall be marked adjacent to the appliance outlet.

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If the **mains** socket-outlet is configured in accordance with IEC TR 60083 or a relevant national standard, the assigned current or power shall be marked. If the voltage of the socket-outlet is the same as the **mains** voltage, the voltage need not be marked.

F.3.5.2 Switch position identification marking

The position of a disconnect switch or circuit-breaker shall be identified. Such identification may be comprised of words, symbols, or an indicator.

If a symbol is used, the symbol shall be in accordance with IEC 60417.

F.3.5.3 Replacement fuse identification and rating markings

If a fuse is replaceable by an **ordinary person** or an **instructed person**, identification of a suitable replacement fuse shall be marked adjacent to the fuseholder. Identification shall include the fuse current rating and the following as appropriate:

– if the fuse needs a special breaking capacity which is necessary for the **safeguard** function, the appropriate symbol that indicates the breaking capacity;

– if the fuse can be replaced with a fuse of a different voltage rating, the fuse voltage rating;

– if the fuse is a time-delay fuse, and the time-delay is necessary for the **safeguard** function, the appropriate symbol that indicates the time-delay.

If a fuse is replaceable by an **ordinary person**, the codings of the relevant fuses shall be explained in the user instructions.

If a fuse is not replaceable by an **ordinary person** or an **instructed person**:

– identification of a suitable replacement fuse shall be marked adjacent to the fuse or shall be provided in the service instructions; and

– if the fuse is, or could be, in the neutral of the **mains** supply and after operation of the fuse, parts of the equipment that remain energized are at ES3 level during servicing, an **instructional safeguard** shall state that the fuse may be in the neutral, and that the **mains** shall be disconnected to de-energize the phase conductors.

If a fuse is not intended to be replaceable, fuse ratings need not be marked.

F.3.5.4 Replacement battery identification marking

If a **battery** can be replaced by an incorrect type of replaceable **battery**, an **instructional safeguard** shall be provided in accordance with Clause M.10.

F.3.5.5 Neutral conductor terminal

For **permanently connected equipment**, the terminal, if any, intended exclusively for connection of the **mains** neutral conductor shall be identified by the capital letter “N”.

F.3.5.6 Terminal marking location

The terminal markings specified in F.3.5.5, F.3.6.1 and F.3.6.3 shall not be placed on screws, removable washers, or other parts that can be removed when conductors are being connected.

F.3.5.7 Compliance criteria

Compliance is checked by inspection.

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F.3.6 Equipment markings related to equipment classification

F.3.6.1 Class I equipment

F.3.6.1.1 Protective earthing conductor terminal

The terminal intended for connection of **class I equipment** to the installation **protective earthing conductor** shall be identified with the symbol  , IEC 60417-5019 (2006-08).

A terminal intended for connection of a class I sub-assembly (for example, a power supply), or a component (for example, a terminal block) to the equipment **protective earthing conductor** may be identified with either symbol  , IEC 60417-5019 (2006-08), or with symbol  , IEC 60417-5017 (2006-08).

F.3.6.1.2 Protective bonding conductor terminals

Terminals for **protective bonding conductors** need not be identified.

If such terminals are identified, they shall be marked with the earth symbol  , IEC 60417-5017 (2006-08). However, a component terminal or a terminal for bonding wiring from the appliance inlet already marked with the symbol  , IEC 60417-5019 (2006-08), is acceptable as identification of a **protective bonding conductor** terminal.

F.3.6.2 Equipment class marking

Class II equipment with a **functional earthing** connection shall bear the symbol  , IEC 60417-6092 (2013-03).

All other **class II equipment** shall bear the symbol  , IEC 60417-5172 (2003-02).

The above symbols shall not be used for **class I equipment**.

Equipment providing **protective earthing** to other equipment shall not be classified as **class II equipment**.

F.3.6.3 Functional earthing terminal marking

Wiring terminals to be used only for the connection of **functional earthing** shall be marked with the symbol  , IEC 60417-5018 (2011-07). These terminals shall not be marked with the symbol  , IEC 60417-5017 (2006-08) or with the symbol  , IEC 60417-5019 (2006-08).

However, these symbols may be used for a wiring terminal provided on a component (for example, a terminal block) or subassembly.

F.3.6.4 Compliance criteria

Compliance is checked by inspection.

F.3.7 Equipment IP rating marking

If the equipment is intended for other than IPX0, the equipment shall bear the IP number according to the degree of protection against ingress of water in accordance with IEC 60529.

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Compliance is checked by inspection.

F.3.8 External power supply output marking

The DC output of an external power supply shall be marked with the voltage rating, the current rating and the polarity. Polarity marking is not required when the pin configuration prevents reversed polarity. The AC output of an external power supply shall be marked with the voltage rating, the current rating and the frequency if it is different from the input frequency.

Compliance is checked by inspection and measurement.

F.3.9 Durability, legibility and permanence of markings

In general, all markings required to be on the equipment shall be durable and legible, and shall be easily discernable under normal lighting conditions.

Unless otherwise specified, **instructional safeguards** do not have to be in colour. If an **instructional safeguard** is in colour to indicate hazard severity, the colour shall be in accordance with the ISO 3864 series. Markings that are engraved or moulded need not be in contrasting colours provided that they are legible and readily discernable under normal lighting conditions.

Printed or screened markings shall also be permanent.

Compliance is checked by inspection. Permanency is determined by the tests of F.3.10.

F.3.10 Test for the permanence of markings

F.3.10.1 General

Each required printed or screened marking shall be tested. However, if the data sheet for a label confirms compliance with the test requirements, the test need not be performed.

F.3.10.2 Testing procedure

The test is conducted by rubbing the marking by hand without appreciable force for 15 s with a piece of cloth soaked with water and at a different place or on a different sample for 15 s with a piece of cloth soaked with the petroleum spirit specified in F.3.10.3.

F.3.10.3 Petroleum spirit

Petroleum spirit is a reagent grade hexane with a minimum of 85 % n-hexane.

NOTE The designation “n-hexane” is chemical nomenclature for“a "normal" or straight chain hydrocarbon. The CAS (American Chemical Society) number of n-hexane is CAS#110-54-3.

F.3.10.4 Compliance criteria

After each test, the marking shall remain legible. If the marking is on a separable label, the label shall show no curling and shall not be removable by hand.

F.4 Instructions

When information with regard to safety is required according to this document, this information shall be given in an instruction for installation or instruction for initial use. This information shall be available prior to installation and initial use of the equipment.

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Equipment for use in locations where children are not likely to be present and that is evaluated using the jointed test probe of Figure V.2 shall have the following or equivalent statement in the user instructions.

NOTE 1 This equipment design typically applies to commercial or industrial equipment expected to be installed in locations where only adults are normally present.

This equipment is not suitable for use in locations where children are likely to be present.

NOTE 2 See also ISO/IEC Guide 37, instructions for use of products of consumer interest.

The instructions shall include the following as far as applicable:

– Instructions to ensure correct and safe installation and interconnection of the equipment.

– For equipment intended only for use in a **restricted access area**, the instructions shall so state.

– If the equipment is intended to be fastened in place, the instructions shall explain how to securely fasten the equipment.

– For audio equipment with terminals classified as ES3 in accordance with Table E.1, and for other equipment with terminals marked in accordance with F.3.6.1, the instructions shall require that the external wiring connected to these terminals shall be installed by a **skilled person**, or shall be connected by means of ready-made leads or cords that are constructed in a way that would prevent contact with any ES3 circuit.

– If **protective earthing** is used as a **safeguard**, the instructions shall require connection of the equipment **protective earthing conductor** to the installation **protective earthing conductor** (for example, by means of a power cord connected to a socket-outlet with earthing connection).

– For equipment with **protective conductor current** on the **protective earthing conductor** exceeding the ES2 limits of 5.2.2.2, the equipment shall bear an **instructional safeguard** in accordance with 5.7.6.

– Graphical symbols placed on the equipment and used as an **instructional safeguard** shall be explained.

– If a **permanently connected equipment** is not provided with an all-pole **mains** switch, the instructions for installation shall state that an all-pole **mains** switch in accordance with Annex L shall be incorporated in the electrical installation of the building.

– If a replaceable component or module provides a **safeguard** function, identification of a suitable replacement component or module shall be provided in the **ordinary person** instructions, or **instructed person** instructions, or **skilled person** instructions, as applicable.

– For equipment containing an **insulating liquid**, safety instructions shall be provided where applicable, including the use of PPE if needed, taking into account the manufacturer's data for the **insulating liquid** and the information in the material safety data sheet.

– The installation instructions for **outdoor equipment** shall include details of any special features needed for protection from conditions in the **outdoor location**.

Compliance is checked by inspection.

F.5 Instructional safeguards

Unless otherwise specified, an **instructional safeguard** is comprised of element 1a or element 2, or both, together with element 3 and element 4. If a suitable symbol for element 1a is not available, then element 1b may be used instead.

Unless otherwise specified, the location of the **instructional safeguard** shall be as follows:

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– the complete **instructional safeguard** shall be marked on the equipment; or

– element 1a or element 2, or both, shall be marked on the equipment and the complete **instructional safeguard** shall be in the text of an accompanying document. If only element 2 is used, the text shall be preceded by the word “Warning” or “Caution” or similar wording.

Any **instructional safeguard** element placed on the equipment shall be visible to the person prior to potential exposure to the class 2 energy source or class 3 energy source parts and as close as reasonably possible to the energy source parts.

Elements 1a, 1b, 2, 3, and 4 are specified in Table F.1.

A single **instructional safeguard** may be related to several parts, provided those parts are closely located near each other. An accompanying document or the instruction manual shall show the locations of these parts, if these parts are not easily identifiable, or not located adjacent to the **instructional safeguard**.

Table F.1 – Instructional safeguard element description and examples

Element	Description	Example
1a	A symbol that identifies the nature of the class 2 or class 3 energy source or the consequences that can be caused by the class 2 or class 3 energy source.	
1b	A symbol such as ISO 7000-0434 (2004-01) or a combination of this symbol and ISO 7000-1641 (2004-01) to refer to text in an accompanying document. These symbols may be combined.	
2	Text that identifies the nature of the class 2 or class 3 energy source or the consequences that can be caused by the energy source, and the location of the energy source.	**Hot parts!**
3	Text that describes the possible consequences of energy transfer from the energy source to a body part.	Burned fingers when handling the parts
4	Text that describes the **safeguard** action necessary to avoid energy transfer to a body part.	Wait one-half hour after switching off before handling parts
The symbols for elements 1a and 1b shall be from IEC 60417, ISO 3864-2, ISO 7000, ISO 7010 or the equivalent.		

Figure F.1 illustrates one example of the arrangement of the four elements that comprise a complete **instructional safeguard**. Other arrangements in the positioning of the elements are also acceptable.

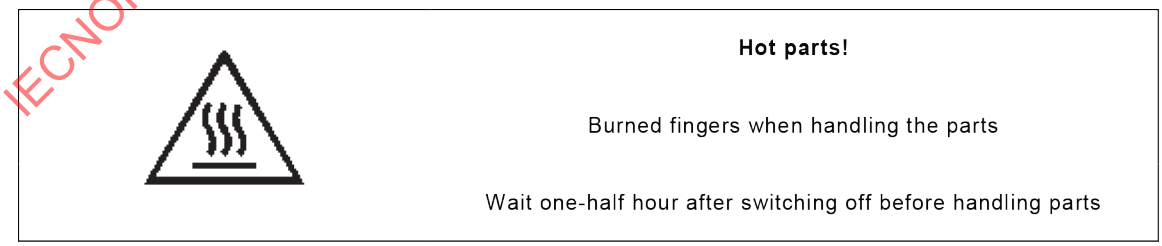


Figure F.1 – Example of an instructional safeguard

See Table F.2 for examples of markings, instructions, and **instructional safeguards**.

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Table F.2 – Examples of markings, instructions, and instructional safeguards

Rating	Example
Rated **DC voltage**	48 V DC 48 V ⎓
Rated AC voltage	230 V ~ 230 V ~ ±10 % 100/120/220/240 V AC 100–250 V AC
Rated 3-phase voltage	400 Y/230 V 3Ø 208 Y/120 V 3-phase 208 Y/120 V 3 ~
Rated frequency	50-60 Hz 50/60 Hz
Rated current	1 A
AC rated power	
DC rated power	
Instruction	**Example**
Positioning of **cell**, IEC 60417-5002 (2002-10)	
AC, IEC 60417-5032 (2002-10)	
DC, IEC 60417-5031 (2002-10)	
Class II equipment, IEC 60417-5172 (2003-02)	
Caution, ISO 7000, 0434a or 0434b (2004-01)	
Dangerous voltage, IEC 60417-5036 (2002-10)	
Earth; ground, IEC 60417-5017 (2006-08)	
Protective earth; protective ground, IEC 60417-5019 (2006-08)	

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Annex G
(normative)

Components

G.1 Switches

G.1.1 General

Requirements for switches that are located in PS3 are specified below.

A switch may be tested separately or in the equipment.

G.1.2 Requirements

Switches used as **disconnect devices** shall comply with the requirements in Annex L.

A switch shall not be fitted in a **mains** supply cord.

A switch shall comply with all of the following:

– comply with the requirements of IEC 61058-1:2016, whereby the following applies:
  - 10 000 operating cycles (see 7.1.4.4 of IEC 61058-1:2016);
  - the switch shall be suitable for use in the **pollution degree** environment in which it is used, typically a **pollution degree** 2 environment (see 7.1.6.2 of IEC 61058-1:2016);
  - the switch have a glow wire temperature of 850 °C (see 7.1.9.3 of IEC 61058-1:2016);
  - for **mains** switches used in CRT televisions, the speed of contact making and breaking shall be independent of the speed of actuation;

    NOTE This is because there is a high inrush current due to the degausing coil.
  - the characteristics of the switch with regard to the ratings and classification (see IEC 61058-1) shall be appropriate for the function of the switch under **normal operating conditions** as given below:
    – the ratings of the switch (see Clause 6 of IEC 61058-1:2016);
    – the classification of the switch according to:
      - nature of supply (see 7.1.1 of IEC 61058-1:2016);
      - type of load to be controlled by the switch (see 7.1.2 of IEC 61058-1:2016);
      - ambient air temperature (see 7.1.3 of IEC 61058-1:2016).

    Compliance is checked according to IEC 61058-1:2016.

– the switch shall be so constructed that it does not attain excessive temperatures under **normal operating conditions**;

  Compliance is checked in the on-position according to 16.2.2 d), l) and m) of IEC 61058-1:2008, except the current is the sum of the equipment current and the maximum current supplied to other equipment, if any.

– a **mains** switch controlling connectors supplying power to other equipment shall withstand the electrical endurance test according to 17.2 of IEC 61058-1:2016, with an additional load according to Figure 9 of IEC 61058-1:2016. The total current rating of the additional load shall correspond to the marking of the connectors supplying power to other equipment. The peak surge current of the additional load shall have a value as shown in Table G.1.

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Table G.1 – Peak surge current

Current rating A	Peak surge current A
up to and including 0,5	20
up to and including 1,0	50
up to and including 2,5	100
over 2,5	150

G.1.3 Test method and compliance criteria

The tests of IEC 61058-1:2016 shall be applied with the modifications shown in G.1.2.

*After the tests, the switch shall show no deterioration of its **enclosure** and no loosening of electrical connections or mechanical fixings.*

G.2 Relays

G.2.1 Requirements

The requirements for relays that are located in a PS3 circuit are specified below.

A relay may be tested separately or in the equipment.

For resistance to heat and fire, see Clause 16 in IEC 61810-1:2015.

A relay shall comply with the requirements of IEC 61810-1:2015, taking into account the following:

– materials shall comply with 6.4.5.2 or pass a glow wire test at 750 °C or a needle flame test;

– 10 000 operating cycles for endurance (see 5.5 of IEC 61810-1:2015) and during the electric endurance test (see Clause 11 of IEC 61810-1:2015), no temporary malfunction shall occur;

NOTE A temporary malfunction is an event that has to be eliminated during the test at latest after one additional energization cycle without any external influence (see Clause 11 of IEC 61810-1:2015).

– the relay shall be suitable for use in the applicable pollution situation (see Clause 13 of IEC 61810-1:2015);

– characteristics of the relay with regard to the ratings and classification (see IEC 61810-1), shall be appropriate for the function of the relay under **normal operating condition** as given below:

- rated coil voltage and rated coil voltage range (see 5.1 of IEC 61810-1:2015);
- rated contact load and the type of load (see 5.7 of IEC 61810-1:2015);
- release voltage (see 5.3 of IEC 61810-1:2015);
- the ambient air temperature and upper and lower limit of the temperature (see 5.8 of IEC 61810-1:2015);
- only relay technology category RT IV and RT V shall be considered to meet **pollution degree** 1 environment, for example, the relay meets 5.4.1.5.2 of this document (see 5.9 of IEC 61810-1:2015);

– electric strength (see 10.3 of IEC 61810-1:2015), except the test voltage shall be the required test voltage specified in 5.4.9.1 of this document;

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– if the **required withstand voltage** (referred to as impulse withstand voltage in IEC 61810-1) exceeds 12 kV, **clearances** shall comply with Table 14 of this document;

– if the **RMS working voltage** (referred to as voltage RMS in IEC 61810-1) exceeds 500 V, **creepage distances** shall comply with Table 17 of this document;

– **solid insulation** in accordance with 13.3 of IEC 61810-1:2015 or with 5.4.4 of this document.

Compliance is checked according to IEC 61810-1 and the requirements of this document.

G.2.2 Overload test

A relay shall withstand the following test.

The contact of the relay is subjected to an overload test consisting of 50 cycles of operation at the rate of 6 to 10 cycles per minute, making and breaking 150 % of the current imposed in the application, except that where a contact switches a motor load, the test is conducted with the rotor of the motor in a locked condition. After the test, the relay shall still be functional.

G.2.3 Relay controlling connectors supplying power to other equipment

*A **mains** relay controlling connectors supplying power to other equipment shall withstand the endurance test of Clause 11 of IEC 61810-1:2015, with an additional load that is equal to the total marked load of the connectors supplying power to other equipment.*

G.2.4 Test method and compliance criteria

*For **mains** relays, the tests of IEC 61810-1 and this document shall be applied with the modifications shown in Clause G.2 of this document.*

*After the tests, the relay shall show no deterioration of its **enclosure**, no reduction of **clearances** and **creepage distances** and no loosening of electrical connections or mechanical fixings.*

G.3 Protective devices

G.3.1 Thermal cut-offs

G.3.1.1 Requirements

A **thermal cut-off** used as a **safeguard** shall comply with requirements a) and b), or c).

NOTE In IEC 60730-1, a "**thermal cut-off**" is a "thermal cut-out"

a) The **thermal cut-off**, when tested as a separate component, shall comply with the requirements and tests of the IEC 60730 series as far as applicable:
   – the **thermal cut-off** shall be of Type 2 action (see 6.4.2 of IEC 60730-1:2013);
   – the **thermal cut-off** shall have at least micro-disconnection, Type 2B (see 6.4.3.2 and 6.9.2 of IEC 60730-1:2013);
   – the **thermal cut-off** shall have a trip-free mechanism in which contacts cannot be prevented from opening against a continuation of a fault, Type 2E (see 6.4.3.5 of IEC 60730-1:2013);
   – the number of cycles of automatic action shall be at least:
      • 3 000 cycles for a **thermal cut-off** with automatic reset used in circuits that are not switched off when the equipment is switched off (see 6.11.8 of IEC 60730-1:2013),
      • 300 cycles for a **thermal cut-off** with automatic reset used in circuits that are switched off together with apparatus and for **thermal cut-off** with no automatic

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reset that can be reset by hand from the outside of the equipment (see 6.11.10 of IEC 60730-1:2013),

- 30 cycles for a **thermal cut-off** with no automatic reset and that cannot be reset by hand from the outside of the equipment (see 6.11.11 of IEC 60730-1:2013);

– the **thermal cut-off** shall be tested as designed for a long period of electrical stress across insulating parts (see 6.14.2 of IEC 60730-1:2013);

– the **thermal cut-off** shall meet the conditioning requirements for an intended use of at least 10 000 h (see 6.16.3 of IEC 60730-1:2013);

– the contact gap, and the distance between the terminations and connecting leads of the contacts, shall comply with 13.1.4 and 13.2 of IEC 60730-1:2013.

b) The characteristics of the **thermal cut-off** with regard to

– the ratings of the **thermal cut-off** (see Clause 5 of IEC 60730-1:2013);

– the classification of the **thermal cut-off** according to the:

- nature of supply (see 6.1 of IEC 60730-1:2013),
- type of load to be controlled (see 6.2 of IEC 60730-1:2013),
- degree of protection provided by **enclosures** against ingress of solid objects and dust (see 6.5.1 of IEC 60730-1:2013),
- degree of protection provided by **enclosures** against harmful ingress of water (see 6.5.2 of IEC 60730-1:2013),
- pollution situation for which the **thermal cut-off** is suitable (see 6.5.3 of IEC 60730-1:2013),
- maximum ambient temperature limit (see 6.7 of IEC 60730-1:2013),

shall be appropriate for the application in the equipment.

c) The **thermal cut-off** when tested as a part of the equipment shall:

– have at least micro-disconnection according to IEC 60730-1 withstanding a test voltage according to 13.2 of IEC 60730-1:2013; and

– have a trip-free mechanism, in which contacts cannot be prevented from opening against a continuation of a fault; and

– be conditioned for 300 h when the equipment is operated under **normal operating conditions** at an ambient temperature of 30 °C or at the maximum ambient temperature specified by the manufacturer, whichever is higher; and

– be subjected to a number of cycles of automatic action as specified under a) for a **thermal cut-off** tested as a separate component, by estimating the relevant fault conditions.

G.3.1.2 Test method and compliance criteria

*The **thermal cut-off** is checked according to the test specifications of IEC 60730 series by inspection and by measurement. The test is made on three specimens.*

*During the test, no sustained arcing shall occur. After the test, the **thermal cut-off** shall show no loosening of electrical connections or mechanical fixings.*

G.3.2 Thermal links

G.3.2.1 Requirements

A thermal link used as a **safeguard** shall meet either requirement a) or b) below:

a) The thermal link when tested as a separate component, shall comply with the requirements of IEC 60691.

The characteristics of the thermal link with regard to:

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- the ambient conditions (see Clause 5 of IEC 60691:2015);
- the electrical conditions (see 6.1 of IEC 60691:2015);
- the thermal conditions (see 6.2 of IEC 60691:2015);
- the rating of the thermal link (see Clause 8 b) of IEC 60691:2015); and
- the suitability for sealing in, or use with impregnating fluids or cleaning solvents (see Clause 8 c) of IEC 60691:2015),

shall be appropriate for the application in the equipment under **normal operating conditions** and under **single fault conditions**.

The electric strength of the thermal link shall meet the requirements of 5.4.9.1 of this document except across the disconnection (contact parts) and except between terminations and connecting leads of the contacts, for which 10.3 of IEC 60691:2015 applies.

b) The thermal link when tested as a part of the equipment shall be:

- aged for 300 h at a temperature corresponding to the ambient temperature of the thermal link when the equipment is operated under **normal operating conditions** at an ambient temperature of 30 °C or at the maximum ambient temperature specified by the manufacturer, whichever is higher; and
- subjected to such **single fault conditions** of the equipment that cause the thermal link to operate. During the test, no sustained arcing shall occur; and
- capable of withstanding two times the voltage across the disconnection and have an insulation resistance of at least 0,2 MΩ, when measured with a voltage equal to two times the voltage across the disconnection.

G.3.2.2 Test method and compliance criteria

If a thermal link is tested as a separate component according to G.3.2.1 a) above, compliance is checked according to the test specifications of IEC 60691, by inspection and measurement.

If a thermal link is tested as a part of the equipment according to G.3.2.1 b) above, compliance is checked by inspection and by the specified tests in the given order. The test is carried out three times. The thermal link is replaced partially or completely after each test.

When the thermal link cannot be replaced partially or completely, the complete component part including the thermal link (for example, a transformer) should be replaced.

No failure is allowed.

G.3.3 PTC thermistors

PTC thermistors used as **safeguards** shall comply with Clauses 15, 17, J.15 and J.17 of IEC 60730-1:2013.

For PTC thermistors,

- whose continuous power dissipation that appears at its maximum voltage at an ambient temperature of 25 °C or otherwise specified by the manufacturer for tripped state, determined as given in 3.38 of IEC 60738-1:2006, exceeds 15 W; and
- with a size of 1 750 mm^3 or more; and
- located in a PS2 or PS3 circuit,

the encapsulation or tubing shall be made of **V-1 class material** or equivalent material.

NOTE Tripped state means the state in which PTC thermistors are shifted to a high resistance condition at a given temperature.

Compliance is checked by inspection.

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G.3.4 Overcurrent protective devices

Except for devices covered by G.3.5, overcurrent protective devices used as a **safeguard** shall comply with their applicable IEC standards in accordance with 4.1.2. Such a protective device shall have adequate breaking (rupturing) capacity to interrupt the maximum fault current (including short-circuit current) that can flow.

Compliance is checked by inspection.

G.3.5 Safeguard components not mentioned in G.3.1 to G.3.4

G.3.5.1 Requirements

Such protective devices (for example, fusing resistors, fuse-links not standardized in IEC 60127 series, IEC 60269 series or miniature circuit breakers) shall have adequate rating including breaking capacity.

For non-resettable protective devices, such as fuse-links, a marking shall be provided in accordance with F.3.5.3.

G.3.5.2 Test method and compliance criteria

*Compliance is checked by inspection and by performing **single fault condition** testing as specified in Clause B.4.*

The test is carried out three times. No failure is allowed.

G.4 Connectors

G.4.1 Clearance and creepage distance requirements

The **clearance** and **creepage distance** between the outer insulating surface of a connector (including an opening in the **enclosure**) and conductive parts that are connected to ES2 within the connector (or in the **enclosure**) shall comply with the requirements for **basic insulation**.

The **clearance** and **creepage distance** between the outer insulating surface of a connector (including an opening in the **enclosure**) and conductive parts that are connected to ES3 within the connector (or in the **enclosure**) shall comply with the requirements for **reinforced insulation**. As an exception, the **clearance** and **creepage distance** may comply with the requirements for **basic insulation** if the connector is:

– fixed to the equipment; and

– located internally to the outer **electrical enclosure** of the equipment; and

– only **accessible** after removal of a subassembly that

- is required to be in place during **normal operating conditions**, and
- is provided with an **instructional safeguard** to replace the removed subassembly.

The tests of 5.3.2 apply to such connectors after removal of the subassembly.

G.4.2 Mains connectors

Mains connectors that are listed in IEC TR 60083 and comply with IEC 60884-1, or that comply with one of the following standards – IEC 60309 series, IEC 60320 series, IEC 60906-1 or IEC 60906-2 – are considered acceptable without further evaluation when used within their ratings for the purpose of connecting or interconnecting **mains** power.

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G.4.3 Connectors other than mains connectors

Connectors other than for connecting **mains** power shall be so designed that the plug has such a shape that insertion into a **mains** socket-outlet or appliance coupler is unlikely to occur.

EXAMPLE Connectors meeting this requirement are those constructed as described in IEC 60130-9, IEC 60169-3 or IEC 60906-3. An example of a connector not meeting the requirements of this subclause is the so-called "banana" plug. Standard 3,5 mm audio plugs are not considered likely to be put in the **mains** socket outlet.

Compliance is checked by inspection.

G.5 Wound components

G.5.1 Wire insulation in wound components

G.5.1.1 General

This clause applies to wound components comprising **basic insulation**, **supplementary insulation** or **reinforced insulation**.

G.5.1.2 Protection against mechanical stress

Where two winding wires, or one winding wire and another wire, are in contact inside the wound component, crossing each other at an angle between 45° and 90°, one of the following applies:

– protection against mechanical stress shall be provided. For example, this protection can be achieved by providing physical separation in the form of insulating sleeving or sheet material, or by using double the required number of insulation layers on the winding wire; or

– the wound component passes the endurance tests of G.5.2.

Additionally, if the above construction provides **basic insulation**, **supplementary insulation** or **reinforced insulation**, the finished wound component shall pass a **routine test** for electric strength in accordance with 5.4.9.2.

G.5.1.3 Test method and compliance criteria

Compliance is checked by 5.4.4.1 and, where required, by G.5.2. If the tests of Annex J are required, they are not repeated if the material data sheets confirm compliance.

G.5.2 Endurance test

G.5.2.1 General test requirements

Where required by G.5.1.2, three samples of the wound component are subjected to 10 test cycles as follows:

– *The samples are subjected to the heat run test of G.5.2.2. After the test, the samples are allowed to cool down to ambient temperature.*

– *The samples are then subjected to the vibration test of G.15.2.4.*

– *The samples are then subjected for two days to the humidity conditioning of 5.4.8.*

The tests described below are made before the start of the 10 cycles and after each cycle.

The electric strength test of 5.4.9.1 is carried out.

*After the electric strength test, the test of G.4.3 is made on wound components that are supplied from the **mains**, except for switching mode power supply.*

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G.5.2.2 Heat run test

Depending on the type thermal classification of the insulation, the specimens are kept in a heating cabinet for a combination of time and temperature as specified in Table G.2. The 10 cycles are carried out with the same combination.

The temperature in the heating cabinet shall be maintained within a tolerance of ± 5 °C.

Table G.2 – Test temperature and testing time (days) per cycle

Thermal classification	Class 105 (A)	Class 120 (E)	Class 130 (B)	Class 155 (F)	Class 180 (H)	Class 200 (N)	Class 220 (R)	Class 250
Test temperature °C	Testing time duration for the test of G.5.2							
290								4 days
280								7 days
270								14 days
260							4 days	
250							7 days	
240						4 days	14 days	
230						7 days		
220					4 days	14 days		
210					7 days			
200					14 days			
190				4 days				
180				7 days				
170				14 days				
160			4 days					
150		4 days	7 days					
140		7 days						
130	4 days							
120	7 days							

The classes are related to the classification of electrical insulating materials and EIS in accordance with IEC 60085. The assigned letter designations are given in parentheses.

The manufacturer shall specify the test duration or the test temperature.

G.5.2.3 Wound components supplied from the mains

*One input circuit is connected to a voltage equal to a test voltage of at least 1,2 times the **rated voltage**, at double the **rated frequency** for 5 min. No load is connected to the transformer. During the test, multiple wire windings, if any, are connected in series.*

*A higher test frequency may be used; the duration of the period of connection, in minutes, then being equal to 10 times the **rated frequency** divided by the test frequency, but not less than 2 min.*

*The test voltage is initially set at **rated voltage** and gradually increased up to 1,2 times the initial value, and then maintained for the time specified. If during the test there is a non-linear change of current in an uncontrollable manner, it is regarded as breakdown between winding turns.*

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G.5.2.4 Compliance criteria

*For wound components supplied from the **mains**, there shall be no breakdown of the insulation between the turns of a winding, between input and output windings, between adjacent input windings and between adjacent output windings, or between the windings and any conductive core.*

G.5.3 Transformers

G.5.3.1 General

Transformers shall comply with one of the following:

– meet the requirements given in G.5.3.2 and G.5.3.3;
– IEC 61204-7 for a transformer used in a low-voltage power supply;
– meet the requirements of IEC 61558-1 and the relevant parts of IEC 61558-2 with the following additions and limitations:
  - the limit values for ES1 of this document apply (see 5.2.2.2);
  - for **working voltages** above 1 000 V RMS, see 18.3 of IEC 61558-1:2017 using the test voltage specified in 5.4.9.1;
  - the overload test according to G.5.3.3; and
  - IEC 61558-2-16 for transformers used in a switch mode power supply; or
– meet the requirements given in G.5.3.4 for a transformer that uses **FIW**.

EXAMPLES The relevant parts of IEC 61558-2 are:
– IEC 61558-2-1: Separating transformers;
– IEC 61558-2-4: Isolating transformers; and
– IEC 61558-2-6: Safety isolating transformers.

G.5.3.2 Insulation

G.5.3.2.1 Requirements

Insulation in transformers shall comply with the following requirements.

Windings and conductive parts of transformers shall be treated as parts of the circuits to which they are connected, if any. The insulation between them shall comply with the relevant requirements of Clause 5 and pass the relevant electric strength tests, according to the application of the insulation in the equipment.

Precautions shall be taken to prevent the reduction below the required minimum values of **clearances** and **creepage distance** that provide **basic insulation**, **supplementary insulation** or **reinforced insulation** by:

– displacement of windings, or their turns;
– displacement of internal wiring or wires for external connections;
– undue displacement of parts of windings or internal wiring, in the event of rupture of wires adjacent to connections or loosening of the connections; and
– bridging of insulation by wires, screws, washers and the like should they loosen or become free.

It is not expected that two independent fixings will loosen at the same time.

All windings shall have the end turns retained by positive means.

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Examples of acceptable forms of construction are the following (there are other acceptable forms of construction):

– windings isolated from each other by placing them on separate limbs of the core, with or without spools;
– windings on a single spool with a partition wall, where either the spool and partition wall are pressed or moulded in one piece, or a pushed-on partition wall has an intermediate sheath or covering over the joint between the spool and the partition wall;
– concentric windings on a spool of insulating material without flanges, or on insulation applied in thin sheet form to the transformer core;
– insulation is provided between windings consisting of sheet insulation extending beyond the end turns of each layer;
– concentric windings, separated by an earthed conductive screen that consists of metal foil extending the full width of the windings, with suitable insulation between each winding and the screen. The conductive screen and its lead-out wire have a cross-section sufficient to ensure that on breakdown of the insulation an overload device will open the circuit before the screen is destroyed. The overload device may be a part of the transformer.

If a transformer is fitted with an earthed screen for protective purposes, the transformer shall pass the test of 5.6.6 between the earthed screen and the earthing terminal of the transformer.

No electric strength test applies to insulation between any winding and the core or screen, provided that the core or screen is totally enclosed or encapsulated and there is no electrical connection to the core or screen. However, the tests between windings that have terminations continue to apply.

G.5.3.2.2 Compliance criteria

Compliance is checked by inspection, measurement and where applicable by test.

G.5.3.3 Transformer overload tests

G.5.3.3.1 Test conditions

If the tests are carried out under simulated conditions on the bench, these conditions shall include any protective device that would protect the transformer in the complete equipment.

Transformers for switch mode power supply units are tested in the complete power supply unit or in the complete equipment. Test loads are applied to the output of the power supply unit.

*A linear transformer or a ferro-resonant transformer has each winding isolated from the **mains** loaded in turn, with any other winding isolated from the **mains** loaded between zero and its specified maximum load to result in the maximum heating effect.*

The output of a switch mode power supply is loaded to result in the maximum heating effect in the transformer.

*Where an overload condition cannot occur or is unlikely to cause a **safeguard** to fail, the tests are not made.*

G.5.3.3.2 Compliance criteria

Maximum temperatures of windings shall not exceed the values in Table G.3 when measured as specified in B.1.5, and determined as specified below:

– *with an external overcurrent protective device: at the moment of operation, for determination of the time until the overcurrent protective device operates, reference may*

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be made to a data sheet of the overcurrent protective device showing the trip time versus the current characteristics;

– *with an automatic reset **thermal cut-off**: as shown in Table G.3 and after 400 h;*

– *with a manual reset **thermal cut-off**: at the moment of operation; or*

– *for current limiting transformers: after the temperature has stabilized.*

If the temperature of the windings of a transformer with a ferrite core, measured as specified in B.1.5, exceeds 180 °C, it shall be retested at maximum rated ambient temperature (T_{amb} = T_{ma}), and not as calculated according to B.2.6.3.

*Windings isolated from the **mains**, that exceed the temperature limits but that become open circuit or otherwise require replacement of the transformer, do not constitute a failure of this test provided that the transformer continues to comply with B.4.8.*

During the test the transformer shall not emit flames or molten-metal. After the test, the transformer shall withstand the electric strength test in 5.4.9.1 as applicable.

Table G.3 – Temperature limits for transformer windings and for motor windings (except for the motor running overload test)

Method of protection	Maximum temperature °C							
	Class 105 (A)	**Class 120** (E)	**Class 130** (B)	**Class 155** (F)	**Class 180** (H)	**Class 200** (N)	**Class 220** (R)	**Class 250** -
No protective device used or protected by internal or external impedance	150	165	175	200	225	245	265	295
Protected by a protective device that operates during the first hour	200	215	225	250	275	295	315	345
Protected by any protective device:								
– maximum after first hour	175	190	200	225	250	270	290	320
– arithmetic average temperature (t_A) during the 2nd hour and during the 72nd hour and during the 400th hour [a]	150	165	175	200	225	245	265	295
The classes are related to the classification of electrical insulating materials and EIS in accordance with IEC 60085. The assigned letter designations are given in parentheses.								

[a] The arithmetic average temperature is determined as follows:

The graph of temperature against time (see Figure G.1), while the power to the transformer is cycling on and off, is plotted for the period of test under consideration. The arithmetic average temperature (t_A) is determined by the formula:

$$t_A = \frac{t_{max} + t_{min}}{2}$$

where:

t_{max} is the average of the maxima,

t_{min} is the average of the minima.

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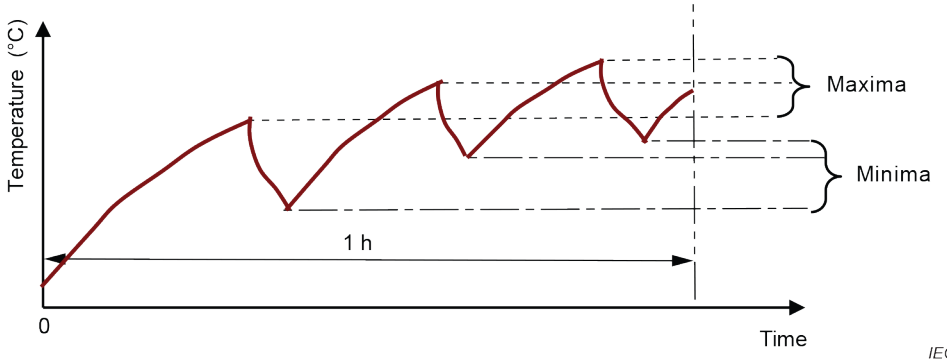


Figure G.1 – Determination of arithmetic average temperature

G.5.3.3.3 Alternative test method

*The transformer is covered with a single layer of **cheesecloth** and is placed on a wooden board that is covered with a single layer of **wrapping tissue**. The transformer is then gradually loaded until one of the following situations occurs:*

- *the overload protective device operates;*
- *the winding becomes an open circuit; or*
- *the load cannot be increased any further without reaching a short-circuit or foldback condition.*

The transformer is then loaded to a point just before the above applicable situation occurs and is operated for 7 h.

*During the test the transformer shall not emit flames or molten metal. The **cheesecloth** or **wrapping tissue** shall not char or catch fire.*

*If the transformer voltage exceeds ES1, the **basic safeguard** or **reinforced safeguard** provided in the transformer shall withstand the electric strength test in 5.4.9.1 as applicable after it has cooled to room temperature.*

G.5.3.4 Transformers using fully insulated winding wire (FIW)

G.5.3.4.1 General

The requirements of G.5.3.4 may only be applied to equipment intended for use in Overvoltage Categories I and II.

Where **FIW** is used within a transformer, the **FIW** shall comply with IEC 60851-5:2008, IEC 60317-0-7 and IEC 60317-56.

FIW windings at ES2 or ES3 levels shall not be **accessible** to an **ordinary person** or an **instructed person**.

If the wire has a nominal diameter other than defined in Table G.5 (FIW3-9), the minimum electric strength value can be calculated according to the formula below Table G.5.

A transformer that uses **FIW** shall comply with IEC 60085 and may only be used up to and including insulation Class 155 (F).

Where mechanical separation is required below, the mechanical separation shall comply with the electric strength test for **basic insulation** in accordance with 5.4.9.1 except that Table G.4 shall be applied instead of Table 26.

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Table G.4 – Test voltages for electric strength tests based on the peak of the working voltages

Voltage up to and including	Test voltage for basic insulation or supplementary insulation	Test voltage for reinforced insulation
V peak	kV peak or DC (Vrms)	
< 70,5	0,35 (0,25)	0,7 (0,5)
212	2 (1,41)	4 (2,82)
423	3 (2,12)	6 (4,24)
846	3,5 (2,47)	7 (4,95)
1 410	3,9 (2,76)	7,8 (5,52)
Linear interpolation may be used between the nearest two points.		
This table is based on Table 14 of IEC 61558-1:2017.		

G.5.3.4.2 Transformers with basic insulation only

FIW serving as **basic insulation** shall be a construction having a minimum test voltage per Table G.5 that exceeds the test voltages for electric strength tests based on 5.4.9.1 except that Table G.4 shall be applied instead of Table 26.

Mechanical separation is required between the **FIW** and enamelled wire.

Clearances and **creepage distances** between the **FIW** and enamelled wire are not required.

NOTE 1 An example of this construction is a transformer with **FIW** as one winding and enamelled wire as the other.

NOTE 2 The specified values in Table G. are RMS

G.5.3.4.3 Transformers with double insulation or reinforced insulation

Transformers with **double insulation** or **reinforced insulation** comprised of:

– two or more **FIW** windings insulated with **basic insulation** and **supplementary insulation**, shall comply with all of the following:
  - **FIW** serving as **basic insulation** and the **FIW** serving as **supplementary insulation** shall each have a minimum test voltage per Table G.5 that exceeds the test voltages for electric strength tests based on 5.4.9.1 except that Table G.4 shall be applied instead of Table 26;
  - mechanical separation that fulfils the electric strength test for **basic insulation** is required between both **FIW** windings; and
  - **clearances** and **creepage distances** between the **FIW** are not required.
– one **FIW** winding provided with **reinforced insulation** shall comply with all of the following:
  - **FIW** serving as **reinforced insulation** shall have a minimum test voltage per Table G.5 that exceeds the test voltages for electric strength tests based on 5.4.9.1 except that Table G.4 shall be applied instead of Table 26;
  - mechanical separation that fulfils the electric strength test for **basic insulation** is required between the **FIW** and enamelled wire windings; and
  - **clearances** and **creepage distances** between the **FIW** and enamelled wire are not required.
– one **FIW** winding provided with **basic insulation** in combination with solid or thin layer insulation serving as **supplementary insulation**, shall comply with all of the following:

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- **FIW** serving as **basic insulation** shall have a minimum test voltage in accordance with Table G.5 that exceeds the test voltages for electric strength tests based on 5.4.9.1 except that Table G.4 shall be applied instead of Table 26;
- solid or thin layer insulation serving as **supplementary insulation** shall comply with Clause 5, including **solid insulation**; and
- **clearances** and **creepage distances** between the **FIW** and enamelled wire are required.

G.5.3.4.4 Transformers with FIW wound on metal or ferrite core

FIW shall be designated **basic insulation** based on the peak of the **working voltage**.

FIW serving as **basic insulation** shall be a construction having a minimum test voltage in accordance with Table G.5 that exceeds the test voltages for electric strength tests based on 5.4.9.1 except that Table G.4 shall be applied instead of Table 26.

Mechanical separation is required between the **FIW** and the metal or ferrite core.

G.5.3.4.5 Thermal cycling test and compliance

*For **transformers** with **FIW** the following test is required:*

Three samples of the transformer shall be used. The samples shall be subjected 10 times to the following sequence of temperature cycles:

– *68 h at the highest winding temperature ± 2 °C measured in normal use plus 10 K with a minimum of 85 °C;*
– *1 h at 25 °C ± 2 °C;*
– *2 h at 0 °C ± 2 °C;*
– *1 h at 25 °C ± 2 °C.*

*During each thermal cycling test, a voltage of twice the value of the **working voltage** at 50 Hz or 60 Hz shall be applied to the samples between the windings.*

After conditioning of the three samples above,

– *two of the three samples are then subjected to the humidity treatment of 5.4.8 (48 h treatment) and the relevant electric strength test of 5.4.9.1, except that* Table G.4 *is applied instead of Table 26; and*
– *the remaining sample shall be subjected to the relevant electric strength test of 5.4.9.1 except that* Table G.4 *is applied instead of Table 26 immediately at the end of the last period at highest temperature during the thermal cycling test.*

There shall be no insulation breakdown during the test.

G.5.3.4.6 Partial discharge test

*If **FIW** is used and if the recurring peak voltage U_t across the insulation is greater than 750 V, a partial discharge test according to IEC 60664-1 (additional test description details below) shall be performed. The partial discharge test shall be done after the thermal cycling test of G.5.3.4.5 at normal room temperature for the two samples that were subjected to the humidity treatment.*

The relevant recurring peak voltage is the maximum measured voltage between the input and the transformer and associated circuitry if the secondary side is earthed.

*The measuring shall be done at the maximum of the **rated voltage** of the equipment.*

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A partial discharge test shall be done at the transformer with the measured recurring peak voltage U_t where:

– *U_t is the maximum peak of the **working voltage**;*

– *t_1 is 5 s;*

– *t_2 is 15 s.*

Partial discharge shall be less than or equal to 10 pC at time t_2. The test shall be done according to Figure G.2. For other applications higher values may be required (for example, IEC 61800-5-1).

G.5.3.4.7 Routine test

*The finished component is subjected to **routine tests** for electric strength (between windings and between windings and the core, see G.5.3.2.1), in accordance with 5.4.9.2.*

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Table G.5 – Values of FIW wires with maximum overall diameter and minimum test voltages according to the enamel increase

Nominal conductor diameter d_{Cu} [mm]	Minimum specific breakdown voltage [a] U_b [V/µm]	Minimum overall FIW diameter d_o [mm]							Minimum dielectric strength test voltage values per wire for basic or reinforced insulation at overall diameter, U_s [V] (duration of 60 s)						
		Grade of FIW 3	Grade of FIW 4	Grade of FIW 5	Grade of FIW 6	Grade of FIW 7	Grade of FIW 8	Grade of FIW 9	Grade of FIW 3	Grade of FIW 4	Grade of FIW 5	Grade of FIW 6	Grade of FIW 7	Grade of FIW 8	Grade of FIW 9
0,04	56	0,055	0,059	0,070	0,080	0,090	0,100		714	904	1 428	1 904	2 380	2 856	
0,045	56	0,062	0,067	0,079	0,090	0,101	0,112		809	1 047	1 618	2 142	2 666	3 189	
0,05	56	0,067	0,073	0,084	0,095	0,106	0,117		809	1 095	1 618	2 142	2 666	3 189	
0,056	56	0,075	0,082	0,093	0,105	0,117	0,129		904	1 238	1 761	2 332	2 904	3 475	
0,063	56	0,084	0,090	0,103	0,116	0,129	0,142		1 000	1 285	1 904	2 523	3 142	3 760	
0,071	56	0,092	0,098	0,111	0,124	0,137	0,150	0,163	1 000	1 285	1 904	2 523	3 142	3 760	4 379
0,08	56	0,102	0,109	0,123	0,137	0,151	0,165	0,179	1 047	1 380	2 047	2 713	3 380	4 046	4 712
0,09	56	0,114	0,121	0,135	0,149	0,163	0,177	0,191	1 142	1 476	2 142	2 808	3 475	4 141	4 808
0,1	56	0,126	0,133	0,149	0,165	0,181	0,197	0,213	1 238	1 571	2 332	3 094	3 856	4 617	5 379
0,112	53	0,140	0,148	0,165	0,182	0,199	0,216	0,233	1 261	1 622	2 388	3 154	3 919	4 685	5 451
0,125	53	0,155	0,164	0,182	0,200	0,218	0,236	0,254	1 352	1 757	2 568	3 379	4 190	5 001	5 811
0,14	53	0,172	0,182	0,202	0,222	0,242	0,262	0,282	1 442	1 892	2 793	3 694	4 595	5 496	6 397
0,16	53	0,195	0,206	0,228	0,250	0,272	0,294	0,316	1 577	2 072	3 063	4 055	5 046	6 037	7 028
0,18	53	0,218	0,230	0,254	0,278	0,302	0,326	0,350	1 712	2 253	3 334	4 415	5 496	6 577	7 659
0,2	53	0,240	0,253	0,278	0,303	0,328	0,353	0,378	1 802	2 388	3 514	4 640	5 766	6 893	8 019
0,224	53	0,267	0,281	0,308	0,335	0,362	0,389	0,416	1 937	2 568	3 784	5 001	6 217	7 433	8 650
0,25	53	0,298	0,313	0,343	0,373	0,403	0,433	0,463	2 162	2 838	4 190	5 541	6 893	8 244	9 596
0,28	53	0,330	0,346	0,377	0,408	0,439	0,470	0,501	2 253	2 973	4 370	5 766	7 163	8 560	9 956
0,315	53	0,368	0,385	0,416	0,447	0,478	0,509	0,540	2 388	3 154	4 550	5 947	7 343	8 740	10 136
0,355	53	0,412	0,429	0,460	0,491	0,522	0,553	0,584	2 568	3 334	4 730	6 127	7 523	8 920	10 316
0,4	49	0,460	0,479	0,510	0,541	0,572	0,603		2 499	3 290	4 582	5 873	7 164	8 455	
0,45	49	0,514	0,534	0,565	0,596	0,627	0,658		2 666	3 499	4 790	6 081	7 372		
0,5	49	0,567	0,588	0,629	0,670	0,711			2 791	3 665	5 373	7 081	8 788		
0,56	37	0,631	0,654	0,695	0,736	0,777			2 233	2 956	4 246	5 535	6 825		
0,63	37	0,705	0,729	0,770	0,811	0,852			2 359	3 114	4 403	5 692	6 982		
0,71	37	0,790	0,815	0,856	0,897	0,938			2 516	3 302	4 592	5 881	7 171		
0,8	37	0,885	0,912	0,963	1,014				2 673	3 522	5 126	6 730			
0,9	37	0,990	1,019	1,070	1,121				2 831	3 743	5 347	6 950			
1	37	1,095	1,125	1,176	1,227				2 988	3 931	5 535	7 139			
1,12	33	1,218	1,249	1,310					2 749	3 618	5 330				
1,25	33	1,350	1,382	1,443					2 805	3 703	5 414				
1,4	33	1,503	1,536	1,597					2 889	3 815	5 526				
1,6	33	1,707	1,741	1,802					3 001	3 955	5 666				

[a] Value according to Table 7 of IEC 60317-0-7:2017.

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*The values of allowed voltage strength for **FIW** dimensions other than specified in Table G.5 are calculated according to the following formula:*

$$V = \frac{d_a - d_{Cu}}{2} \times U \times 10^3$$

where:

d_a *is the maximum overall diameter in mm;*

d_{Cu} *is the nominal copper diameter in mm;*

U *is the voltage value according to Table 7 of IEC 60317-0-7:2017 (see column 2) in V/µm;*

V *is the allowed voltage strength for **FIW** wire in volts.*

Higher voltage values, based on the "enamel increase" of Table 6 of IEC 60317-0-7:2017, are under consideration.

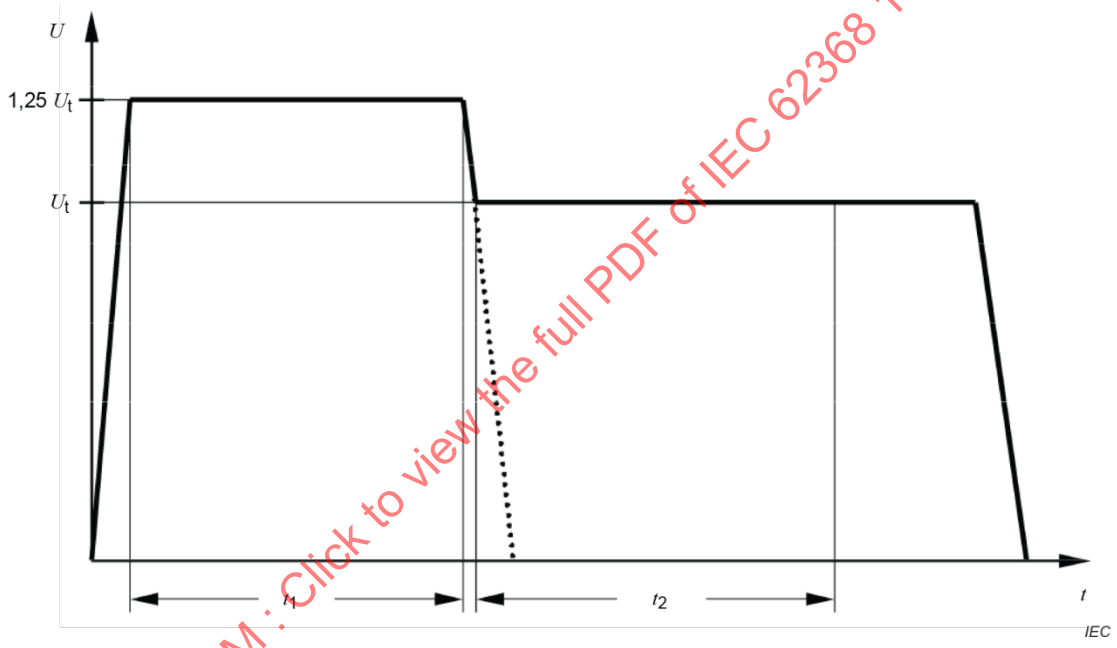


Figure G.2 – Test voltages

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G.5.4 Motors

G.5.4.1 General requirements

DC motors supplied from PS2 or PS3 circuits isolated from the AC **mains** shall comply with the tests of G.5.4.5, G.5.4.6 and G.5.4.9. DC motors that by their intrinsic operation normally operate under locked-rotor conditions, such as stepper motors, are not tested and DC motors that are used for air-handling only and where the air propelling component is directly coupled to the motor shaft are not required to pass the test of G.5.4.5.

All other motors supplied from PS2 or PS3 circuits shall comply with the overload tests of G.5.4.3 and G.5.4.4 and, where applicable, G.5.4.7, G.5.4.8 and G.5.4.9.

However, the following motors are exempt from the test of G.5.4.3:

– motors that are used for air-handling only and where the air-propelling component is directly coupled to the motor shaft; and

– shaded pole motors whose values of locked-rotor current and no-load current do not differ by more than 1 A and have a ratio of not more than 2/1.

G.5.4.2 Motor overload test conditions

Unless otherwise specified, during the test, the equipment is operated at ***rated voltage*** *or at the highest voltage of the* ***rated voltage range****.*

The tests are carried out either in the equipment or under simulated conditions on the bench. Separate samples may be used for bench tests. Simulated conditions include:

– *any protective device that would protect the motor in the complete equipment; and*

– *use of any mounting means that may serve as a heat sink to the motor frame.*

Temperatures of windings are measured as specified in B.1.5. Where thermocouples are used they are applied to the surface of the motor windings. Temperatures are measured at the end of the test period where specified, otherwise when the temperature has stabilized, or at the instant of operation of fuses, ***thermal cut-offs****, motor protective devices and the like.*

For totally enclosed, impedance-protected motors, the temperatures are measured by thermocouples applied to the motor case.

When motors without inherent thermal protection are tested under simulated conditions on the bench, the measured winding temperature is adjusted to take into account the ambient temperature in which the motor is normally located within the equipment.

G.5.4.3 Running overload test and compliance criteria

A running overload test is carried out by operating the motor under ***normal operating conditions****. The load is then increased so that the current is increased in appropriate gradual steps, the motor supply voltage being maintained at its original value. When steady conditions are established, the load is again increased. The load is thus progressively increased in appropriate steps but without reaching locked-rotor condition (see G.5.4.4), until the overload protective device operates.*

Compliance is checked by measuring the motor winding temperatures during each steady period. The measured temperatures shall not exceed the values in Table G.6*.*

Table G.6 – Temperature limits for running overload tests

Maximum temperature °C							
Class 105 (A)	**Class 120 (E)**	**Class 130 (B)**	**Class 155 (F)**	**Class 180 (H)**	**Class 200 (N)**	**Class 220 (R)**	**Class 250 -**
140	155	165	190	215	235	255	275
The classes are related to the classification of electrical insulating materials and EIS in accordance with IEC 60085. The assigned letter designations are given in parentheses.							

G.5.4.4 Locked-rotor overload

G.5.4.4.1 Test method

A locked-rotor test is carried out starting at room temperature.

The duration of the test is as follows:

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– *a motor protected by inherent or external impedance is operated on locked-rotor for 15 days except that testing is discontinued when the windings of the motor reach a constant temperature, provided that the constant temperature is not more than that specified in Table 9 for the insulation system used;*

– *a motor with an automatic reset protective device is cycled on locked-rotor for 18 days;*

– *a motor with a manual reset protective device is cycled on locked-rotor for 60 cycles, the protective device being reset after each operation as soon as possible for it to remain closed, but after not less than 30 s;*

– *a motor with a non-resettable protective device is operated until the device operates.*

G.5.4.4.2 Compliance criteria

Compliance is checked by measuring temperatures at regular intervals during the first three days for a motor with inherent or external impedance protection or with an automatic reset protective device, or during the first 10 cycles for a motor with a manual reset protective device, or at the time of operation of a non-resettable protective device. The measured temperatures shall not exceed the values in Table G.3.

During the test, protective devices shall operate reliably without permanent damage to the motor including:

– *severe or prolonged smoking or flaming;*

– *electrical or mechanical breakdown of any associated component part such as a capacitor or starting relay;*

– *flaking, embrittlement or charring of insulation; or*

– *deterioration of the insulation.*

Discoloration of the insulation may occur, but charring or embrittlement to the extent that insulation flakes off or material is removed when the winding is rubbed with the thumb is not acceptable.

After the period specified for temperature measurement, the motor shall withstand the electric strength test of 5.4.9.1 after the insulation has cooled to room temperature and with test voltages reduced to 0,6 times of the specified values.

NOTE Continuation of the test of an automatic reset protective device beyond 72 h, and of a manual reset protective device beyond 10 cycles, is only for the purpose of demonstrating the capability of the device to make and break locked-rotor current for an extended period of time.

G.5.4.5 Running overload for DC motors

G.5.4.5.1 Requirements

The test of G.5.4.5.2 is carried out only if a possibility of an overload occurring is determined by inspection or by review of the design. For example, the test need not be carried out where electronic drive circuits maintain a substantially constant drive current.

If difficulty is experienced in obtaining accurate temperature measurements, due to the small size or unconventional design of the motor, the method of G.5.4.5.3 can be used instead.

G.5.4.5.2 Test method and compliance criteria

*The motor is operated under **normal operating conditions**. The load is then increased so that the current is increased in appropriate gradual steps, the motor supply voltage being maintained at its original value. When steady conditions are established, the load is again increased. The load is thus progressively increased in appropriate steps until either the overload protection device operates, the winding becomes an open circuit or the load cannot be increased any further without reaching a locked rotor condition.*

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The motor winding temperatures are measured during each steady period. The measured temperatures shall not exceed the values in Table G.6.

*Following the test, if the motor voltage exceeds ES1, the **basic safeguard** or **reinforced safeguard** provided in the motor shall withstand the electric strength test in 5.4.9.1 after it has cooled to room temperature, but with test voltages reduced to 0,6 times the specified values.*

G.5.4.5.3 Alternative method

*The motor is covered with a single layer of **cheesecloth** and placed on a wooden board that is covered with a single layer of **wrapping tissue**. The motor is then gradually loaded until one of the following situations occur:*

- *the overload protective device operates;*
- *the winding becomes an open circuit; or*
- *the load cannot be increased any further without reaching a locked rotor condition.*

*During the test, the motor shall not emit flames or molten metal. The **cheesecloth** or **wrapping tissue** shall not char or catch fire.*

*Following the test, if the motor voltage exceeds ES1, the **basic safeguard** or **reinforced safeguard** provided in the motor shall withstand the electric strength test in 5.4.9.1 after it has cooled to room temperature, but with test voltages reduced to 0,6 times the specified values.*

G.5.4.6 Locked-rotor overload for DC motors

G.5.4.6.1 Requirements

Motors shall pass the test in G.5.4.6.2.

Where difficulty is experienced in obtaining accurate temperature measurements because of the small size or unconventional design of the motor, the method of G.5.4.6.3 can be used instead.

G.5.4.6.2 Test method and compliance criteria

The motor is operated at the voltage used in its application and with its rotor locked for 7 h or until steady state conditions are established, whichever is longer. However, if the motor winding opens, or the motor otherwise becomes permanently de-energized, the test is discontinued.

Compliance is checked by measuring the motor winding temperatures during the test. The measured temperatures shall not exceed the values in Table G.3.

Following the test, if the motor voltage exceeds ES1, and after it has cooled to room temperature, the motor shall withstand the electric strength test in 5.4.9.1 but with test voltages reduced to 0,6 times the specified values.

G.5.4.6.3 Alternative method

*The motor is covered with a single layer of **cheesecloth** and placed on a wooden board that is covered with a single layer of **wrapping tissue**.*

The motor is then operated at the voltage used in its application and with its rotor locked for 7 h or until steady state conditions are established, whichever is the longer. However, if the motor winding opens, or the motor otherwise becomes permanently de-energized, the test is discontinued.

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*During the test, the motor shall not emit flames or molten metal. The **cheesecloth** or **wrapping tissue** shall not char or catch fire.*

Following the test, if the motor voltage exceeds ES1, and after it has cooled to room temperature, the motor shall withstand the electric strength test in 5.4.9.1 but with test voltages reduced to 0,6 times the specified values.

G.5.4.7 Test method and compliance criteria for motors with capacitors

Motors having phase-shifting capacitors are tested under locked-rotor conditions with the capacitor short-circuited or open-circuited (whichever is the more unfavourable).

The short-circuit test is not made if the capacitor is so designed that, upon failure, it will not remain short-circuited.

Compliance is checked by measuring the motor winding temperatures during the test. The measured temperatures shall not exceed the values in Table G.3.

G.5.4.8 Test method and compliance criteria for three-phase motors

*Three-phase motors are tested under **normal operating conditions**, with one phase disconnected, unless circuit controls prevent the application of voltage to the motor when one or more supply phases are missing.*

The effect of other loads and circuits within the equipment may necessitate that the motor be tested within the equipment and with the three supply phases disconnected one at a time.

Compliance is checked by measuring the motor winding temperatures during the test. The measured temperatures shall not exceed the values in Table G.3.

G.5.4.9 Test method and compliance criteria for series motors

Series motors are operated at a voltage equal to 1,3 times the voltage rating of the motor for 1 min with the lowest possible load.

*After the test, windings and connections shall not have worked loose and all applicable **safeguards** shall remain effective.*

G.6 Wire insulation

G.6.1 General

Except for enamelled winding insulation, the following requirements apply to all wires, including wires in wound components (see also Clause G.5), lead-out wires and the like, whose insulation provides **basic insulation**, **supplementary insulation** or **reinforced insulation**.

NOTE 1 For insulation provided in addition to insulation on winding wire, see 5.4.4.

If the peak of the **working voltage** does not exceed ES2, there is no dimensional or constructional requirement.

If the peak of the **working voltage** exceeds ES2, one of the following applies:

a) There is no dimensional or constructional requirement for **basic insulation** that is not under mechanical stress (for example, from winding tension). For **basic insulation** that is under such mechanical stress, b) or c) applies.

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NOTE 2 This exception does not apply to **supplementary insulation** or **reinforced insulation**.

b) For **basic insulation**, **supplementary insulation** or **reinforced insulation**, the insulation on the wire shall:
   - have a thickness of at least 0,4 mm provided by a single layer; or
   - comply with 5.4.4.6 if the wire is not a winding wire; or
   - comply with Annex J if the wire is a winding wire.

c) The winding wire shall comply with Annex J. The minimum number of overlapping layers of spirally wrapped tape or extruded layers of insulation shall be as follows:
   - for **basic insulation**: one layer;
   - for **supplementary insulation**: two layers;
   - for **reinforced insulation**: three layers.

d) **FIW** used as a **safeguard** in transformers shall comply with G.5.3.4.

For insulation between two adjacent winding wires, one layer on each conductor is considered to provide **supplementary insulation**.

Spirally wrapped tape shall be sealed and pass the tests of 5.4.4.5 a), b) or c).

NOTE 3 For wires insulated by an extrusion process, sealing is inherent to the process.

The winding wire shall pass a **routine test** for electric strength test, using the test as specified in J.3.2.

G.6.2 Enamelled winding wire insulation

Enamelled winding wire is not considered to provide **supplementary insulation** or **reinforced insulation**, unless it complies with the requirements for **FIW** as specified in G.5.3.4.

Other enamelled winding wires used as **basic insulation** shall comply with all the following conditions:

– the insulation provides **basic insulation** in a wound component between an **external circuit** and an internal circuit operating at ES2 and ES1;

– the insulation over all conductors comprises enamel complying with the requirements of a grade 2 winding wire of IEC 60317 series of standards with the **routine test** conducted at the highest voltage of Table 25 and Table 26;

– the finished component is subjected to a **type test** for electric strength (between windings and between windings and the core, see G.5.3.2.1), in accordance with 5.4.9.1; and

– the finished component is subjected to **routine tests** for electric strength (between windings and between windings and the core, see G.5.3.2.1), in accordance with 5.4.9.2.

G.7 Mains supply cords

G.7.1 General

A **mains** supply cord shall be of the sheathed type and comply with the following as appropriate:

– if rubber sheathed, be of synthetic rubber and not lighter than ordinary tough rubber-sheathed flexible cord according to IEC 60245-1 (designation 60245 IEC 53);

– if PVC sheathed:
   - for equipment provided with a **non-detachable power supply cord** and having a mass not exceeding 3 kg, be not lighter than light PVC sheathed flexible cord according to IEC 60227-1 (designation 60227 IEC 52),

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- for equipment provided with a **non-detachable power supply cord** and having a mass exceeding 3 kg, be not lighter than ordinary PVC sheathed flexible cord according to IEC 60227-1 (designation 60227 IEC 53),

  NOTE 1 There is no limit on the mass of the equipment if the equipment is intended for use with a detachable power supply cord.

- for equipment provided with a detachable power supply cord, be not lighter than light PVC sheathed flexible cord according to IEC 60227-1 (designation 60227 IEC 52),
- for screened cords of **movable equipment**, the flexing test of 3.1 of IEC 60227-2:1997;

  NOTE 2 Although screened cords are not covered in the scope of IEC 60227-2, the relevant flexing tests of IEC 60227-2 are used.

– other types of cords may be used if they have similar electro-mechanical and fire safety properties as above.

  NOTE 3 Where national or regional standards exist, they can be used to show compliance with the above paragraph.

For **pluggable equipment type A** or **pluggable equipment type B** that has **protective earthing**, a **protective earthing conductor** shall be included in the **mains** supply cord. For all other equipment, if a **mains** supply cord is supplied without a **protective earthing conductor**, a **protective earthing conductor** cable shall be supplied as well.

Equipment intended to be used by musicians while performing (for example, musical instruments and amplifiers) shall have:

– an appliance inlet according to IEC 60320-1 for connection to the **mains** by detachable cord sets; or
– a means of stowage to protect the **mains** supply cord when not in use (for example, a compartment, hooks or pegs).

Compliance is checked by inspection. For screened cords, damage to the screen is acceptable provided that:

– *during the flexing test the screen does not make contact with any conductor; and*
– *after the flexing test, the sample withstands the appropriate electric strength test between the screen and all other conductors.*

G.7.2 Cross sectional area

Mains supply cords shall have conductors with cross-sectional areas not less than those specified in Table G.7 (see also 5.6.3).

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Table G.7 – Sizes of conductors

Rated current of the equipment up to and including [a]	Minimum conductor sizes	
	Cross-sectional area	AWG or kcmil
A	mm^2	[cross-sectional area in mm^2] [e]
3	0,5 [b]	20 [0,5]
6	0,75	18 [0,8]
10	1,00 (0,75) [c]	16 [1,3]
16	1,50 (1,0) [d]	14 [2]
25	2,5	12 [3]
32	4	10 [5]
40	6	8 [8]
63	10	6 [13]
80	16	4 [21]
100	25	2 [33]
125	35	1 [42]
160	50	0 [53]
190	70	000 [85]
230	95	0000 [107]
		kcmil
		[cross-sectional area in mm^2] [e]
260	120	250 [126]
300	150	300 [152]
340	185	400 [202]
400	240	500 [253]
460	300	600 [304]

NOTE 1 IEC 60320-1 specifies acceptable combinations of appliance couplers and flexible cords, including those covered by footnotes [b], [c] and [d]. However, a number of countries have indicated that they do not accept all of the values listed in this table, particularly those covered by footnotes [b], [c] and [d].

NOTE 2 For higher currents see the IEC 60364 series.

[a] The **rated current** includes currents that can be drawn from a socket outlet providing **mains** power for other equipment. If the **rated current** of the equipment is not declared by the manufacturer, it is the calculated value of the **rated power** divided by **rated voltage**.

[b] For **rated current** up to 3 A, a nominal cross-sectional area of 0,5 mm^2 may be used in some countries provided that the length of the cord does not exceed 2 m.

[c] The value in parentheses applies to detachable power supply cords fitted with the connectors rated 10 A in accordance with IEC 60320-1 (types C13, C15, C15A and C17) provided that the length of the cord does not exceed 2 m.

[d] The value in parentheses applies to detachable power supply cords fitted with the connectors rated 16 A in accordance with IEC 60320-1 (types C19, C21 and C23) provided that the length of the cord does not exceed 2 m.

[e] AWG and kcmil sizes are provided for information only. The associated cross-sectional areas, in square brackets, have been rounded to show significant figures only. AWG refers to the American Wire Gage and the term "cmil" refers to circular mils where one circular mil is equal to the area of a circle having a diameter of one mil (one thousandth of an inch). These terms are commonly used to designate wire sizes in North America.

Compliance is checked by inspection.

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G.7.3 Cord anchorages and strain relief for non-detachable power supply cords

G.7.3.1 General

Safeguards against strain being transmitted to the equipment terminations of the conductors of cords or interconnecting cables connected to ES2 circuits, ES3 circuits or PS3 circuits are specified below.

G.7.3.2 Cord strain relief

G.7.3.2.1 Requirements

A knot shall not be used as a strain relief mechanism.

A screw that bears directly on the cord or cable shall not be used as a strain relief mechanism unless the cord anchorage, including the screw, is made of insulating material and the screw is of comparable size to the diameter of the cord being clamped.

When a linear force and a torque are applied to a **non-detachable power supply cord** or cable, a **basic safeguard** shall minimize strain from being transmitted to the cord or cable terminations.

The linear force applied to the cord or cable is specified in Table G.8. The force is applied in the most unfavourable direction for 1 s and repeated 25 times.

Table G.8 – Strain relief test force

Mass of the equipment kg	Force N
Up to and including 1	30
Over 1 up to and including 4	60
Over 4	100

A torque of 0,25 Nm is applied for 1 min to the cord or cable immediately after the linear force application. The torque is applied as close as practicable to the strain relief mechanism and is repeated in the opposite direction.

Compliance is determined by applying the specified force and torque, by measurement, and visual inspection. There shall be no damage to the cord or conductors and the displacement of the conductors shall not exceed 2 mm. Stretching of the cord outer jacket without displacement of the conductors is not considered displacement.

G.7.3.2.2 Strain relief mechanism failure

If the **basic safeguard** (strain relief mechanism) should fail and strain is transmitted to the **non-detachable power supply cord** or cable terminations, a **supplementary safeguard** shall ensure that the earth termination is the last to take the strain.

*Compliance is determined by inspection and, if necessary, by defeating the **basic safeguard** and inspecting the conductor slack while applying the force in Table G.8.*

G.7.3.2.3 Cord sheath or jacket position

The cord or cable sheath or jacket shall extend from the **basic safeguard** (strain relief mechanism) into the equipment at least one-half the diameter of the cord or cable.

Compliance is checked by inspection.

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G.7.3.2.4 Strain relief and cord anchorage material

The cord anchorage shall either be made of insulating material or have a lining of insulating material complying with the requirements for **basic insulation**. Where the cord anchorage is a bushing that includes the electrical connection to the screen of a screened power cord, this requirement shall not apply.

If the **basic safeguard** (strain relief mechanism) is made of polymeric material, the **basic safeguard** shall retain its structural properties following the mould stress relief according to Clause T.8.

*Compliance is determined by inspection and by applying the force and torque tests of G.7.3.2.1 after the **basic safeguard** has come to room temperature.*

G.7.4 Cord entry

Safeguards against electric shock and electrically-caused fire from cords or cables connected to ES2 circuits, ES3 circuits or PS3 circuits are specified below.

The entry of a cord or cable into the equipment shall be provided with **safeguards** against electric shock as specified in Clause 5. If the cord jacket passes the electric strength test of 5.4.9.1 for **supplementary insulation**, the cord jacket may be considered a **supplementary safeguard**.

The cord or cable entry shall be provided with a **supplementary safeguard** to:

– prevent abrasion of the cord or cable outer surface; and

– prevent the cord or cable from being pushed into the equipment to such an extent that the cord or its conductors, or both, could be damaged or internal parts of the equipment could be displaced.

*Compliance is determined by an electric strength test between the cord or cable conductors and **accessible** conductive parts following the tests of G.7.3.2.1. The test voltage shall be for **reinforced insulation** in accordance with 5.4.9.1.*

G.7.5 Non-detachable cord bend protection

G.7.5.1 Requirements

The **non-detachable power supply cord** of **hand-held equipment** or equipment intended to be moved while in operation shall be provided with a **safeguard** against jacket, insulation, or conductor damage due to bending at the equipment entrance.

Alternatively, the inlet or bushing shall be provided with a smoothly rounded bell-mouthed opening having a radius of curvature equal to at least 1,5 times the overall diameter of the cord with the largest cross-sectional area to be connected.

The cord bending **safeguard** shall:

– be so designed as to protect the cord against excessive bending where it enters the equipment; and

– be of insulating material; and

– be fixed in a reliable manner; and

– project outside the equipment beyond the inlet opening for a distance of at least five times the overall diameter or, for flat cords, at least five times the major overall cross-sectional dimension of the cord.

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G.7.5.2 Test method and compliance criteria

*The equipment is so placed that the axis of the cord bending **safeguard**, where the cord emerges, projects at an angle of 45° when the cord is free from stress. A mass equal to* $10 \times D^2$ *g is then attached to the free end of the cord, where* D *is the overall diameter or, for flat cords, the minor overall dimension of the cord, in millimetres.*

If the cord guard is of temperature-sensitive material, the test is made at 23 °C $\pm$ *2 °C.*

Flat cords are bent in the plane of least resistance.

Immediately after the mass has been attached, the radius of curvature of the cord shall nowhere be less than 1,5 D.

Compliance is checked by inspection, by measurement and, where necessary, by test with the cord as delivered with the equipment.

G.7.6 Supply wiring space

G.7.6.1 General requirements

The supply wiring space provided inside, or as part of, the equipment for permanent connection or for connection of an ordinary **non-detachable power supply cord** shall be designed:

– to allow the conductors to be introduced and connected easily; and

– so that the uninsulated end of a conductor is unlikely to become free from its terminal, or, should it do so, cannot come into contact with:

  - an **accessible** conductive part that is not connected to a **protective conductor**; or
  - an **accessible** conductive part of **hand-held equipment**; and

– to permit checking before fitting the cover, if any, that the conductors are correctly connected and positioned; and

– so that covers, if any, can be fitted without risk of damage to the supply conductors or their insulation; and

– so that covers, if any, giving access to the terminals can be removed with a **tool**.

Compliance is checked by inspection and by an installation test with cords of the largest cross-sectional area of the appropriate range specified in Table G.9.

Table G.9 – Range of conductor sizes to be accepted by terminals

Rated current of equipment A	**Nominal cross-sectional area** mm^2	
	Flexible cords	**Other cables**
Up to and including 3	0,5 to 0,75	1 to 2,5
Over 3 up to and including 6	0,75 to 1	1 to 2,5
Over 6 up to and including 10	1 to 1,5	1 to 2,5
Over 10 up to and including 13	1,25 to 1,5	1,5 to 4
Over 13 up to and including 16	1,5 to 2,5	1,5 to 4
Over 16 up to and including 25	2,5 to 4	2,5 to 6
Over 25 up to and including 32	4 to 6	4 to 10
Over 32 up to and including 40	6 to 10	6 to 16
Over 40 up to and including 63	10 to 16	10 to 25

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G.7.6.2 Stranded wire

G.7.6.2.1 Requirements

The end of a stranded conductor shall not be consolidated by soft soldering at places where the conductor is subject to contact pressure unless the method of clamping is designed so as to reduce the likelihood of a bad contact due to cold flow of the solder.

Spring terminals that compensate for the cold flow are considered to satisfy this requirement.

Preventing the clamping screws from rotating is not considered to be adequate.

Terminals shall be located, guarded or insulated so that, should a strand of a flexible conductor escape when the conductor is fitted, there is no likelihood of accidental contact between such a strand and:

– **accessible** conductive parts; or
– unearthed conductive parts separated from **accessible** conductive parts by **supplementary insulation** only.

G.7.6.2.2 Test method and compliance criteria

Compliance is checked by inspection and, unless a special cord is prepared in such a way as to prevent the escape of strands, by the following test.

A piece of insulation approximately 8 mm long is removed from the end of a flexible conductor having the appropriate nominal cross-sectional area. One wire of the stranded conductor is left free and the other wires are fully inserted into, and clamped in the terminal. Without tearing the insulation back, the free wire is bent in every possible direction, but without making sharp bends around the guard.

*If the conductor is an ES3 source, the free wire shall not touch any conductive part which is **accessible** or is connected to an **accessible** conductive part or, in the case of double insulated equipment, any conductive part which is separated from **accessible** conductive parts by **supplementary insulation** only.*

If the conductor is connected to an earthing terminal, the free wire shall not touch any ES3 source.

G.8 Varistors

G.8.1 General

A varistor shall comply with IEC 61051-2 or IEC 61643-331:2017, whether a **fire enclosure** is provided or not, taking into account all of the following:

– Preferred climatic categories (see 2.1.1 of IEC 61051-2:1991):
  - lower category temperature: −10 °C
  - upper category temperature: +85 °C
  - duration of damp heat, steady state test: 21 days,

  or

  Preferred climatic categories (see 4.1 of IEC 61643-331:2017)
  - lower category temperature: −40 °C
  - upper category temperature: +85 °C
  - relative humidity: 25 % to 75 %.

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– Maximum continuous voltage:
  - at least 1,25 times the **rated voltage** of the equipment; or
  - at least 1,25 times the upper voltage of the **rated voltage range**.

  NOTE The maximum continuous voltages are not limited to values specified in 2.1.2 of IEC 61051-2:1991 or the values in Table 1 and Table 2 of IEC 61643-331:2017, other voltages can be used.

– Combination pulse (Table I group 1 of IEC 61051-2:1991/AMD1:2009 or 8.1.1 of IEC 61643-331:2017, Figure 4).

  For the test, a combination pulse is selected from 2.3.6 in IEC 61051-2:1991/AMD1:2009 or from 8.1.1 of IEC 61643-331:2017, Figure 4. The test consists of 10 positive pulses or 10 negative pulses, each having a shape of 1,2/50 μs for voltage and 8/20 μs for current.

  For the selection, AC **mains** voltage and overvoltage category, see Table 12.

  Mains under 300 V is considered to be 300 V.

  For Overvoltage Category IV of Table 12, a combination pulse 6kV/3kA is used except for 600 V, for which a combination pulse of 8 kV/4 kA is used. As an alternative, the combination pulse test of IEC 61051-2:1991/AMD1:2009 (2.3.6, Table I group 1 and Annex A) or the combination pulse test of 8.1.1 Figure 4 of IEC 61643-331:2017, including consideration of the nominal **mains** voltage and overvoltage category, is acceptable.

  After the test, the varistor voltage at the manufacturer's specified current shall not have changed by more than 10 % when compared to the value before the test.

The body of surge suppression varistor shall comply with the needle flame according to IEC 60695-11-5, with the following test severities:

– Duration of application of the test flame: 10 s.
– After flame time: 5 s.

If the body of surge suppression varistor complies with **V-1 class material**, the needle flame test does not need to be performed.

NOTE 1 A varistor is sometimes referred to as an MOV or a VDR.

NOTE 2 Nominal varistor voltage is a voltage, at a specified DC current, used as a reference point in the component characteristic (see IEC 61051-1).

G.8.2 Safeguards against fire

G.8.2.1 General

This subclause applies to varistors used as a **safeguard** against fire:

– when the method “reduce the likelihood of ignition” of 6.4.1 is chosen; or
– when the method “control fire spread” of 6.4.1 is chosen and the **enclosure** is made of **combustible material** and located less than 13 mm from the varistor.

The **safeguards** in this subclause are not applicable to a varistor used in a suppression circuit whose nominal varistor voltage, as specified in IEC 61051-1, is above AC **mains transient voltage**.

A varistor shall be regarded as a **PIS**.

The varistor overload test of G.8.2.2 and the **temporary overvoltage** test of G.8.2.3 shall be performed depending on the maximum continuous AC voltage of the varistor according to Table G.10.

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Table G.10 – Varistor overload and temporary overvoltage test

Maximum continuous AC voltage of a varistor	Connection between		
	L to N or L to L	L to PE	N to PE
1,25 × V_r to 2 × V_r	G.8.2.2	G.8.2.2 and G.8.2.3	G.8.2.2 and G.8.2.3
Over 2 × V_r to 1 200 + 1,1 × V_r	No test	G.8.2.3	G.8.2.3
Over 1 200 + 1,1 × V_r	No test	No test	No test
V_r is the **rated voltage** or the upper voltage of the **rated voltage range** of the equipment.			

G.8.2.2 Varistor overload test

*The following test is simulated as required by Table G.10 to either a varistor or a surge suppression circuit containing varistors connected across the **mains** (L to L or L to N), line to protective earth (L to PE), or neutral to protective earth (N to PE).*

The following test simulation circuit shall be used:

- *Voltage is the AC source of 2 × V_r.*
- *Current is the current resulted from a test resistor R_x connected in series with the AC source.*
- *V_r is the **rated voltage** or the upper voltage of the **rated voltage range** of the equipment.*

The test shall be performed with an initial test resistor R_1 = 16 × V_r.

If the circuit does not open immediately during the initial application of test current, the test shall be continued until temperature stability (see B.1.5).

Subsequently, the test shall be repeated with new values of R_x (R_2, R_3, R_4, etc.) until the circuit opens, where:

- R_2 = 8 × V_r Ω
- R_3 = 4 × V_r Ω
- R_4 = 2 × V_r Ω
- R_x = 0,5 × (R_{x-1}) × V_r Ω.

Components in parallel with the varistor that may be affected by this test shall be disconnected.

*During and following the test, there shall be no risk of fire and **equipment safeguards**, other than the varistor under test, shall remain effective.*

During the test, the circuit may:

- *open due to the operation of a protective device such as a fuse, a thermal fuse; or*
- *close due to the operation of a GDT.*

G.8.2.3 Temporary overvoltage test

*The **temporary overvoltage** test is simulated by the following test methods where applicable:*

*A surge suppression circuit containing varistors connected between the **mains** conductors and the earth is tested according to 8.3.8.1 and 8.3.8.2 of IEC 61643-11:2011. The*

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compliance criteria of B.4.8 may be used as an alternative to the compliance criteria of IEC 61643-11.

If a surge suppression circuit is used, the combination pulse specified in G.8.2 is applied before this test.

During the test, the circuit may:

– *open due to the operation of a protective device such as a thermal fuse; or*

– *close due to the operation of a GDT.*

NOTE For different power distribution systems, the **temporary overvoltages** are defined in Annex B of IEC 61643-11:2011.

Components in parallel with the varistor that may be affected by this test shall be disconnected.

G.9 Integrated circuit (IC) current limiters

G.9.1 Requirements

IC current limiters used for current limiting in power sources so that the available output power becomes PS1 or PS2 are not shorted from input to output if they comply with all of the following:

– the IC current limiters limit the current to manufacturer's defined value (not to be more than 5 A) under **normal operating conditions** with any specified drift taken into account;

– the IC current limiters are entirely electronic and have no means of manual operation or reset;

– the IC current limiters output current is limited to 5 A or less (specified maximum load);

– the IC current limiters limit the current or voltage to the required value with the manufacturer's defined drift, as applicable, taken into account after each of the conditioning tests; and

– the test program as specified in G.9.2.

G.9.2 Test program

The test program consists of the performance tests outlined in Table G.11.

The following specifications are to be supplied by the manufacturer for application of tests:

– *power source limitation/specification (if less than 250 VA);*

– *maximum input voltage (volts); and*

– *maximum output load (amperes).*

Six samples are used for testing as follows:

Sample 1: Line 1

Sample 2: Lines 2 and 3

Sample 3: Lines 4 and 5

Sample 4: Line 6

Sample 5: Line 7

Sample 6: Line 8.

The power source for the tests should be capable of delivering 250 VA minimum, unless the IC current limiter has a lower specification or is tested in the end product.

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Table G.11 – Performance test program for integrated circuit (IC) current limiters

Line	Test category	Test condition	Cycles	Device condition temperature °C [a b c]	Device enable voltage	Device input voltage	Device output load (amperes) to RTN [d,e]
1	Start up	Enable pin – cycle	10 000	25	Off to On	Maximum (rated)	Maximum (rated)
2	"	Enable pin – cycle	50	70	Off to On	Maximum (rated)	0 Ω || 470 µF
3	"	Enable pin – cycle	50	-30	Off to On	Maximum (rated)	0 Ω || 470 µF
4	"	Input power pin – cycle	50	70	On	Maximum (rated)	0 Ω || 470 µF
5	"	Input power pin – cycle	50	-30	On	Maximum (rated)	0 Ω || 470 µF
6	Short Circuit	Output power pin – short circuit	50	70	On	Maximum (rated)	Open to 0 Ω (open to short)
7	Overload	Enable pin – cycle	50	25	Off to On	Maximum (rated)	150 % maximum
8	"	Input power pin – cycle	50	25	On	Maximum (rated)	150 % maximum

RTN = Return

\|\| = in parallel

[a] T_{ma} not applied

[b] ± 2 °C

[c] sample conditioned 3 h before test

[d] ± 20 %

[e] Load should be implemented through a suitably rated capacitor and a parallel conductive wire providing similar characteristics to a shorted, zero ohm (0 Ω) resistive load. The capacitor voltage rating should be not less than the maximum voltage rating of the component under test.

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G.9.3 Compliance criteria

After the test program, the device shall limit the current in accordance with its specification as applicable or the device shall become open circuit. The open circuited device is replaced with a new sample and tests continued as applicable.

G.10 Resistors

G.10.1 General

For each of the tests in this clause, ten samples of resistors are tested. A sample is a single resistor if used alone or a group of resistors as used in the application. Prior to each test, the resistance of the samples is measured, followed by the conditioning of G.10.2.

G.10.2 Conditioning

The samples shall be subjected to the damp heat test according to IEC 60068-2-78, with the following details:

– *temperature:* *(40 ± 2) °C;*

– *humidity:* *(93 ± 3) % relative humidity;*

– *test duration:* *21 days.*

G.10.3 Resistor test

Each sample is then subjected to 10 impulses of alternating polarity, using the impulse test generator circuit 2 of Table D.1. The interval between successive impulses is 60 s, and U_c is equal to the applicable ***required withstand voltage****.*

After the test, the resistance of each sample shall not have changed by more than 10 %. No failure is allowed.

The lowest resistance value of the ten samples tested is used to measure the current when determining compliance with Table 4*.*

G.10.4 Voltage surge test

Each sample is subjected to 50 discharges from the impulse test generator circuit 3 of Table D.1, at not more than 12 discharges per minute, with U_c equal to 10 kV.

After the tests, the resistance of each sample shall not have changed by more than 20 %. No failure is allowed.

G.10.5 Impulse test

Each sample is subjected to 10 pulses from the impulse test generator circuit 1 of Table D.1, with U_c equal to 4 kV or 5 kV of alternating polarity with a minimum of 60 s interval between pulses as applicable (see Table 13).

After the tests, the resistance of each sample shall not have changed by more than 20 %. No failure is allowed.

G.10.6 Overload test

The samples are each subjected to a voltage of such a value that the current through it is 1,5 times the value measured through a resistor, having a resistance equal to the specified rated value, which is fitted to the equipment, when operated under ***single fault conditions****. During the test the voltage is kept constant. The test is performed until thermal steady state is reached.*

After the tests, the resistance of each sample shall not have changed by more than 20 %. No failure is allowed.

G.11 Capacitors and RC units

G.11.1 General

The requirements below specify conditioning criteria when testing capacitors and RC units or discrete components forming an RC unit and serving as **safeguards** and provides selection criteria for capacitors and RC units that comply with IEC 60384-14.

G.11.2 Conditioning of capacitors and RC units

When required by 5.5.2.1, the following conditioning is applied when evaluating a capacitor or an RC unit to the requirements of IEC 60384-14.

The duration of the damp heat, steady state test as specified in 4.12 of IEC 60384-14:2005, shall be 21 days at a temperature of (40 ± 2) °C and a relative humidity of (93 ± 3) %.

Capacitors subjected to a duration that is longer than 21 days during the above test are considered acceptable.

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G.11.3 Rules for selecting capacitors

The appropriate capacitor subclass shall be selected from those listed in Table G.12, according to the rules of application in the table.

Table G.12 – Capacitor ratings according to IEC 60384-14

Capacitor subclass according to IEC 60384-14	Rated voltage of the capacitor V RMS	Type test impulse test voltage of the capacitor kV peak	Type test RMS test voltage of the capacitor kV RMS
Y1	Up to and including 500	8	4
Y2	Over 150 up to and including 300	5 [a]	1,5
Y4	Up to and including 150	2,5	0,9
X1	Up to and including 760	4 [a]	-
X2	Up to and including 760	2,5 [a]	-

Rules for the application of this table.

1 The voltage rating of the capacitor shall be at least equal to the **RMS working voltage** across the insulation being bridged, determined according to 5.4.1.8.2. As an exception to the requirements in the table, one Y2 capacitor may be used in cases where 2,5 kV is required.

2 For a single capacitor (X type) serving as **functional insulation**, failure of the capacitor shall not result in the failure of a **safeguard** and the **type test** impulse test voltage shall be at least equal to the **required withstand voltage**.

3 A higher grade capacitor than the one specified may be used, as follows:

- subclass Y1 if subclass Y2 is specified;
- subclass Y1 or Y2 if subclass Y4 is specified;
- subclass Y1 or Y2 if subclass X1 is specified;
- subclass X1, Y1 or Y2 if subclass X2 is specified.

4 Two or more capacitors may be used in series in place of the single capacitor specified, as follows:

- subclass Y1 or Y2 if subclass Y1 is specified;
- subclass Y2 or Y4 if subclass Y2 is specified;
- subclass X1 or X2 if subclass X1 is specified.

5 If two or more capacitors are used in series they shall comply with 5.5.2.1 as applicable and comply with the other rules above.

[a] For capacitance values of more than 1 µF, this test voltage is reduced by a factor equal to $\sqrt{C}$, where C is the capacitance value in µF.

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G.12 Optocouplers

Optocouplers shall comply with the requirements of IEC 60747-5-5:2007. In the application of IEC 60747-5-5:2007,

– the **type testing** as specified in 7.4.3 of IEC 60747-5-5:2007 shall be performed with a voltage $V_{ini,a}$ that is at least equal to the appropriate test voltage in 5.4.9.1 of this document; and

– the **routine testing** as specified in 7.4.1 of IEC 60747-5-5:2007 shall be performed with a voltage $V_{ini,b}$ that is at least equal to the appropriate test voltage in 5.4.9.2 of this document.

G.13 Printed boards

G.13.1 General

The requirements for **basic insulation**, **supplementary insulation**, **reinforced insulation** and **double insulation** on printed boards are specified below.

These requirements also apply to the windings of a planar transformer.

G.13.2 Uncoated printed boards

The insulation between conductors on the outer surfaces of an uncoated printed board shall comply with the minimum **clearance** requirements of 5.4.2 and the minimum **creepage distance** requirements of 5.4.3.

Compliance is checked by inspection and by measurement.

G.13.3 Coated printed boards

The requirements for separation distances before the boards are coated are specified below.

An alternative method to qualify coated printed boards is given in IEC 60664-3.

For printed boards whose outer surfaces are to be coated with a suitable coating material, the minimum separation distances of Table G.13 apply to conductive parts before they are coated.

Double insulation and **reinforced insulation** shall pass **routine tests** for electric strength of 5.4.9.2.

Either one or both conductive parts and the entire distances over the surface between the conductive parts shall be coated.

The minimum **clearances** of 5.4.2 and the minimum **creepage distances** of 5.4.3 shall apply:

– if the above conditions are not met;
– between any two uncoated conductive parts; and
– over the outside of the coating.

Compliance is checked by inspection and measurement, taking Figure O.11 and Figure O.12 into account, and by the tests of G.13.6.

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Table G.13 – Minimum separation distances for coated printed boards

Peak of the working voltage up to and including V peak	Basic insulation or supplementary insulation mm	Reinforced insulation mm
71 [a]	0,025	0,05
89 [a]	0,04	0,08
113 [a]	0,063	0,125
141 [a]	0,1	0,2
177 [a]	0,16	0,32
227 [a]	0,25	0,5
283 [a]	0,4	0,8
354 [a]	0,56	1,12
455 [a]	0,75	1,5
570	1,0	2,0
710	1,3	2,6
895	1,8	3,6
1 135	2,4	3,8
1 450	2,8	4,0
1 770	3,4	4,2
2 260	4,1	4,6
2 830	5,0	5,0
3 540	6,3	6,3
4 520	8,2	8,2
5 660	10	10
7 070	13	13
8 910	16	16
11 310	20	20
14 140	26	26
17 700	33	33
22 600	43	43
28 300	55	55
35 400	70	70
45 200	86	86
Linear interpolation may be used between the nearest two points, the calculated spacing being rounded up to the next higher 0,1 mm increment.		
[a] The test of G.13.6 is not required.		

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G.13.4 Insulation between conductors on the same inner surface

The requirements for insulation on the same inner layer of a multilayer board are specified below.

On an inner surface of a multi-layer printed board (see Figure O.14), the path between any two conductors shall comply with the requirements for a cemented joint in 5.4.4.5.

G.13.5 Insulation between conductors on different surfaces

The requirements for insulation on the different layers of a multilayer board are specified below.

For **basic insulation** there is no thickness requirement.

Supplementary insulation or **reinforced insulation** between conductive parts on different surfaces in double-sided single-layer printed boards, multi-layer printed boards and metal core printed boards, shall either have a minimum thickness of 0,4 mm provided by a single layer or conform with one of the specifications and pass the relevant tests in Table G.14.

Table G.14 – Insulation in printed boards

Specification of insulation	Type tests [a]	Routine tests for electric strength [c]
Two layers of sheet insulating material including pre-preg [b]	No	Yes
Three or more layers of sheet insulating material including pre-preg [b]	No	No
An insulation system with ceramic coating over a metallic substrate, cured at ≥ 500 °C	No	Yes
An insulation system, with two or more coatings other than ceramic over a metallic substrate, cured at < 500 °C	Yes	Yes
NOTE 1 Pre-preg is the term used for a layer of glass cloth impregnated with a partially cured resin. NOTE 2 For definition of ceramic, see IEC 60050-212:2010, 212-15-25.		
[a] Thermal conditioning of G.13.6.2 followed by the electric strength test of 5.4.9.1. [b] Layers are counted before curing. [c] Electric strength testing is carried out on the finished printed board.		

G.13.6 Tests on coated printed boards

G.13.6.1 Sample preparation and preliminary inspection

Three sample printed boards (or, for coated components in Clause G.14, two components and one board) identified as samples 1, 2 and 3 are required. Either actual boards or specially produced samples with representative coating and minimum separations may be used. Each sample board shall be representative of the minimum separations used, and coated. Each sample is subjected to the full sequence of manufacturing processes, including soldering and cleaning, to which it is normally subjected during equipment assembly.

When visually inspected, the boards shall show no evidence of pinholes or bubbles in the coating or breakthrough of conductive tracks at corners.

G.13.6.2 Test method and compliance criteria

Sample 1 is subjected to the thermal cycling sequence of 5.4.1.5.3.

Sample 2 is aged in a full draught oven at a temperature and for a time duration chosen from the graph shown in Figure G.3 using the temperature index line that corresponds to the maximum operating temperature of the coated board. The temperature of the oven is maintained at the specified temperature ± 2 °C. The temperature used to determine the temperature index line is the highest temperature on the board where safety is involved.

When using Figure G.3, interpolation may be used between the nearest two temperature index lines.

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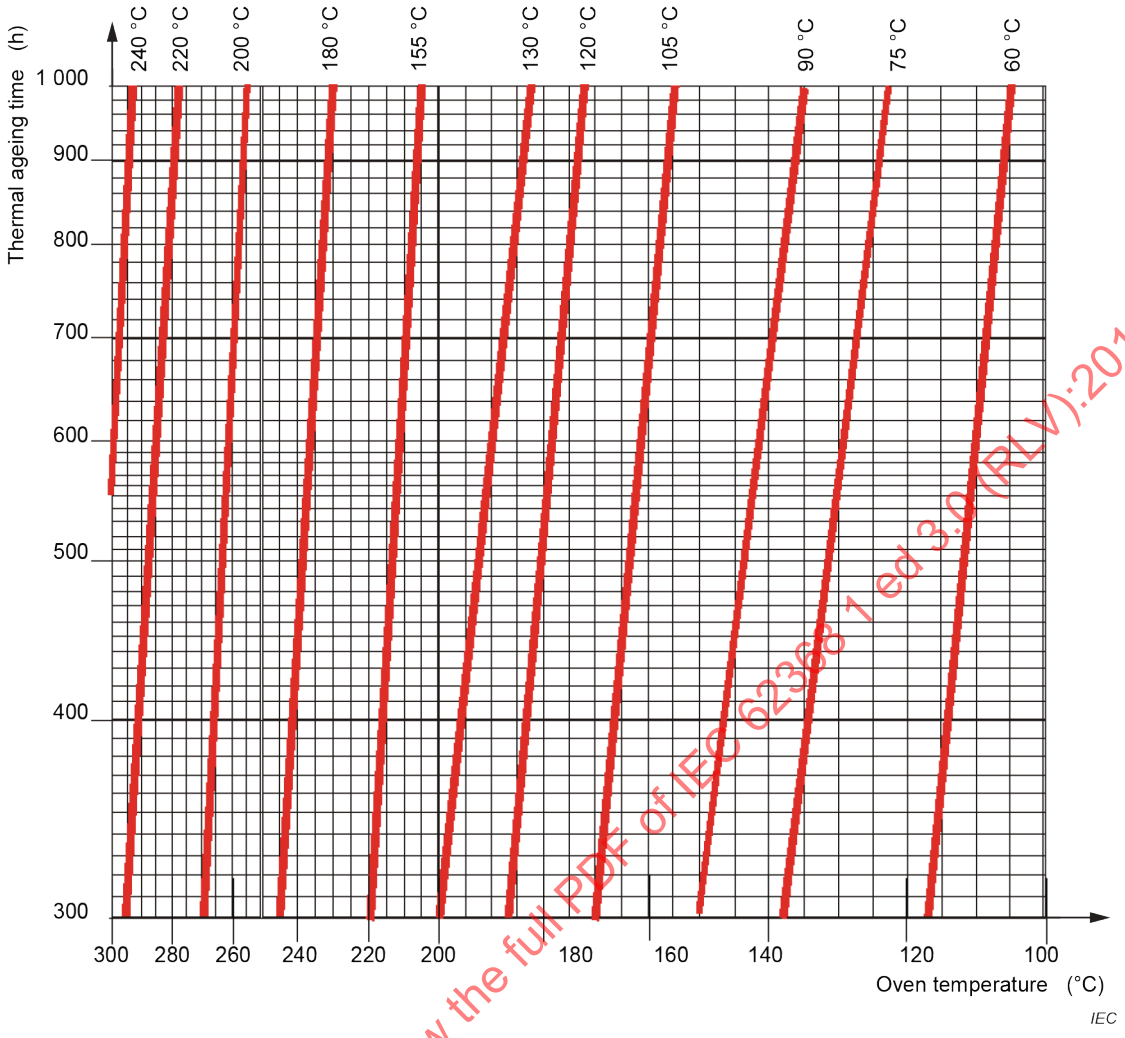


Figure G.3 – Thermal ageing time

Samples 1 and 2 are then subjected to the humidity conditioning of 5.4.8 and shall withstand the electric strength test of 5.4.9.1 between conductors.

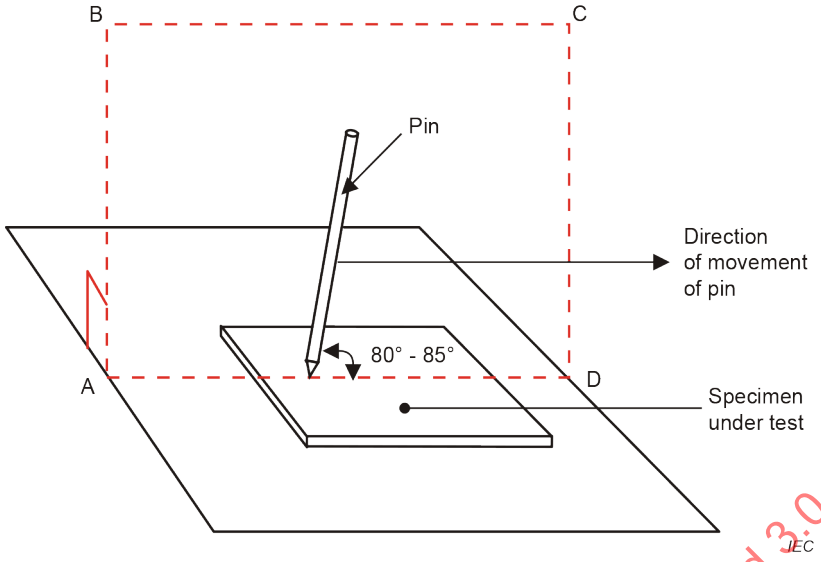
Sample board 3 is subjected to the following abrasion resistance test:

Scratches are made across five pairs of conducting parts and the intervening separations at points where the separations will be subject to the maximum potential gradient during the tests.

The scratches are made by means of a hardened steel pin, the end of which has the form of a cone having a tip angle of 40°, its tip being rounded and polished, with a radius of 0,25 mm ± 0,02 mm.

Scratches are made by drawing the pin along the surface in a plane perpendicular to the conductor edges at a speed of 20 mm/s ± 5 mm/s as shown in Figure G.4. The pin is so loaded that the force exerted along its axis is 10 N ± 0,5 N. The scratches shall be at least 5 mm apart and at least 5 mm from the edge of the specimen.

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NOTE The pin is in the plane ABCD that is perpendicular to the specimen under test.

Figure G.4 – Abrasion resistance test for coating layers

After the test, the coating layer shall neither have loosened nor have been pierced. The coating shall withstand an electric strength test as specified in 5.4.9.1 between conductors. In the case of metal core printed boards, the substrate is one of the conductors.

If mechanical stress or bending is applied to the board, additional tests to identify cracking may be needed (see IEC 60664-3).

G.14 Coatings on component terminals

G.14.1 Requirements

The requirements for coatings on component terminals and the like, where the coating is used to reduce **clearances** and **creepage distances** are specified below.

Coatings may be used over external terminations of components to increase effective **clearances** and **creepage distances** (see Figure O.11). The minimum separation distances of Table G.13 apply to the component before coating, and the coating shall meet all the requirements of G.13.3. The mechanical arrangement and rigidity of the terminations shall be adequate to ensure that, during normal handling, assembly into equipment and subsequent use, the terminations will not be subject to deformation that would crack the coating or reduce the separation distances between conductive parts below the values in Table G.13 (see G.13.3).

G.14.2 Test method and compliance criteria

Compliance is checked by inspection taking into account Figure O.11 and by applying the sequence of tests covered by G.13.6. These tests are carried out on a completed assembly including the component(s).

The abrasion resistance test of G.13.6.2 is carried out on a specially prepared sample printed board as described for sample 3 in G.13.6.1, except that the separation between the conductive parts shall be representative of the minimum separations and maximum potential gradients used in the assembly.

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G.15 Pressurized liquid filled components

G.15.1 Requirements

An LFC located internal to the equipment shall comply with all of the following requirements:

– flammable or conductive liquid shall be stored in a container, and the LFC shall comply with the tests of G.15.2.3, G.15.2.4, G.15.2.5 and G.15.2.6;

– the liquid shall be provided with protection in accordance with Clause 7 (**hazardous substances**);

– non-metallic parts of the container system shall withstand the tests of G.15.2.1 and G.15.2.2; and

– the LFC shall be mounted within the equipment in such a way that the tubing shall not come into contact with sharp edges or any other surface that could damage the tubing and if the LFC bursts or relieves its pressure, the liquid cannot defeat a **safeguard**.

The order of tests is not specified. The tests may be performed on separate samples, except after the test of G.15.2.2, the test of G.15.2.1 is conducted.

G.15.2 Test methods and compliance criteria

G.15.2.1 Hydrostatic pressure test

Compliance is checked by evaluation of the available data or by the following test. An LFC that is open to the atmosphere or is non-pressurised (for example, an ink cartridge) is not subjected to this test.

One sample of the LFC is subjected to a hydrostatic pressure test for 2 min at room temperature and at a pressure that is the highest of the following:

– *three times the maximum working pressure specified by the manufacturer at the maximum temperature measured during **normal operating conditions**; and*

– *two times the maximum measured working pressure at the maximum temperature measured during application of the **abnormal operating conditions** of Clause B.3 and **single fault conditions** of Clause B.4.*

G.15.2.2 Creep resistance test

Two samples of the LFC, of which one or more parts are made of non-metallic materials, shall be conditioned for 14 days at a temperature of 87 °C and placed in a full draft air-circulating oven. Following the conditioning, the system shall comply with the test of G.15.2.1 and non-metallic parts shall show no sign of deterioration such as cracking and embrittlement.

G.15.2.3 Tubing and fittings compatibility test

Ten samples of the test specimens made of the material used for the tubing and associated fittings of the LFC, of which one or more parts are made of non-metallic materials, shall be tested for tensile strength in accordance with the ISO 527 series. Five specimens shall be tested in the condition as received and the remaining five specimens after a conditioning test for 40 days in a water bath filled with the intended liquid and maintained at 38 °C. The internal pressure of the assemblies is maintained at atmospheric pressure. The tensile strength after conditioning shall not be less than 60 % of the tensile strength before the tests.

Alternatively, the five samples of the finished LFC assembly may be tested as far as the part under test is suitable for the tensile strength test. The samples of finished assembly filled with the intended liquid at the internal pressure maintained at atmospheric pressure is conditioned for 40 days at 38 °C in a full draft air-circulating oven.

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G.15.2.4 Vibration test

One sample of the LFC, or the equipment containing the LFC, shall be fastened to the vibration generator in its normal position of use, as specified in IEC 60068-2-6, by means of screws, clamps or straps round the component. The direction of vibration is vertical, and the severities are:

– *duration:* *30 min;*
– *amplitude:* *0,35 mm;*
– *frequency range:* *10 Hz, 55 Hz, 10 Hz;*
– *sweep rate:* *approximately one octave per minute.*

G.15.2.5 Thermal cycling test

*One sample of the LFC is subjected to three cycles of conditioning for 7 h at a temperature that is 10 °C above the maximum temperature obtained during **normal operating conditions**, **abnormal operating conditions** of Clause B.3 and **single fault conditions** of Clause B.4, followed by room temperature for 1 h.*

NOTE The LFC is not energized during the above test.

G.15.2.6 Force test

*One sample of the LFC is subjected to the tests of Clause T.2 (10 N test applied to fittings **accessible** to a **skilled person**) and Clause T.3 (30 N test applied to fittings **accessible** to an **instructed person** or to an **ordinary person**).*

G.15.3 Compliance criteria

Compliance is checked by inspection and evaluation of the available data or by the tests of G.15.2. During and after these tests, there shall be no rupture, no leaks and no loosening of any connection or part.

G.16 IC that includes a capacitor discharge function (ICX)

G.16.1 Requirements

An ICX and any associated components critical to the discharge function of a capacitor (such as the **mains** capacitor) to an **accessible** part are fault tested unless one of the following conditions is met:

– the ICX with the associated circuitry as provided in the equipment complies with the tests of G.16.2. Any impulse attenuating components (such as varistors and GDTs) that attenuate the impulse to the ICX and the associated circuitry are disconnected; or
– the ICX tested separately complies with the requirements of G.16.2. If discharge components external to the ICX are necessary:
  - they shall be included in the test of G.16.2, and
  - the discharge components used in the equipment shall be within the range tested.

G.16.2 Tests

Where the ICX is tested by itself, the test set up shall be as recommended by the ICX manufacturer.

– *humidity treatment of 5.4.8 for 120 h.*
– *100 positive impulses and 100 negative impulses between line and neutral using a capacitor with the smallest capacitance and a resistor with the smallest resistance specified by the manufacturer of the ICX. The time between any two impulses shall not be*

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less than 1 s. The impulse shall be as specified in circuit 2 of Table D.1 with U_c equal to the transient voltage as determined in 5.4.2.3.2.2.

*The impulses are to be superimposed on the **mains** voltage. The **mains** voltage is taken as the maximum of:*

- *the equipment **rated voltage range** when tested in the equipment, or*
- *the maximum **mains** voltage as specified by the ICX manufacturer when tested separately.*

– *Application of an AC **mains** voltage that is 120 % of the **rated voltage** for 2,5 min.*

– *10 000 cycles of the connection and disconnection of the **mains**. If the ICX is tested by itself, a capacitor with the largest capacitance and a resistor with the smallest resistance as specified by the manufacturer shall be used. The connection and disconnection cycle time shall not be less than 2 s.*

If any of the associated circuitry components other than those critical for the discharge function fails, it may be replaced with a new component.

G.16.3 Compliance criteria

*Compliance is checked by evaluation of the available data or by conducting the above tests. The capacitor discharge test is conducted after the above tests, ensuring the ICX or the EUT provided with the ICX continues to provide the **safeguard** function.*

NOTE Evaluation of available data includes information of failure of any associated circuitry components that keeps the discharge mode in the on/stay mode.

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Annex H
(normative)

Criteria for telephone ringing signals

H.1 General

The two alternative methods described in this annex reflect satisfactory experience in different parts of the world. Method A is typical of analogue telephone networks in Europe, and Method B of those in North America. The two methods result in standards of electrical safety that are broadly equivalent.

H.2 Method A

This method requires that the currents I_{TS1} and I_{TS2} flowing through a 5 000 Ω resistor, between any two conductors or between one conductor and protective earth do not exceed the limits specified, as follows:

a) *For **normal operating conditions**, I_{TS1}, the current determined from the calculated or measured current for any single active ringing period t_1 (as defined in Figure H.1), does not exceed:*

   – *for cadenced ringing ($t_1 < \infty$), the current given by the curve of Figure H.2 at t_1;*

   – *for continuous ringing ($t_1 = \infty$), 16 mA.*

   I_{TS1}, in mA, is as given by

$$I_{TS1} = \frac{I_p}{\sqrt{2}} \qquad \text{for } (t_1 \le 600\,\text{ms})$$

$$I_{TS1} = \frac{t_1 - 600}{600} \times \frac{I_{pp}}{2\sqrt{2}} + \frac{1200 - t_1}{600} \times \frac{I_p}{\sqrt{2}} \qquad \text{for } (600\,\text{ms} < t_1 < 1200\,\text{ms})$$

$$I_{TS1} = \frac{I_{pp}}{2\sqrt{2}} \qquad \text{for } (t_1 \ge 1200\,\text{ms})$$

   where:

   I_p *is the peak current, in mA, of the relevant waveform given in Figure H.3;*

   I_{pp} *is the peak-to-peak current, in mA, of the relevant waveform given in Figure H.3;*

   t_1 *is expressed in ms.*

b) *For **normal operating conditions**, I_{TS2}, the average current for repeated bursts of a cadenced ringing signal calculated for one ringing cadence cycle t_2 (as defined in Figure H.1), does not exceed 16 mA RMS*

   I_{TS2} in mA is as given by

$$I_{TS2} = \left[\frac{t_1}{t_2} \times I_{TS1}^2 + \frac{t_2 - t_1}{t_2} \times \frac{I_{dc}^2}{3{,}75^2} \right]^{1/2}$$

   where:

   I_{TS1} *in mA, is as given by H.2 a);*

   I_{dc} *is the DC current in mA flowing through the 5 000 Ω resistor during the non-active period of the cadence cycle;*

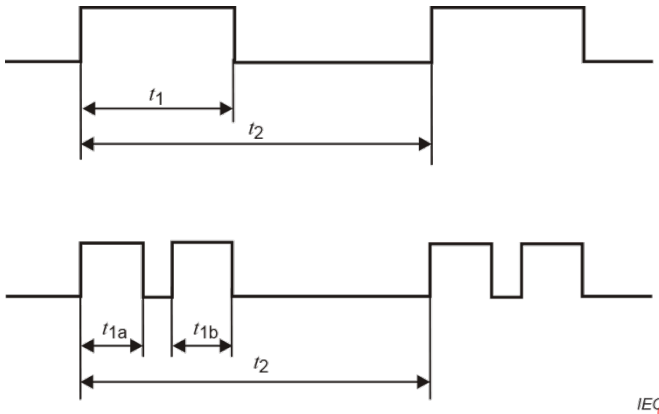
   t_1 *and* t_2 *are expressed in ms.*

NOTE The frequencies of telephone ringing voltages are normally within the range of 14 Hz to 50 Hz.

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*c) Under **single fault conditions**, including where cadenced ringing becomes continuous:*

- *I_{TS1} shall not exceed the current given by the curve of Figure H.2, or 20 mA, whichever is greater; and*
- *I_{TS2} shall not exceed a limit of 20 mA.*



Key

t_1 is

- the duration of a single ringing period, where the ringing is active for the whole of the single ringing period;
- the sum of the active periods of ringing within the single ringing period, where the single ringing period contains two or more discrete active periods of ringing, as in the example shown, for which $t_1 = t_{1a} + t_{1b}$.

t_2 is the duration of one complete cadence cycle.

Figure H.1 – Definition of ringing period and cadence cycle

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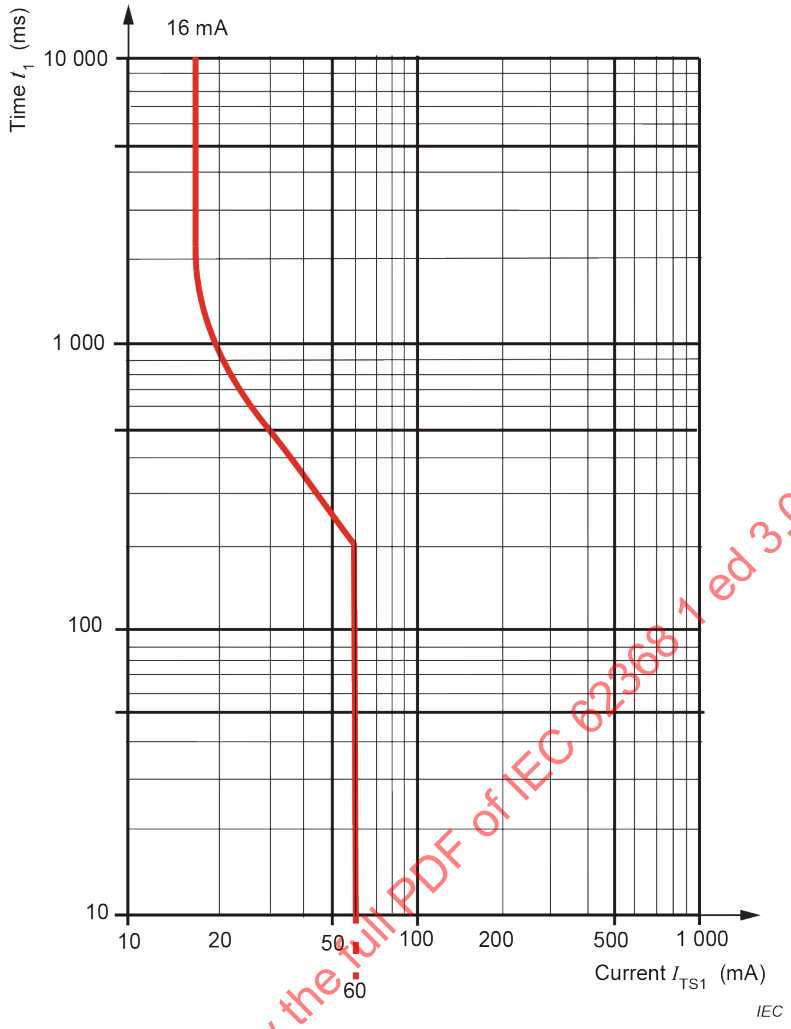


Figure H.2 – I_{TS1} limit curve for cadenced ringing signal

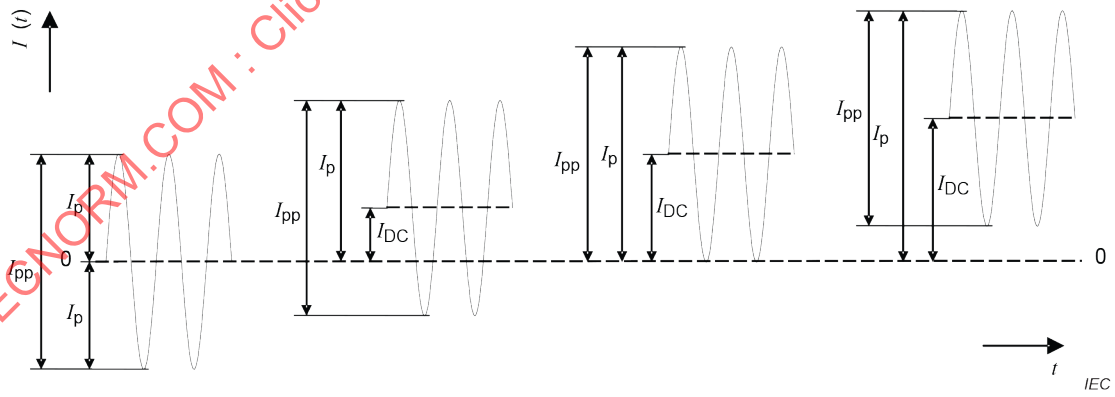


Figure H.3 – Peak and peak-to-peak currents

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H.3 Method B

H.3.1 Ringing signal

H.3.1.1 Frequency

The ringing signal shall use only frequencies whose fundamental component is equal to or less than 70 Hz.

H.3.1.2 Voltage

The ringing voltage shall be less than 300 V peak-to-peak and less than 200 V peak with respect to earth, measured across a resistance of at least 1 MΩ.

H.3.1.3 Cadence

The ringing voltage shall be interrupted to create quiet intervals of at least 1 s duration separated by no more than 5 s. During the quiet intervals, the voltage to earth shall not exceed 60 V DC.

H.3.1.4 Single fault current

Where cadenced ringing becomes continuous as a consequence of a single fault, the current through a 5 000 Ω resistor connected between any two output conductors or between one output conductor and earth shall not exceed 56,5 mA peak-to-peak, as shown in Figure H.3.

H.3.2 Tripping device and monitoring voltage

H.3.2.1 Conditions for use of a tripping device or a monitoring voltage

A ringing signal circuit shall include a tripping device as specified in H.3.2.2, or provide a monitoring voltage as specified in H.3.2.3, or both, depending on the current through a specified resistance connected between the ringing signal generator and earth, as follows:

– if the current through a 500 Ω or greater resistor does not exceed 100 mA peak-to-peak, neither a tripping device nor a monitoring voltage is required;

– if the current through a 1 500 Ω or greater resistor exceeds 100 mA peak-to-peak, a tripping device shall be included. If the tripping device meets the trip criteria specified in Figure H.4 with $R \geq 500\ \Omega$, no monitoring voltage is required. If, however, the tripping device only meets the trip criteria with $R \geq 1\ 500\ \Omega$, a monitoring voltage shall also be provided;

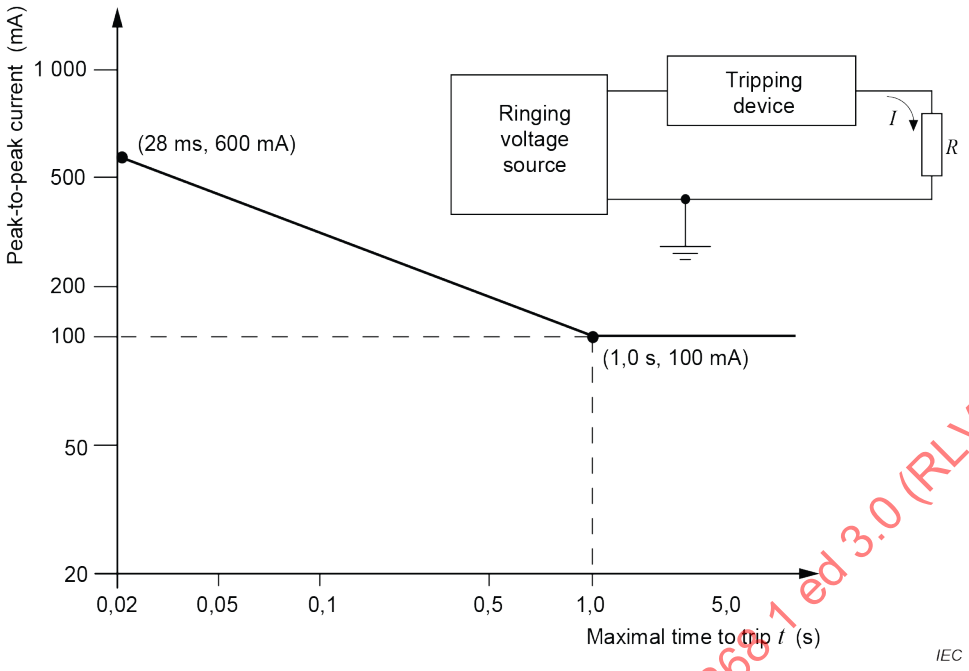
– if the current through a 500 Ω or greater resistor exceeds 100 mA peak-to-peak, but the current through a 1 500 Ω or greater resistor does not exceed this value, either:

  - a tripping device shall be provided, meeting the trip criteria specified in Figure H.4 with $R \geq 500\ \Omega$, or
  - a monitoring voltage shall be provided.

NOTE 1 Tripping devices are, in general, current-sensitive and do not have a linear response, due to the resistance/current characteristics and time delay/response factor in their design.

NOTE 2 In order to minimize testing time, a variable resistor box is normally used.

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NOTE 1 t is measured from the time of connection of the resistor R to the circuit.

NOTE 2 The sloping part of the curve is defined as $I = 100 / \sqrt{t}$.

Figure H.4 – Ringing voltage trip criteria

H.3.2.2 Tripping device

A series current-sensitive tripping device in the ringlead that will trip ringing as specified in Figure H.4.

H.3.2.3 Monitoring voltage

A voltage to earth on the tip or ring conductor with a magnitude of at least 19 V peak, but not exceeding 60 V DC, whenever the ringing voltage is not present (idle state).

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Annex I
(informative)

Overvoltage categories
(see IEC 60364-4-44)

The concept of overvoltage categories is used for equipment energized directly from the AC **mains**.

The largest transient voltage likely to be experienced at the power input interface of equipment connected to the **mains** is known as the **mains transient voltage**. In this document, minimum **clearances** for insulation in circuits connected to the **mains** are based on the **mains transient voltage**.

According to IEC 60664-1, the value of the **mains transient voltage** is determined from the **mains** voltage and the Overvoltage Category, I to IV (see Table 12 of this document).

The overvoltage category therefore shall be identified for each equipment intended to be connected to the **mains** (see Table I.1).

The overvoltage categories have a probabilistic implication rather than the meaning of physical attenuation of the transient voltage downstream in the installation.

NOTE 1 This concept of overvoltage categories is used in IEC 60364-4-44:2007, section 443.

NOTE 2 The term overvoltage category in this document is synonymous with impulse withstand category used in IEC 60364-4-44:2007, section 443.

The term overvoltage category is not used in connection with DC power distribution systems in this document.

Table I.1 – Overvoltage categories

Overvoltage category	Equipment and its point of connection to the **AC** mains	Examples of equipment
IV	Equipment that will be connected to the point where the **mains** supply enters the building	• Electricity meters • Communications ITE for remote electricity metering
III	Equipment that will be an integral part of the building wiring	• Socket outlets, fuse panels and switch panels • Power monitoring equipment
II	Pluggable or **permanently connected equipment** that will be supplied from the building wiring	• Household appliances, portable tools, home electronics • Most ITE used in the building
I	Equipment that will be connected to a special **mains** in which measures have been taken to reduce transients	• ITE supplied via an external filter or a motor driven generator

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Annex J
(normative)

Insulated winding wires for use without interleaved insulation

J.1 General

Requirements for winding wires whose insulation may be used to provide **basic insulation**, **supplementary insulation**, **double insulation** or **reinforced insulation** in wound components without interleaved insulation are specified below.

This annex applies to:

– solid round winding wires having diameters between 0,01 mm and 5,0 mm, and stranded winding wires with equivalent cross-sectional areas; and

– solid square and solid rectangular (flatwise bending) winding wires with cross-sectional areas of 0,03 mm^2 to 19,6 mm^2.

NOTE See G.6.1 for the minimum number of overlapping layers.

J.2 Type tests

J.2.1 General

*Unless otherwise specified, the winding wire shall pass the following **type tests**, carried out at a temperature between 15 °C and 35 °C and a relative humidity between 45 % and 75 %.*

J.2.2 Electric strength

J.2.2.1 Solid round winding wires and stranded winding wires

J.2.2.1.1 Wires with a nominal conductor diameter up to and including 0,1 mm

The test specimen is prepared according to 4.3 of IEC 60851-5:2008. The specimen is then subjected to the electric strength test of 5.4.9.1, between the conductor of the wire and the cylinder, with a minimum test voltage of:

– *3 kV RMS or 4,2 kV peak for **reinforced insulation**; or*

– *1,5 kV RMS or 2,1 kV peak for **basic insulation** or **supplementary insulation**.*

J.2.2.1.2 Wires with a nominal conductor diameter over 0,1 mm up to and including 2,5 mm

The test specimen is prepared according to 4.4.1 of IEC 60851-5:2008. The specimen is then subjected to the electric strength test of 5.4.9.1 with a test voltage that is not less than twice the appropriate voltage of 5.4.9.1, with a minimum of:

– *6 kV RMS or 8,4 kV peak for **reinforced insulation**; or*

– *3 kV RMS or 4,2 kV peak for **basic insulation** or **supplementary insulation**.*

J.2.2.1.3 Wires with a nominal conductor diameter over 2,5 mm

The test specimen is prepared according to 4.5.1 of IEC 60851-5:2008. The specimen is then subjected to the electric strength test of 5.4.9.1 between the conductor of the wire and the shot, with a minimum test voltage of:

– *3 kV RMS or 4,2 kV peak for **reinforced insulation**; or*

– *1,5 kV RMS or 2,1 kV peak for **basic insulation** or **supplementary insulation**.*

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J.2.2.2 Square or rectangular wires

The test specimen is prepared according to 4.7.1 of IEC 60851-5:2008 (single conductor surrounded by metal shots). The specimen is then subjected to the electric strength test of 5.4.9.1, with a minimum test voltage of:

– *3 kV RMS or 4,2 kV peak for **reinforced insulation**; or*

– *1,5 kV RMS or 2,1 kV peak for **basic insulation** or **supplementary insulation**.*

J.2.3 Flexibility and adherence

Clause 5.1.1 (in Test 8) of IEC 60851-3:2009 shall be used, using the mandrel diameters of Table J.1.

The test specimen is then examined in accordance with 5.1.1.4 of IEC 60851-3:2009, followed by the electric strength test of 5.4.9.1 in this document, with minimum test voltage of:

– *3 kV RMS or 4,2 kV peak for **reinforced insulation**; or*

– *1,5 kV RMS or 2,1 kV peak for **basic insulation** or **supplementary insulation**.*

The test voltage is applied between the wire and the mandrel.

Table J.1 – Mandrel diameter

Nominal conductor diameter or thickness mm	Mandrel diameter mm
less than 0,35	4,0 ± 0,2
less than 0,50	6,0 ± 0,2
less than 0,75	8,0 ± 0,2
less than 2,50	10,0 ± 0,2
less than 5,00	Four times the conductor diameter or thickness [a]
[a] In accordance with IEC 60317-43.	

The tension to be applied to the wire during winding on the mandrel is calculated from the wire diameter to be equivalent to 118 MPa ± 10 % (118 N/mm^2 ± 10 %).

Edgewise bending on the smaller dimension side (width) is not required for rectangular wire.

For mandrel winding test of the square and rectangular wire, two adjacent turns do not need to contact each other.

J.2.4 Heat shock

The test specimen shall be prepared in accordance with 5.1.1 (in Test 8) of IEC 60851-3:2009, followed by the electric strength test of 5.4.9.1 in this document, with a minimum test voltage of:

– *3 kV RMS or 4,2 kV peak for **reinforced insulation**; or*

– *1,5 kV RMS or 2,1 kV peak for **basic insulation** or **supplementary insulation**.*

The test voltage is applied between the wire and the mandrel. The oven temperature is the relevant temperature of the thermal class of insulation in Table J.2. The mandrel diameter and tension applied to the wire during winding on the mandrel are as specified in J.2.3. The electric strength test is conducted at room temperature after removal from the oven.

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Table J.2 – Oven temperature

Thermal class	Class 105 (A)	Class 120 (E)	Class 130 (B)	Class 155 (F)	Class 180 (H)	Class 200 (N)	Class 220 (R)	Class 250 -
Oven temperature °C	200	215	225	250	275	295	315	345
Oven temperatures shall be maintained within ± 5° of the specified temperature. The classes are related to the classification of electrical insulating materials and EISs in accordance with IEC 60085. The assigned letter designations are given in parentheses.								

Edgewise bending on the smaller dimension side (width) is not required for rectangular wire.

J.2.5 Retention of electric strength after bending

Five specimens are prepared as in J.2.3 and tested as follows. Each specimen is removed from the mandrel, placed in a container and positioned so that it can be surrounded by at least 5 mm of metal shot. The ends of the conductor in the specimen shall be sufficiently long to avoid flash over. The shot shall be not more than 2 mm in diameter and shall consist of balls of stainless steel, nickel or nickel plated iron. The shot is gently poured into the container until the specimen under test is covered by at least 5 mm of shot. The shot shall be cleaned periodically with a suitable solvent.

NOTE The above test procedure is reproduced from 4.6.1 c) of IEC 60851-5:1996, now withdrawn. It is not included in the fourth edition (2008) of that standard.

The specimen shall be subjected to the electric strength test of 5.4.9.1, with a minimum test voltage of:

– *3 kV RMS or 4,2 kV peak for **reinforced insulation**; or*
– *1,5 kV RMS or 2,1 kV peak for **basic insulation** or **supplementary insulation**.*

The mandrel diameter and tension applied to the wire during winding on the mandrel are as in Table J.1.

J.3 Testing during manufacturing

J.3.1 General

The wire manufacturer shall subject the wire to a spark test during manufacture according to IEC 62230 as specified in J.3.2 and J.3.3.

J.3.2 Spark test

The test voltage for the spark test shall be in accordance with the electric strength test of 5.4.9.1, with a minimum of:

– *3 kV RMS or 4,2 kV peak for **reinforced insulation**; or*
– *1,5 kV RMS or 2,1 kV peak for **basic insulation** or **supplementary insulation**.*

J.3.3 Sampling test

*The **sampling test** shall be conducted according to the suitable test specified in J.2.2.*

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Annex K
(normative)

Safety interlocks

K.1 General

K.1.1 General requirements

Safety interlocks shall be so designed that, for an **ordinary person**, the class 2 energy sources and class 3 energy sources will be removed before the cover, door, etc. is in a position that those parts become **accessible** as a class 1 energy source.

Safety interlocks shall be so designed that, for an **instructed person**, the class 3 energy sources will be removed before the cover, door, etc. is in a position that this part becomes **accessible** as a class 2 energy source or less.

The interlock shall either:

– necessitate previous de-energization of such parts; or
– automatically initiate disconnection of the supply to such parts, and to reduce to a:
  • class 1 energy source within 2 s for an **ordinary person**, and
  • class 2 energy source within 2 s for an **instructed person**.

If reduction of the energy source class takes longer than 2 s, then an **instructional safeguard** shall be provided in accordance with Clause F.5, except that:

– element 1a shall be placed on the door, cover or other part that initiates the interlock action and is opened or removed to gain access; and
– element 3 is optional.

The elements of the **instructional safeguard** shall be as follows:

– element 1a:  , IEC 60417-6057 (2011-05) for moving parts or

 , IEC 60417-5041 (2002-10) for hot parts

– element 2: not specified
– element 3: not specified
– element 4: the time when the energy source will be reduced to the required class

K.1.2 Test method and compliance criteria

The energy level of class 2 or class 3 energy source parts are monitored.

Compliance is checked by inspection, measurement and use of the straight unjointed version of the test probe according to Annex V.

K.2 Components of the safety interlock safeguard mechanism

The components comprising the **safety interlock** mechanism shall be considered **safeguards**, and shall comply with Annex G or K.7.1 where applicable.

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Compliance is checked in accordance with Annex G or K.7.1 and by inspection.

K.3 Inadvertent change of operating mode

A **safety interlock** shall not be operable by means of probes specified in Figure V.1 or Figure V.2, as applicable so as to change the energy class within the area, space or access point being controlled to a class 3 energy source for an **instructed person**, or to a class 2 energy source or a class 3 energy source for an **ordinary person**.

Compliance is checked in accordance with Annex V and by inspection.

K.4 Interlock safeguard override

A **safety interlock** may be overridden by a **skilled person**. The **safety interlock** override system:

– shall require an intentional effort to operate; and

– shall reset automatically to normal operation when servicing is complete, or prevent normal operation unless the **skilled person** has carried out restoration; and

– if located in an area **accessible** to an **ordinary person** or, if applicable, an **instructed person**, shall not be operable by means of probes specified in Annex V, and shall require a **tool** for operation.

Compliance is checked in accordance with Annex V and by inspection.

K.5 Fail-safe

K.5.1 Requirement

In the event of any **single fault condition** in the **safety interlock** system, the space controlled by the **safety interlock** shall:

– revert to a class 1 energy source for an **ordinary person** or a class 2 energy source for an **instructed person**; or

– be locked in the **normal operating condition** and comply with applicable requirements for a class 3 energy source.

K.5.2 Test method and compliance criteria

*Compliance is checked by introduction of electrical, electro-mechanical, and mechanical component faults, one at a time. **Single fault conditions** are described in Clause B.4. For each fault, the space controlled by the **safety interlock** shall comply with the applicable requirements for **single fault conditions** for the respective energy source.*

*The components and parts of the **safety interlock** used as a **safeguard** mechanism are not subjected to **single fault conditions** if they comply with K.2 or K.6 as applicable.*

*Fixed separation distances in **safety interlock** circuits (for example, those associated with printed boards) are not subjected to simulated **single fault conditions** if the separation distances comply with K.7.1.*

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K.6 Mechanically operated safety interlocks

K.6.1 Endurance requirement

Moving mechanical parts in mechanical and electromechanical **safety interlock** systems shall have adequate endurance.

K.6.2 Test method and compliance criteria

*Compliance is checked by inspection of the **safety interlock** system, available data and, if necessary, by cycling the **safety interlock** system through 10 000 operating cycles. In the event of any fault during or after the 10 000 operating cycles in the **safety interlock** system, the space controlled by the **safety interlock** shall:*

– *revert to a class 1 energy source for an **ordinary person** or a class 2 energy source for an **instructed person**; or*

– *be locked in the **normal operating condition** and comply with applicable requirements for a class 3 energy source.*

NOTE The above test is conducted to check the endurance of moving parts other than those in **safety interlock** systems, switches and relays. **Safety interlock** systems, switches and relays, if any, are subject to Annex G or K.7.1.

K.7 Interlock circuit isolation

K.7.1 Separation distances for contact gaps and interlock circuit elements

Separation distances for contact gaps and interlock circuit elements shall comply with the following requirements as applicable.

a) If the switch or relay disconnects a circuit conductor in a circuit connected to the **mains**, the separation distances for contact gaps and their related circuits shall be not less than that for a **disconnect device** (see Annex L).

b) If the switch or relay is in a circuit isolated from the **mains**, the separation distances for contact gaps shall be not less than the relevant minimum **clearance** value for **basic insulation** for isolation of class 2 energy sources. Interlock circuit elements, the failure of which can defeat the interlock system, such as the fixed separation distances in a **safety interlock** circuit, shall comply with the requirements of 5.4.2 for **basic insulation**. The **temporary overvoltage** is not taken into account to determine the voltage to be used in Table 10 and Table 11 unless the circuit is subject to a **temporary overvoltage**.

c) If the switch or relay is in a circuit isolated from the **mains**, the separation distances for contact gaps shall be not less than the relevant minimum **clearance** value for **reinforced insulation** for isolation of class 3 energy sources. Interlock circuit elements, the failure of which can defeat the interlock system, such as the fixed separation distances in a **safety interlock** circuit, shall comply with the requirement of 5.4.2 for **basic insulation**, except that if a life threatening hazard is involved in the interlocked space, the fixed separation distances shall comply with the requirement for **reinforced insulation**. The **temporary overvoltage** is not taken into account to determine the voltage to be used in Table 10 and Table 11 unless the circuit is subject to a **temporary overvoltage**.

As an alternative to a), b) and c), the separation distances for the contact gap between contacts in the off position shall withstand the electric strength test of 5.4.9.1 required for **basic insulation** or **reinforced insulation**, as applicable. The contact gap shall comply with the above requirements before and after the test of K.7.2.

The altitude multiplication factor of Table 16 does not need to be taken into account.

The separation distances for the contact gap of the switch or relay shall comply with K.7.3 and K.7.4 in addition to the above requirements, unless the switch or relay complies with G.1 and G.2 respectively. The endurance test condition shall represent the maximum **normal**

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operating condition within the equipment with respect to voltage and current that the contacts interrupt.

Two independent interlock systems, in series, using **basic insulation** may be used as an alternative to the provision of **reinforced insulation**.

K.7.2 Overload test

*The contact of a switch or relay in the **safety interlock** system is subjected to an overload test consisting of 50 cycles of operation at the rate of 6 to 10 cycles per minute, making and breaking 150 % of the current imposed in the application, except that where a switch or relay contact switches a motor load, the test is conducted with the rotor of the motor in a locked condition.*

*After the test, the **safety interlock** system, including the switch or relay, shall still be functional.*

K.7.3 Endurance test

*The contact of a switch or relay in the **safety interlock** system is subjected to an endurance test, making and breaking 100 % of the current imposed in the application at a rate of 6 to 10 cycles of operation per minute. A higher rate of cycling may be used if requested by the manufacturer.*

*For reed switches used in a **safety interlock** system in ES1 or ES2, the test is 100 000 operating cycles. For other switches and relays in a **safety interlock** system, the test is 10 000 operating cycles.*

*After the test, the **safety interlock** system, including the switch or relay, shall still be functional.*

K.7.4 Electric strength test

*Except for reed switches in ES1 or ES2, an electric strength test as specified in 5.4.9.1 is applied between the contacts after the tests of K.7.3. If the contact is in a circuit connected to the **mains**, the test voltage is as specified for **reinforced insulation**. If the contact is in a circuit isolated from the **mains**, the test voltage is as specified for **basic insulation** in a circuit connected to the **mains**.*

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Annex L
(normative)

Disconnect devices

L.1 General requirements

A **disconnect device** shall be provided to disconnect the equipment from the supply. If a **disconnect device** interrupts the neutral conductor, it shall simultaneously interrupt all phase conductors.

A **disconnect device** may be:

– the plug on the power supply cord; or
– an appliance coupler; or
– an isolating switch; or
– a circuit breaker; or
– any equivalent means for disconnection.

For equipment intended to be powered from an AC **mains** that is Overvoltage Category I, Overvoltage Category II or Overvoltage Category III, or from a DC **mains** that is ES3, a **disconnect device** shall have a contact separation of at least 3 mm. For an AC **mains** that is Overvoltage Category IV, IEC 60947-1 shall apply. When incorporated in the equipment, the **disconnect device** shall be connected as closely as practicable to the incoming supply.

For equipment intended to be powered from a DC **mains** that is not at ES3,

– a **disconnect device** shall have a contact separation at least equal to the minimum **clearance** for **basic insulation**; and
– a removable fuse may be used as a **disconnect device**, provided that it is **accessible** only to an **instructed person** or to a **skilled person**.

L.2 Permanently connected equipment

For **permanently connected equipment** the **disconnect device** shall be incorporated in the equipment, unless the equipment is accompanied by installation instructions stating that an appropriate **disconnect device** shall be provided as part of the building installation.

NOTE External **disconnect devices** will not necessarily be supplied with the equipment.

L.3 Parts that remain energized

Parts on the supply side of a **disconnect device** in the equipment, that remain energized when the **disconnect device** is switched off, shall be guarded to reduce the risk of accidental contact by **skilled persons**.

As an alternative, instructions shall be provided in the service manual.

L.4 Single-phase equipment

For single-phase equipment, the **disconnect device** shall disconnect both poles simultaneously, except that a single-pole **disconnect device** can be used to disconnect the phase conductor when it is possible to rely on the identification of the neutral in the **mains**. If only a single pole **disconnect device** is provided in the equipment, instructions shall be given

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for the provision of an additional two-pole **disconnect device** in the building installation when the equipment is used where identification of the neutral in the **mains** is not possible.

EXAMPLE Cases where a two-pole **disconnect device** is required are:

- on equipment supplied from an IT power system;
- on pluggable equipment supplied through a reversible appliance coupler or a reversible plug (unless the appliance coupler or plug itself is used as the **disconnect device**;
- on equipment supplied from a socket-outlet with indeterminate polarity.

L.5 Three-phase equipment

For three-phase equipment, the **disconnect device** shall disconnect simultaneously all phase conductors of the supply. For equipment requiring a neutral connection to an IT power system, the **disconnect device** shall be a four-pole device and shall disconnect all phase conductors and the neutral conductor. If this four-pole device is not provided in the equipment, the installation instructions shall specify the need for its provision as part of the building installation.

L.6 Switches as disconnect devices

Where the **disconnect device** is a switch incorporated in the equipment, the on and off positions shall be marked in accordance with F.3.5.2.

L.7 Plugs as disconnect devices

Where a plug on the power supply cord is used as the **disconnect device**, the installation instructions shall state that for pluggable equipment, the socket-outlet shall be easily **accessible**. For pluggable equipment intended for installation by an **ordinary person**, the installation instructions shall be made available to the **ordinary person**.

L.8 Multiple power sources

Where a unit receives power from more than one source (for example, different voltages/frequencies or as redundant power), there shall be a prominent **instructional safeguard** in accordance with Clause F.5 near each **disconnect device** giving adequate instructions for the removal of all power from the unit.

One **instructional safeguard** may be used for more than one **disconnect device**, as long as it is clearly visible from the disconnect points.

The elements of the **instructional safeguard** shall be as follows:

– element 1a:  , IEC 60417-6042 (2010-11); and

 , IEC 60417-6172 (2012-09)

– element 2: “Caution” or equivalent word or text, and “Shock hazard” or equivalent text

– element 3: optional

– element 4: “Disconnect all power sources” or equivalent text

Equipment incorporating an internal UPS shall have provisions for reliably disabling the UPS and disconnecting its output prior to servicing the equipment. Instructions for disconnection of

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the UPS shall be provided. The internal energy source of the UPS shall be marked appropriately and guarded against accidental contact by a **skilled person**.

L.9 Compliance criteria

Compliance is checked by inspection.

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Annex M
(normative)

Equipment containing batteries and their protection circuits

M.1 General requirements

This annex provides additional requirements for equipment that contains **batteries**. Use of **batteries** in the equipment may require **safeguards** that have not been addressed in other parts of this document. This annex does not cover requirements for external **batteries**, installation of external **batteries** or **battery** maintenance other than **battery** replacement by an **ordinary person** or an **instructed person**.

Where a **battery** safety standard contains equivalent requirements to the requirements in this annex, a **battery** in compliance with that **battery** standard is considered to fulfil the corresponding requirements of this annex, and tests that are part of the **battery** safety standard need not be repeated under this annex.

For consumer grade, non-rechargeable carbon-zinc or alkaline **batteries**, M.3 and M.10 apply.

M.2 Safety of batteries and their cells

M.2.1 Requirements

Batteries and their **cells** shall comply with the relevant IEC standards for **batteries** as listed below.

IEC 60086-4, IEC 60086-5, IEC 60896-11, IEC 60896-21, IEC 60896-22, IEC 61056-1 and IEC 61056-2, IEC 61427 (all parts), IEC TS 61430, IEC 61434, IEC 61959, IEC 62133 (all parts), IEC 62133-1, IEC 62133-2, IEC 62281, IEC 62485-2 and IEC 62619.

NOTE Other **battery** safety standards are under development, and are intended to be included in future.

M.2.2 Compliance criteria

Compliance is checked by inspection or evaluation based on data provided by the manufacturer.

M.3 Protection circuits for batteries provided within the equipment

M.3.1 Requirements

Protection circuits or construction for **batteries** provided within the equipment and that are not an integral part of the **battery** shall be so designed that:

– **safeguards** are effective during **normal operating conditions**, **abnormal operating conditions**, **single fault conditions**, installation conditions and transportation conditions; and

– the output characteristics of a **battery** charging circuit are compatible with its rechargeable **battery**; and

– for non-rechargeable **batteries**, discharging at a rate exceeding the **battery** manufacturer's recommendations and unintentional charging are prevented; and

– for rechargeable **batteries**, charging and discharging at a rate exceeding the **battery** manufacturer's recommendations, and reversed charging are prevented; and

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– **batteries** in **hand-held equipment**, **direct plug-in equipment** and **transportable equipment** that are replaceable by an **ordinary person** shall be inherently protected to avoid creating a class 2 energy source or a class 3 energy source; and

– for **batteries** that are replaceable by an **ordinary person**, reverse polarity installation shall be prevented if this could create a class 2 or class 3 energy source (see also B.3.6).

NOTE Reversed charging of a rechargeable **battery** occurs when the polarity of the charging circuit is reversed, aiding the discharge of the **battery**.

M.3.2 Test method

*Protection circuits for **batteries** are checked by inspection and by evaluation of the data provided by the equipment manufacturer and **battery** manufacturer for charging and discharging rates.*

*When appropriate data is not available, compliance is checked by test. However, **batteries** that are inherently safe for the conditions given are not tested under those conditions. Consumer grade, non-rechargeable carbon-zinc or alkaline **batteries** are considered safe under short-circuiting conditions and therefore are not tested for discharge; nor are such **batteries** tested for leakage under storage conditions.*

*The **battery** used for the following tests is either a new non-rechargeable **battery** or a fully charged rechargeable **battery** as provided with the equipment, or recommended by the manufacturer for use with the equipment. The test for **battery** protection circuits in the equipment may be performed using a **battery** simulator replacing the **battery** itself. The temperature test is conducted in a temperature controlled chamber. A control signal simulating the actual signal from the temperature sensor in the **battery** may be used in order to perform the test.*

– *Overcharging of a rechargeable **battery**. The **battery** is charged while briefly subjected to the simulation of any **single fault condition** that is likely to occur in the charging circuit and that results in overcharging of the **battery**. To minimize testing time, the failure is chosen that causes the worst-case overcharging condition. The **battery** is then charged for a single period of 7h with the simulated failure in place.*

– *Excessive discharging. The **battery** is subjected to rapid discharge by open-circuiting or short-circuiting any current limiting or voltage limiting component in the load circuit of the **battery** under test (one component at a time).*

– *Unintentional charging of a non-rechargeable **battery**. The **battery** is charged while briefly subjected to the simulation of any single component failure that is likely to occur in the circuit and that would result in unintentional charging of the **battery**. To minimize testing time, the failure is chosen that causes the highest charging current. The **battery** is then charged for a single period of 7 h with the simulated failure in place.*

*Where more than one **cell** is provided in a **battery**, all **cells** shall be tested as a unit.*

NOTE Some of the tests specified can be hazardous to the persons performing the tests. Use appropriate measures to protect such persons against possible chemical or **explosion** hazards.

*For equipment where the **battery** can be removed from the equipment by an **ordinary person**, the following additional test applies:*

– *Reverse charging of a rechargeable **battery**. Check whether the equipment containing a **battery** has such construction design that the **battery** may be placed into the equipment in the manner causing reverse charging. Also it will be checked if the electrical connection is made. If a reverse charging is judged possible by the inspection, the following test is applied. However, when relevant IEC **battery** standards cover this requirement, the test is considered to be performed.*

  *The **battery** is installed in the reverse orientation and then the charging circuit is subject to simulation of any single component failure. To minimize testing time, the failure is chosen that causes the highest reverse charging current. The **battery** is then reverse charged for a single period of 7 h with the simulated failure in place.*

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M.3.3 Compliance criteria

These tests shall not result in any of the following:

– *chemical leakage caused by cracking, rupturing or bursting of the **battery** jacket, if such leakage could adversely affect a **safeguard**; or*

– *spillage of liquid from any pressure relief device in the **battery**, unless such spillage is contained by the equipment without risk of damage to a **safeguard** or harm to an **ordinary person** or an **instructed person**; or*

– ***explosion** of the **battery**, if such **explosion** could result in injury to an **ordinary person** or an **instructed person**; or*

– *emission of flame or expulsion of molten metal to the outside of the equipment **enclosure**.*

Throughout the tests:

– *the **battery** temperature shall not exceed the allowable temperature of the **battery** as specified by the **battery** manufacturer; and*

– *the maximum current drawn from the **battery** shall be within the range of the specification of the **battery**.*

M.4 Additional safeguards for equipment containing a portable secondary lithium battery

M.4.1 General

Equipment designed to be operated while incorporating one or more portable sealed **secondary lithium batteries** are subject to the requirements in this clause.

M.4.2 Charging safeguards

M.4.2.1 Requirements

Under **normal operating conditions**, **abnormal operating conditions** or **single fault conditions** the charging voltage per **secondary lithium battery** and the charging current per **secondary lithium battery** shall not exceed the **maximum specified charging voltage** and **maximum specified charging current**.

Under **abnormal operating conditions**, the **battery** charging circuit shall:

– stop charging when the temperature of the **battery** exceeds the **highest specified charging temperature**; and

– limit the current to the value specified by the **battery** manufacturer when the **battery** temperature is lower than the **lowest specified charging temperature**.

M.4.2.2 Compliance criteria

*Compliance is checked by measuring the charging voltage, the charging current and the temperature of each individual **cell** of the **secondary lithium battery** under **normal operating conditions**, **abnormal operating conditions** and **single fault conditions**. The **cell** temperature shall be measured at the points specified by the **battery** manufacturer. **Single fault conditions** that may affect the charging voltage or charging current or the temperature shall be applied in accordance with Clause B.4.*

NOTE 1 For potted assemblies, thermocouples could be attached to the **cell** surface before potting.

*A higher charging voltage than the **maximum specified charging voltage** or a higher charging current than the **maximum specified charging current**, that occurs just after the introduction of an **abnormal operating condition** or a **single fault condition**, may be*

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*ignored if the operation of a protective device or circuitry, provided in addition to the normal regulating circuitry, prevents an unsafe condition of the **battery**.*

*Where appropriate, for the purpose of the measurement, the **battery** may be replaced by a circuit simulating the **battery** load.*

*The charging voltage shall be measured when the **secondary lithium battery** becomes fully charged. The charging current shall be measured during the entire charging cycle up to the **maximum specified charging voltage**.*

During and after the test, the following applies:

- *The charging voltage shall not exceed the **maximum specified charging voltage**.*
- *The charging current shall not exceed the **maximum specified charging current**.*
- *The charging of the **battery** shall stop when the temperature of the **battery** exceeds the **highest specified charging temperature**.*
- *The **battery** charging circuit shall limit the current to the value specified by the **battery** manufacturer when the **battery** temperature is lower than the **lowest specified charging temperature**.*

*In addition, for equipment where the **battery** can be removed from the equipment by an **ordinary person**, compliance is checked by measuring the charging voltage and the charging current, and by evaluating the temperature control function of the equipment under **normal operating conditions**, **abnormal operating conditions** and **single fault conditions**.*

*All parameters controlled by the protection circuit for the **battery** shall be within those specified in the relevant IEC **battery** standard, and shall cover the following:*

- *the maximum current drawn from the **battery** shall be within the range of the specification of the **battery**; and*
- *throughout the tests, the **battery** temperature shall not exceed the allowable temperature of the **battery** as specified by the **battery** manufacturer.*

NOTE 2 The controlling elements are voltage, current, and temperature.

M.4.3 Fire enclosure

Secondary lithium batteries shall be provided with a **fire enclosure** according to 6.4.8. The **fire enclosure** may be that of the **secondary lithium battery** itself, of the **cell** or of a combination of **cells** or that of the equipment containing the **secondary lithium battery**.

Equipment with **batteries** are exempt from the above requirement if the equipment uses a **cell** that complies with PS1.

*Compliance is checked by inspection of the relevant material or by evaluation of the **secondary lithium battery** data sheet.*

M.4.4 Drop test of equipment containing a secondary lithium battery

M.4.4.1 General

The tests for **direct plug-in equipment**, **hand-held equipment** and **transportable equipment** that contain a **secondary lithium battery** are specified below. These tests are specified to verify that mechanical shock will not compromise a **safeguard** within the **battery** or the equipment.

M.4.4.2 Preparation and procedure for the drop test

The drop test is conducted in the following order:

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– *Step 1: drop of the equipment containing a **battery** as specified in M.4.4.3.*
– *Step 2: check the charge and discharge function of the dropped equipment as specified in M.4.4.4.*
– *Step 3: conduct a charge and discharge cycle test of the dropped **battery** as specified in M.4.4.5.*

*As a preparation of the drop test, two **batteries** are fully charged at the same time under the same charging conditions. The open circuit voltages of both **batteries** are measured to confirm the initial voltages are the same. One **battery** is used for the drop test and the other is used as a reference.*

M.4.4.3 Drop

*The equipment with a fully charged **battery** installed shall be subjected to the drop test of Clause T.7.*

*After the drop test, the **battery** is removed from the equipment. The open circuit voltages of the dropped **battery** and the reference (undropped) **battery** are periodically monitored during the following 24 hour period. The voltage difference shall not exceed 5 %.*

M.4.4.4 Check of the charge / discharge function

*The charging/discharging circuit functions (charging- control voltage, charging control current, and temperature control) are checked to determine that they continue to operate and that all **safeguards** are effective. A dummy **battery** or appropriate measurement tool that represents the **battery** characteristics may be used for this examination in order to differentiate between **battery** damage and equipment malfunctions.*

If the charge/discharge function does not operate, the test is terminated, continuation with step 3 is not necessary and compliance is determined by M.4.4.6.

M.4.4.5 Charge / discharge cycle test

*If the dropped equipment is still functioning, the dropped equipment with the dropped **battery** installed is subject to three complete discharge and charge cycles under **normal operating conditions**.*

M.4.4.6 Compliance criteria

*During the tests, fire or **explosion** of the **battery** shall not occur unless an appropriate **safeguard** is provided that contains the **explosion** or fire. If venting occurs, any electrolyte leakage shall not defeat a **safeguard**.*

*When a protection circuitry for charging or discharging in the equipment or the **battery** detects an abnormality in the **battery** and stops charging or discharging, the result is considered to be acceptable.*

M.5 Risk of burn due to short-circuit during carrying

M.5.1 Requirements

Battery terminals shall be protected from the possible burn that may occur to an **ordinary person** or an **instructed person** during the carrying of a **battery** with exposed bare conductive terminals (such as in the user's carrying bag) due to a short-circuit caused by metal objects, such as clips, keys and necklaces.

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M.5.2 Test method and compliance criteria

*If the **battery** is designed to be carried with bare conductive terminals, the **battery** shall comply with the test of P.2.3.*

The compliance criteria of M.3.3 apply.

M.6 Safeguards against short-circuits

M.6.1 Requirements

The electric energy stored in **cells** or **batteries** may be released in an inadvertent and uncontrolled manner due to external short-circuiting of the terminals or an internal **safeguard** failure, such as a metal contaminant bridging the insulation. As a result, the considerable amount of energy, heat and pressure generated by the high current can produce molten metal, sparks, **explosion** and vaporisation of electrolyte.

To address external faults, the main connections from the **battery** terminals shall either:

– be provided with a sufficient overcurrent protective device to prevent any accidental short-circuit inducing conditions as mentioned above; or

– the **battery** connections up to the first overcurrent protective device shall be constructed so that a short-circuit is not likely to occur and connections shall be designed to withstand the electromagnetic forces experienced during a short-circuit.

NOTE 1 Where terminals and conductors are not insulated, by design or for maintenance purposes, only insulated **tools** are to be used in that area.

Unless internal fault testing has been conducted on the **cell** as part of compliance with an IEC **battery** standard in M.2.1, the internal fault testing as described below is required.

NOTE 2 Not all **battery** standards in M.2.1 contain a similar internal fault test.

Each **cell** in a **battery** shall be faulted to ensure that each **cell** vents safely without introducing an **explosion** or fire. Where a **cell** is incorporated into a **battery** or the equipment, sufficient spacing shall be allowed for the proper vent operation of each **cell**.

M.6.2 Compliance criteria

For external faults, compliance may be checked by inspection.

The sample shall not explode or emit molten material at any time during any of the tests.

M.7 Risk of explosion from lead acid and NiCd batteries

M.7.1 Ventilation preventing an explosive gas concentration

Where **batteries** are provided within an equipment such that emitted gases may concentrate in a confined equipment space, the **battery** construction, air flow or ventilation shall be such that the atmosphere within the equipment does not reach an **explosive** concentration.

In a compartment containing both a **battery** and electrical components, the risk of ignition of local concentrations of hydrogen and oxygen by adjacent operational arcing parts, such as contactors and switches close to **battery** vents or valves, shall be controlled. This shall be achieved, for example, by the use of fully enclosed components, separation of **battery** compartments or adequate ventilation.

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The ventilation system shall be so constructed that any potential fault, including distortion of the **battery** cases due to overheating or thermal runaway, does not result in the ventilation system failing to vent **explosive** gasses.

If ventilation tubes are used for conducting **explosive** gas from the **battery** cases to the outside air, they shall not be the only means of eliminating the build-up of gas from the cabinet. An independent means of natural ventilation that adequately ventilates the **enclosure** containing the **batteries** shall be provided.

If mechanical or forced-air ventilation is used, adequate ventilation shall continue to be provided under **single fault conditions**.

Enclosures with mechanical or electromechanical dampers shall continue to provide adequate ventilation when the damper is in the closed position.

Clause M.7 is applied for open type **batteries** and valve regulated type **batteries**. Sealed type **batteries** with a mechanism of reducing gas are considered to comply with this requirement.

If it can be shown that the ventilation capability of the **enclosure** is compliant with the calculated required ventilation air flow (Q) according to M.7.2, the equipment is in compliance with Clause M.7. Unless it can be demonstrated under a **single fault condition** in the charging circuitry that the charge voltage cannot exceed the values for float charging in Table M.1, or if the **battery enclosure** contains no internal charging capability, calculations shall be conducted for boost charge condition for the **battery** types and maximum capacity specified and approved by the manufacturer. If the ventilation cannot be adequately shown, one of the ventilation tests in M.7.3 shall be conducted in order to ensure adequate ventilation.

The hydrogen generation (flow rate for testing) for the maximum supported **battery** capacity and supported **battery** types shall be calculated using data from the **battery** manufacturer, or the values for I_{float} and I_{boost} with supporting data as given in Table M.1 or by the following:

$$q_{\text{Batt}} = 0{,}45 \times 10^{-3} \frac{\text{m}^3}{\text{Ah}} \times I_{\text{gas}} \times C_{\text{rt}} \times n$$

with I_{gas}, C_{rt}, and n as described in M.7.2.

M.7.2 Test method and compliance criteria

*The purpose of ventilating a **battery** location or **enclosure** is to maintain the hydrogen concentration below the **explosive** 4 $\%_{vol}$ hydrogen LEL threshold. The hydrogen gas concentration shall not exceed 1 % by volume if the mixture is in proximity to an ignition source and not exceed 2 % by volume if the mixture is not in proximity to an ignition source.*

NOTE 1 When a **cell** reaches its fully charged state, water electrolysis occurs according to the Faraday's law.

Under standard conditions of normal temperature and pressure where T = 273 K, P = 1 013 hPa:

- *1 Ah decomposes H_2O into 0,42 l H_2 + 0,21 l O_2,*
- *decomposition of 1 cm^3 (1 g) H_2O requires 3 Ah,*
- *26,8 Ah decomposes H_2O into 1 g H_2 + 8 g O_2.*

*When the charging operation is stopped, the emission of gas from the **cells** can be regarded as having come to an end 1 h after having switched off the charging current.*

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*The minimum air flow rate for ventilation of a **battery** location or compartment shall be calculated by the following formula:*

$$Q = v \times q \times s \times n \times I_{gas} \times C_{rt} \times 10^{-3} \quad \left[m^3 / h\right]$$

where:

Q *is the ventilation air flow in m3/h;*

v *is the necessary dilution of hydrogen:*

$\frac{(100 - 4)\,\%}{4\,\%} = 24$;

q = $0{,}45 \times 10^{-3}$ $\left[\,m^3/Ah\,\right]$ *generated hydrogen at 20 °C;*

s *= 5, general safety factor;*

n *is the number of **cells**;*

I_{gas} *is the current producing gas in mA / Ah rated capacity for the float charge current I_{float} or the boost charge current I_{boost};*

C_{rt} *is the capacity C_{10} for lead acid **cells** (Ah) or capacity C_5 for NiCd **cells** (Ah)*

NOTE 2 C_{10} is the 10 h rate with current I_{10} for lead acid **cells**: (Ah) to U_{final} = 1,80 V/**cell** at 20 °C.

C_5 is the 5 h rate with current I_5 for NiCd **cells**: (Ah) to U_{final} = 1,00 V/**cell** at 20 °C.

with $v \times q \times s = 0{,}05 \left[m^3/Ah\right]$ *the ventilation air flow calculation formula is:*

$$Q = 0{,}05 \times n \times I_{gas} \times C_{rt} \times 10^{-3} \quad \left[m^3 / h\right]$$

The current I_{gas} in mA producing gas is determined by one of the following formulas:

$$I_{gas} = I_{float} \times f_g \times f_s \left[mA/Ah\right] \text{ or}$$

$$I_{gas} = I_{boost} \times f_g \times f_s \left[mA/Ah\right]$$

where:

I_{gas} *is the current producing gas in mA / Ah rated capacity for the float charge current I_{float} or the boost charge current I_{boost};*

I_{float} *is the float charge current under fully charged condition at a defined float charge voltage at 20 °C;*

I_{boost} *is the boost charge current under fully charged condition at a defined boost charge voltage at 20 °C;*

f_g *is the gas emission factor, proportion of current at fully charged state producing hydrogen (see* Table M.1*);*

f_s *is the safety factor, to accommodate faulty **cells** in a **battery** and an aged **battery** (see* Table M.1*).*

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Table M.1 – Values for current I_{float} and I_{boost}, factors f_g and f_s, and voltages U_{float} and U_{boost}

Parameter	Lead-acid batteries vented cells Sb < 3 % [a]	Lead-acid batteries VRLA cells	NiCd batteries vented cells [b]
Gas emission factor f_g	1	0,2	1
Gas emission safety factor f_s (incl. 10 % faulty **cells** and ageing)	5	5	5
Float charge voltage U_{float} [c] V/**cell**	2,23	2,27	1,40
Typical float charge current I_{float} A/Ah	1	1	1
Current (float) I_{gas} mA/Ah (under float charge conditions relevant for air flow calculation)	5	1	5
Boost charge voltage U_{boost} [c] V/**cell**	2,40	2,40	1,55
Typical boost charge current I_{boost} mA/Ah	4	8	10
Current (boost) I_{gas} mA/Ah (under boost charge conditions relevant for air flow calculation)	20	8	50

[a] For an antimony (Sb) content higher than 3 %, the current used for calculations shall be doubled.

[b] For recombination type NiCd **cells** consult the manufacturer.

[c] Float and boost charge voltage can vary with the specific gravity of electrolyte in lead-acid **cells**.

The values of float and boost charge current increase with temperature. The consequences of an increase in temperature, up to a maximum of 40 °C, have been accommodated in the values in Table M.1.

In case of use of gas recombination vent plugs, the gas producing current I_{gas} the values for vented cells can be reduced to 50 % of the values for vented **cells**.

The ventilation air volume requirements, for example, for two 48 V strings of VRLA **cells** in the same **battery** cabinet and each with 120 Ah rated C_{10} capacity amount, under float and under boost charge service conditions are:

– service with float charge condition only: Q = 0,05 × 24 × 1 × 120 × 0,001 = 0,144 m^3/h per string or 288 l/h total;

– service with boost charge condition: Q = 0,05 × 24 × 8 × 120 × 0,001 = 1,15 m^3/h per string or 2 300 l/h total.

*For recombinant NiCd cells, or for lead-acid **battery** types where the gassing rate in volts per cell per hour (per ampere-hour) is published by the manufacturer, it is permitted to determine the minimum air flow rate Q using the measure gas emissions at boost-charge volts per cell charging, unless it can be verified that the output voltage of the charging circuit cannot exceed the float voltage under any conditions required by this document. The equation for Q becomes:*

$$Q = v \times s \times n \times r\ (\times C_{rt}) \times 10^{-3}\ (m^3/h)$$

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where:

v = *24, the necessary dilution of hydrogen:*

s = *5, general safety factor;*

n *is the number of* ***cells****;*

r *is the outgassing rate at a given voltage per cell per hour (may be per ampere-hour rating);*

C_{rt} *is the capacity* C_{10} *for lead acid* ***cells*** *(Ah) or capacity* C_5 *for NiCd* ***cells*** *(Ah).*

NOTE C_{rt} is not required for determining Q if the gassing rate r is provided in ml/(h-***cell***) or the equivalent.

For the purpose of calculating the area of ventilation openings required for natural ventilation, the air velocity is assumed to be 0,1 m/s.

Alternately, the following equation can be used:

$$A = 28 \times Q$$

where:

Q *is the ventilation rate of fresh air* (m^3/h);

A *is the free area of openings in air inlet and outlet* (cm^2).

M.7.3 Ventilation tests

M.7.3.1 General

The test shall be performed with the EUT stabilized at 25 °C. If forced air ventilation is used, it shall be run under ***single fault conditions****. Movable mechanical or electro-mechanical dampers shall be closed or in the unpowered position. The air movement around the cabinet shall be minimized, or the EUT shall be placed in a cabinet to prevent air movement around the EUT during testing.*

M.7.3.2 Ventilation test – alternative 1

Samples of the atmosphere within the ***battery*** *compartment are to be taken after 7 h of operation. The samples are to be taken at locations where the greatest concentration of hydrogen gas is likely. The hydrogen gas concentration shall not exceed 1 % by volume if the mixture is in proximity to an ignition source, and not exceed 2 % by volume if the mixture is not in proximity to an ignition source. See M.3.2 for evaluating the overcharging of a rechargeable* ***battery****.*

M.7.3.3 Ventilation test – alternative 2

The performance of the EUT ***battery*** *ventilation system shall be verified by conducting a test utilizing hydrogen, or helium to represent hydrogen.*

The test will determine if the EUT is capable of ventilating the calculated hydrogen generation rate.

Step 1 *Helium or hydrogen sensors (depending on the chosen gas) shall be placed in all cabinet compartments that are subjected to hydrogen evolution from the* ***battery*** *compartment.*

Step 2 *Helium or hydrogen shall be injected into the* ***battery*** *compartment until a concentration of 1 % or 2 % as required below is reached. The rate of helium or hydrogen injection required to maintain the concentration under steady state conditions shall be reported. Steady state shall be defined as a maximum variation of ± 0,25 % over a period of 1 h.*

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Step 3 Compare the rate of helium or hydrogen obtained in Step 2 with the calculated hydrogen generation rate in M.7.1.

*If the calculated hydrogen generation rate for the maximum **battery** capacity as specified by the manufacturer exceeds the amount of helium or hydrogen that was being injected by more than 1 % by volume if the mixture is in proximity to an ignition source, or exceeds 2 % by volume if the mixture is not in proximity to an ignition source, the EUT compartment ventilation system is not in compliance with this requirement.*

*If the calculated hydrogen generation rate, for the maximum **battery** capacity as specified by the manufacturer, is less than or equal to the rate of helium or hydrogen that was being injected, the EUT compartment ventilation system is in compliance with this requirement.*

M.7.3.4 Ventilation test – alternative 3

*The test shall be performed as described in M.7.3.1 with a hydrogen or helium source used to inject a flow rate described in M.7.1. Samples of the atmosphere within the **battery** compartment or other area where hydrogen may accumulate is continuously monitored for 7 h or until the levels are stable. Steady state shall be defined as a maximum variation of ±0,25 % over a period of 1 h. The gas monitored in this manner is to be returned to the EUT under test. The hydrogen gas concentration shall not exceed 1 % by volume if the mixture is in proximity to an ignition source, and not exceed 2 % by volume if the mixture is not in proximity to an ignition source. The sampling method in the original test may also be used, however, if hydrogen is used, care should be taken to establish that safe levels exist in the EUT prior to injecting for 7 h.*

NOTE This method is particularly suited to evaluating mixed or complex systems or ventilation patterns.

M.7.4 Marking requirement

Unless the **batteries** are provided with the equipment, the compartment shall be marked either with the supported **battery** types and the maximum capacities or “Use only batteries approved by the manufacturer”, provided that this information is specified in the installation/service instructions.

M.8 Protection against internal ignition from external spark sources of batteries with aqueous electrolyte

M.8.1 General

The requirements specified below apply to rechargeable **batteries** providing a venting system.

NOTE For example, a **battery** used in a UPS.

The level of air ventilation rate shall ensure that a risk of **explosion** does not exist by keeping the hydrogen content in air below 1 $\%_{vol}$ at the **PIS**.

The use of an effective flame arrester in the **battery** venting system will prevent an external **explosion** propagating into the **battery**.

Clause M.8 is applied for open type **batteries** and valve regulated type **batteries**. Sealed type **batteries** with a mechanism of reducing gas are considered to comply with this requirement.

M.8.2 Test method

M.8.2.1 General

The test shall be carried out according to IEC 60896-21:2004, 6.4.

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NOTE 1 This test is designed to reveal the protection afforded by the valve unit against the ignition of the gases within a **cell** by an external ignition source. During this test, use proper precautions to **safeguard** persons and equipment from **explosion** and burns.

A minimum distance d extending through air shall be maintained within which a maximum surface temperature of 300 °C shall not be exceeded (no flames, sparks, arcs or glowing devices).

NOTE 2 When calculating the minimum distance d to protect against **explosion** in close proximity to the source of release of a **cell** or **battery**, the dilution of **explosive** gases is not always ensured. The dispersion of **explosive** gas depends on the gas release rate and the ventilation characteristics close to the source of release.

*The minimum distance d can be estimated by calculating the dimensions of a hypothetical volume V_z of potentially **explosive** gas around the source of release, outside of which the concentration of hydrogen is below the safe concentration of the LEL.*

$$d = 28{,}8 \times \sqrt[3]{I_{gas}} \times \sqrt[3]{C_{rt}} \quad [\text{mm}]$$

where:

I_{gas} *is the current producing gas [mA / Ah];*

C_{rt} *is the rated capacity [Ah].*

NOTE 3 The required distance d can be achieved by the use of a partition wall between the **battery** and sparking device.

*Where **batteries** form an integral part of a power supply system (for example, in a UPS system), the distance d, where d is the minimum distance (**clearance**) between the ventile of the **battery** and the electronic equipment that may exhibit flames, sparks, arcs or glowing devices (maximum surface temperature 300 °C), may be reduced according to the equipment manufacturer's calculations or measurements. The level of air ventilation rate should ensure that a risk of **explosion** does not exist by keeping the hydrogen content in air below 1 $\%_{vol}$ plus a margin at the **PIS.***

M.8.2.2 Estimation of hypothetical volume V_z

The theoretical minimum ventilation flow rate to dilute the flammable gas (hydrogen) to a concentration below the LEL can be calculated by means of the formula:

$$\left(\frac{dV}{dt}\right)_{min} = \frac{(dG/dt)_{max}}{k \times \text{LEL}} \times \frac{T}{293}$$

where:

dV/dt_{min} is the minimum volumetric flow rate of fresh air required to dilute the gas (m^3/s);

dG/dt_{max} is the maximum gas release rate (kg/s);

LEL is 4 $\%_{vol}$ for hydrogen (kg/m^3);

k is the factor applied to the LEL; k = 0,25 is chosen for dilution of hydrogen gas;

T is the ambient temperature in kelvin (293 K = 20 °C).

The volume V_z represents the volume over which the mean concentration of flammable gas will be 0,25 times the LEL. This means that at the extremities of the hypothetical volume, the concentration of gas will be significantly below the LEL (for example, the hypothetical volume where the concentration is above LEL would be less than V_z).

NOTE See B.4.2.2 in IEC 60079-10:2002 for the calculation of LEL.

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M.8.2.3 Correction factors

With a given number of air changes per unit time, c, related to the general ventilation the hypothetical volume V_z of potentially **explosive** atmosphere around the source of release can be estimated as follows:

$$V_z = \left(\frac{dV}{dt}\right)_{min} / c$$

where c is the number of fresh air changes per unit time (s^{-1}).

The above formula holds for an instantaneous and homogenous mixing at the source of release given ideal flow conditions of fresh air. In practice, ideal conditions rarely exist. Therefore a correction factor f is introduced to denote the effectiveness of the ventilation.

$$V_z = f \times \left(\frac{dV}{dt}\right)_{min} / c$$

where f is the ventilation effectiveness factor, denoting the efficiency of the ventilation in terms of its effectiveness in diluting the **explosive** atmosphere, f ranging from 1 (ideal) to typically 5 (impeded air flow). For **battery** installations the ventilation effectiveness factor is f = 1,25.

M.8.2.4 Calculation of distance d

The term $\left(\frac{dV}{dt}\right)_{min}$ including all factors corresponds with the hourly ventilation air flow Q (in m^3/h) for secondary **batteries** calculated under

$$Q = f \times \left(\frac{dV}{dt}\right)$$

$$Q = 0{,}05 \times (N) \times I_{gas} \times C_{rt} \times 10^{-3} \quad [m^3/h]$$

This hourly ventilation air flow Q can be used to define a hypothetical volume. Assuming a hemispherical dispersal of gas, a volume of a hemisphere V_z = 2/3 π d^3 can be defined, where d is the distance from the source of release.

This results in the calculation formula for the distance d, with c = 1 air change per hour within the hemisphere:

$$d^3 = \frac{3}{2\pi} \times 0{,}05 \times 10^6 \times (N) \times I_{gas} \times C_{rt} \quad [mm^3]$$

$$d = 28{,}8 \times \left(\sqrt[3]{N}\right) \times \sqrt[3]{I_{gas}} \times \sqrt[3]{C_{rt}} \quad [mm]$$

Depending on the source of gas release, the number of **cells** per monobloc **battery** (N) or vent openings per **cell** involved ($1/N$) shall be taken into consideration (for example, by the factor $\sqrt[3]{N}$, respectively $\sqrt[3]{1/N}$).

The distance d as a function of the rated capacity for various charge currents I (mA/Ah) is shown in Figure M.1.

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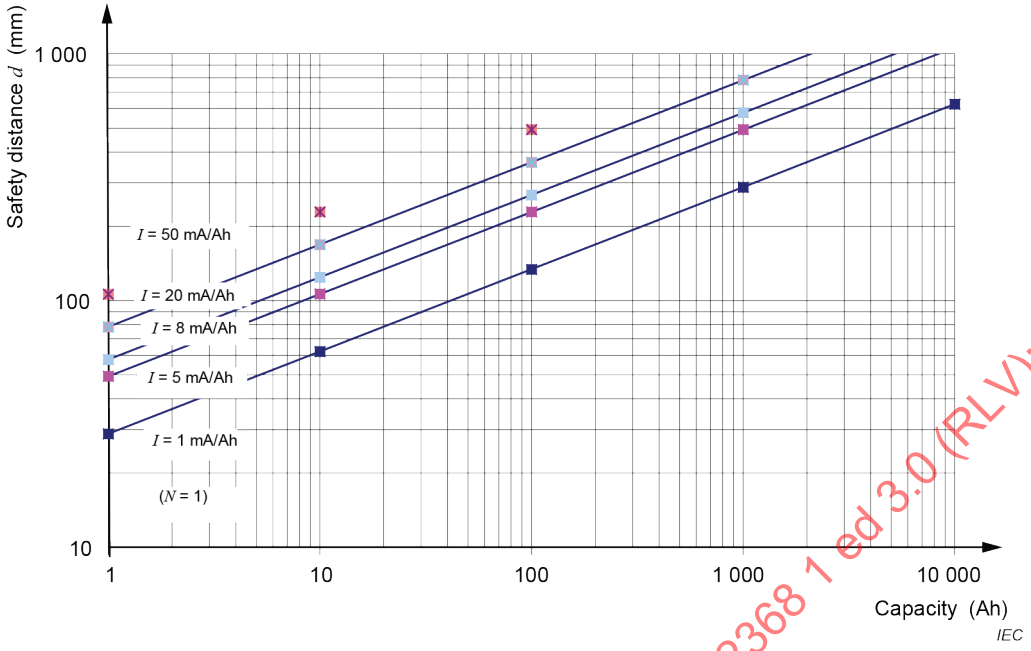


Figure M.1 – Distance d as a function of the rated capacity for various charge currents I (mA/Ah)

M.9 Preventing electrolyte spillage

M.9.1 Protection from electrolyte spillage

Equipment shall be constructed so that spillage of electrolyte from **batteries**, that may have an adverse effect on skin, eye and other human body parts, other **safeguards** or the premises, is unlikely. All possible operating modes during maintenance should be taken into account, including replacement of the **battery** and refilling of consumed material.

Compliance is checked by inspection.

M.9.2 Tray for preventing electrolyte spillage

If **cell** failure could result in the spillage of electrolyte, the spillage shall be contained (for example, by use of a retaining tray adequate to contain the electrolyte) taking into account the maximum possible spillage amount.

This requirement is applicable to **stationary equipment** and does not apply if the construction of the **battery** is such that leakage of the electrolyte from the **battery** is unlikely, or if spillage of electrolyte does not adversely affect required insulation.

NOTE An example of a **battery** construction where leakage of the electrolyte is considered to be unlikely is the sealed **cell** valve-regulated type.

Compliance is checked by inspection.

M.10 Instructions to prevent reasonably foreseeable misuse

A **battery** incorporated in the equipment and a **battery** together with its associated components (including **cells** and electric power generators) shall be so constructed that an electric shock or fire **safeguard** failure (for example, flammable chemical leakage causing fire

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or insulation damage) is unlikely, taking all reasonably foreseeable conditions into account. If applicable, this shall include extreme conditions as specified by the manufacturer, such as:

– high or low extreme temperatures that a **battery** can be subjected to during use, storage or transportation; and

– low air pressure at high altitude.

Where providing safety devices or design in a **battery** or equipment is not reasonably practical considering the functional nature of the **battery** or equipment containing a **battery**, **instructional safeguards** in accordance with Clause F.5 shall be provided to protect the **battery** from extreme conditions or user's abuse. Examples that shall be considered include:

– replacement of a **battery** with an incorrect type that can defeat a **safeguard** (for example, in the case of some lithium **battery** types);

– disposal of a **battery** into fire or a hot oven, or mechanically crushing or cutting of a **battery**, that can result in an **explosion**;

– leaving a **battery** in an extremely high temperature surrounding environment that can result in an **explosion** or the leakage of flammable liquid or gas; and

– a **battery** subjected to extremely low air pressure that may result in an **explosion** or the leakage of flammable liquid or gas.

For equipment containing a **battery** that is replaceable by an **ordinary person**, an **instructional safeguard** shall be provided in accordance with Clause F.5, except that the complete **instructional safeguard** may be provided in the instructions.

The elements of the **instructional safeguard** shall be as follows:

– elements 1a or 1b: not required

– element 2: “CAUTION” or equivalent word or text

– element 3: “Risk of fire or explosion if the battery is replaced by an incorrect type” or equivalent text

– element 4: optional

Compliance is checked by inspection or by evaluation of available data provided by the manufacturer.

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Annex N
(normative)

Electrochemical potentials (V)

Magnesium, magnesium alloys	Zinc, zinc alloys	80 tin/20 zinc on steel, zinc on iron or steel l	Aluminium	Cadmium on steel	Aluminium/magnesium alloy	Mild steel	Duralumin	Lead	Chromium on steel, soft solder	Cr on Ni on steel, tin on steel, 12 % Cr stainless steel	High chromium stainless steel	Copper, copper alloys	Silver solder, austenitic stainless steel	Nickel on steel	Silver	Rhodium on silver on copper, silver/gold alloy	Carbon	Gold, platinum	
0	0,5	0,55	0,7	0,8	0,85	0,9	1,0	1,05	1,1	1,15	1,25	1,35	1,4	1,45	1,6	1,65	1,7	1,75	Magnesium, magnesium alloys
	0	0,05	0,2	0,3	0,35	0,4	0,5	0,55	0,6	0,65	0,75	0,85	0,9	0,95	1,1	1,15	1,2	1,25	Zinc, zinc alloys
		0	0,15	0,25	0,3	0,35	0,45	0,5	0,55	0,6	0,7	0,8	0,85	0,9	1,05	1,1	1,15	1,2	80 tin/20 zinc on steel, zinc on iron or steel
			0	0,1	0,15	0,2	0,3	0,35	0,4	0,45	0,55	0,65	0,7	0,75	0,9	0,95	1,0	1,05	Aluminium
				0	0,05	0,1	0,2	0,25	0,3	0,35	0,45	0,55	0,6	0,65	0,8	0,85	0,9	0,95	Cadmium on steel
					0	0,05	0,15	0,2	0,25	0,3	0,4	0,5	0,55	0,6	0,75	0,8	0,85	0,9	Aluminium/magnesium alloy
						0	0,1	0,15	0,2	0,25	0,35	0,45	0,5	0,55	0,7	0,75	0,8	0,85	Mild steel
							0	0,05	0,1	0,15	0,25	0,35	0,4	0,45	0,6	0,65	0,7	0,75	Duralumin
								0	0,05	0,1	0,2	0,3	0,35	0,4	0,55	0,6	0,66	0,7	Lead
									0	0,05	0,15	0,25	0,3	0,35	0,5	0,55	0,6	0,65	Chromium on steel, soft solder
Cr = Chromium Ni = Nickel										0	0,1	0,2	0,25	0,3	0,45	0,5	0,55	0,6	Cr on Ni on steel, tin on steel, 12 % Cr stainless steel
											0	0,1	0,15	0,2	0,35	0,4	0,45	0,5	High chromium stainless steel
												0	0,05	0,1	0,25	0,3	0,35	0,4	Copper, copper alloys
													0	0,05	0,2	0,25	0,3	0,35	Silver solder, austenitic stainless steel
														0	0,15	0,2	0,25	0,3	Nickel on steel
															0	0,05	0,1	0,15	Silver
																0	0,05	0,1	Rhodium on silver on copper, silver/gold alloy
																	0	0,05	Carbon
																		0	Gold, platinum

Corrosion due to electrochemical action between dissimilar metals that are in contact is minimized if the combined electrochemical potential is below about 0,6 V. In the table the combined electrochemical potentials are listed for a number of pairs of metals in common use; combinations above the dividing line should be avoided.

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Annex O
(normative)

Measurement of creepage distances and clearances

In the following Figures O.1 to O.16, the value of X is given in Table O.1. Where the distance shown is less than X, the depth of the gap or groove is disregarded when measuring a **creepage distance**.

If the required minimum **clearance** is more than 3 mm, the value of X is given in Table O.1.

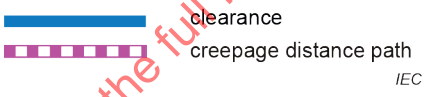
If the required minimum **clearance** is less than 3 mm, the value of X is the smaller of:

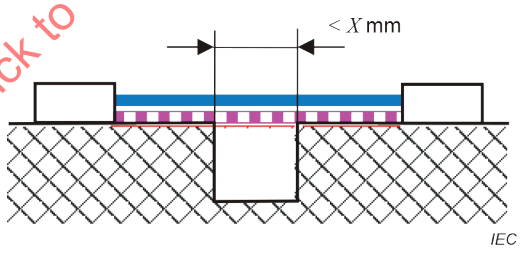
– the relevant value in Table O.1; or
– one third of the required minimum **clearance**.

Table O.1 – Value of X

Pollution degree (see 5.4.1.5)	X mm
1	0,25
2	1,00
3	1,50

NOTE Throughout this annex, the following convention is used:



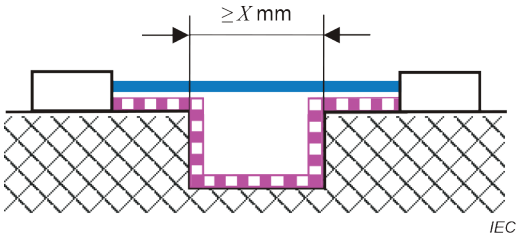


Condition: Path under consideration includes a parallel or converging-sided groove of any depth with width less than X mm.

Rule: **Creepage distance** and **clearance** are measured directly across the groove.

Figure O.1 – Narrow groove

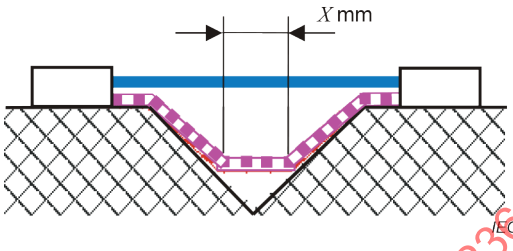
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Condition: Path under consideration includes a parallel-sided groove of any depth, and equal to or more than X mm wide.

Rule: **Clearance** is the "line of sight" distance. **Creepage distance** path follows the contour of the groove.

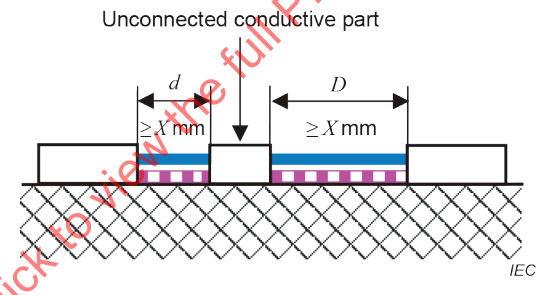
Figure O.2 – Wide groove



Condition: Path under consideration includes a V-shaped groove with an internal angle of less than 80° and a width greater than X mm.

Rule: **Clearance** is the "line of sight" distance. **Creepage distance** path follows the contour of the groove but "short-circuits" the bottom of the groove by X mm link.

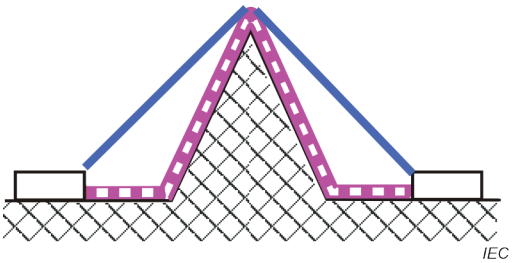
Figure O.3 – V-shaped groove



Condition: Insulation distance with intervening, unconnected conductive part.

Rule: **Clearance** is the distance $d + D$, **creepage distance** is also $d + D$. Where the value of d or D is smaller than X mm it shall be considered as zero.

Figure O.4 – Intervening unconnected conductive part

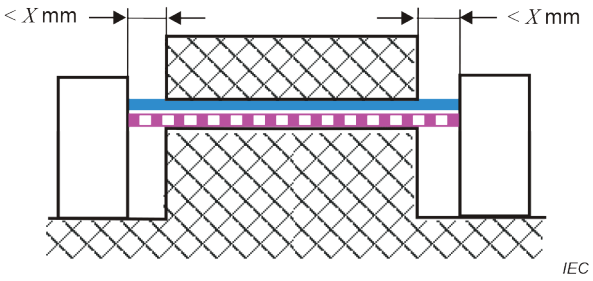


Condition: Path under consideration includes a rib.

Rule: **Clearance** is the shortest direct air path over the top of the rib. **Creepage distance** path follows the contour of the rib.

Figure O.5 – Rib

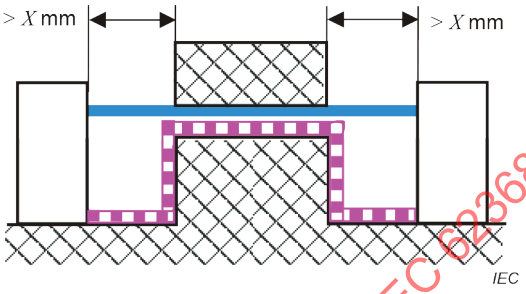
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Condition: Path under consideration includes an uncemented joint with grooves less than X mm wide on either side.

Rule: **Clearance** and **creepage distance** path is the "line of sight" distance shown.

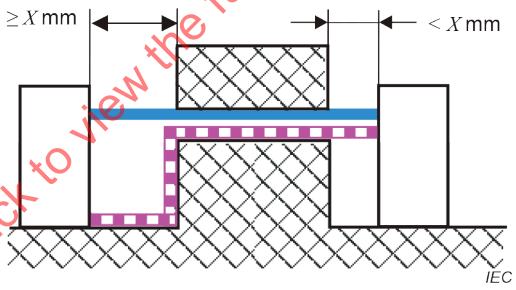
Figure O.6 – Uncemented joint with narrow groove



Condition: Path under consideration includes an uncemented joint with a groove equal to or more than X mm wide each side.

Rule: **Clearance** is the "line of sight" distance. **Creepage distance** path follows the contour of the groove.

Figure O.7 – Uncemented joint with wide groove

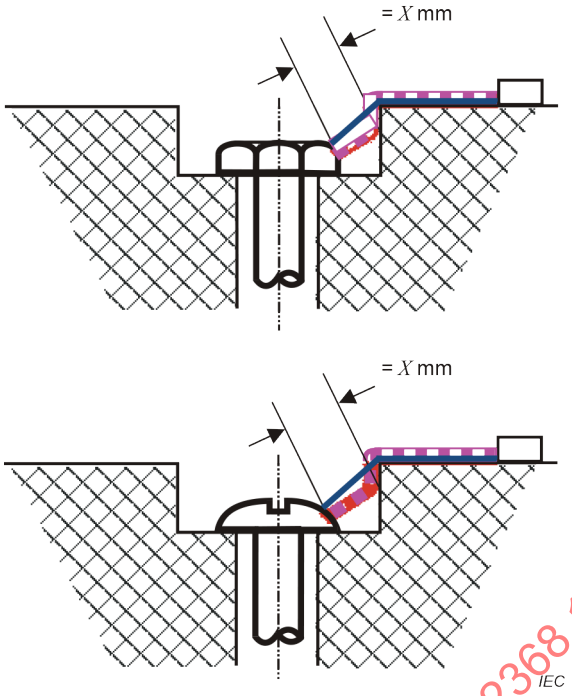


Condition: Path under consideration includes an uncemented joint with grooves on one side less than X mm wide, and a groove on the other equal to or more than X mm wide.

Rule: **Clearance** and **creepage distance** path are as shown.

Figure O.8 – Uncemented joint with narrow and wide grooves

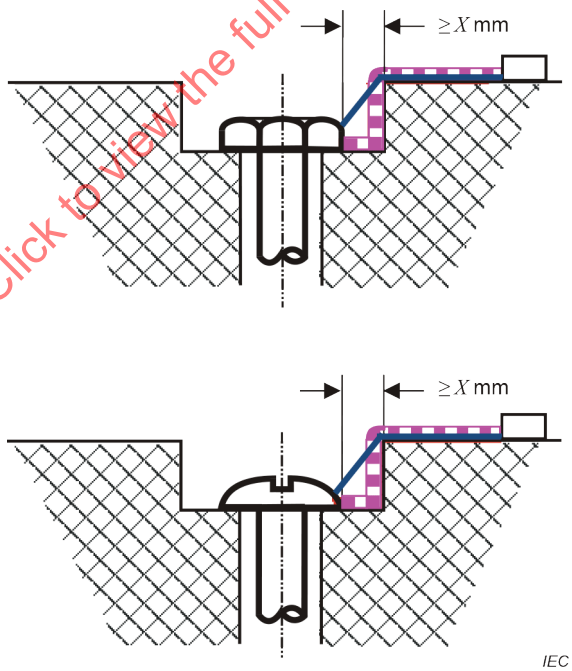
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Gap between head of screw and wall of recess too narrow to be taken into account.

Where the gap between the head of the screw and the wall of recess is smaller than X mm, the measurement of **creepage distance** is made from the screw to the wall at the place where the distance is equal to X mm.

Figure O.9 – Narrow recess



Gap between head of screw and wall of recess wide enough to be taken into account.

Figure O.10 – Wide recess

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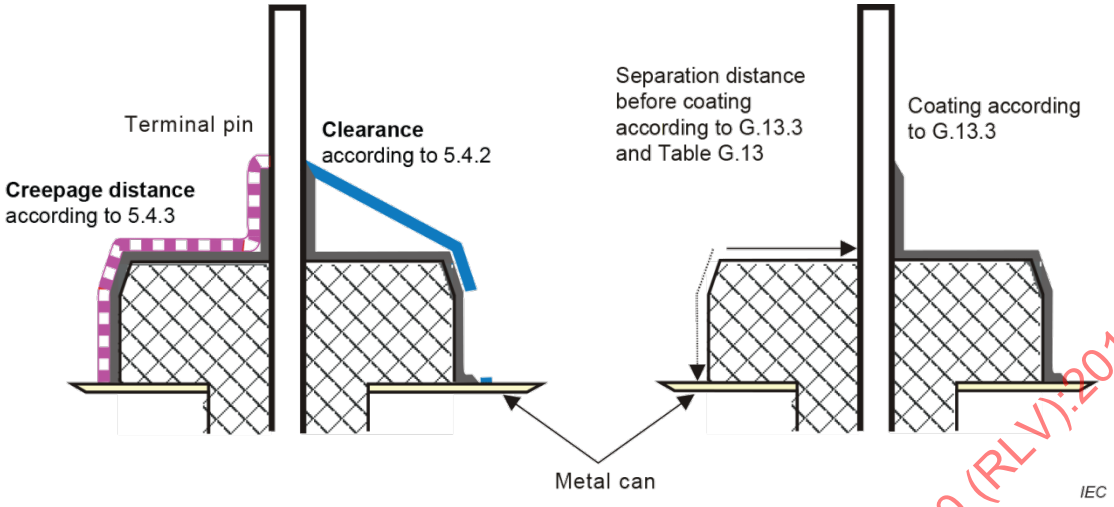


Figure O.11 – Coating around terminals

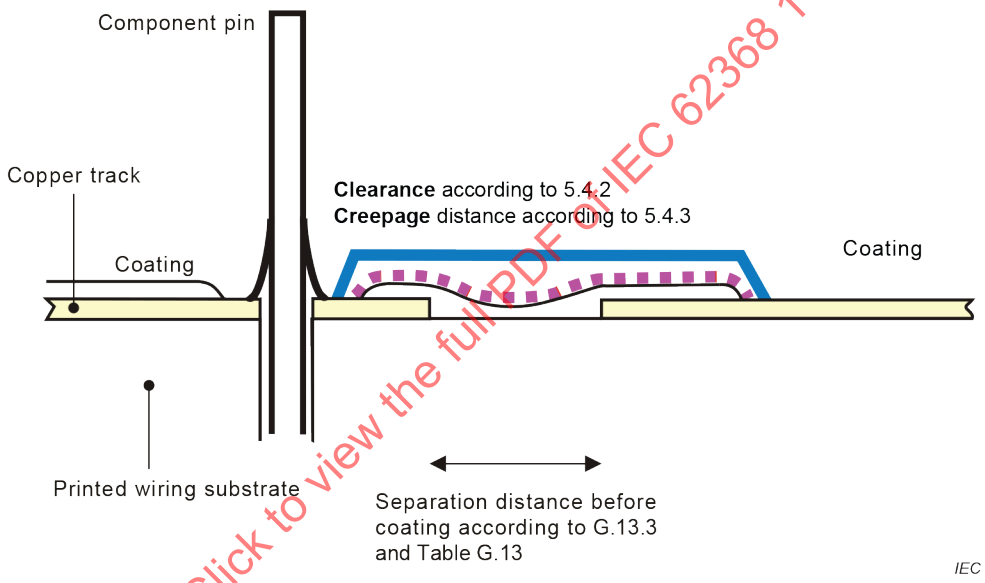


Figure O.12 – Coating over printed wiring

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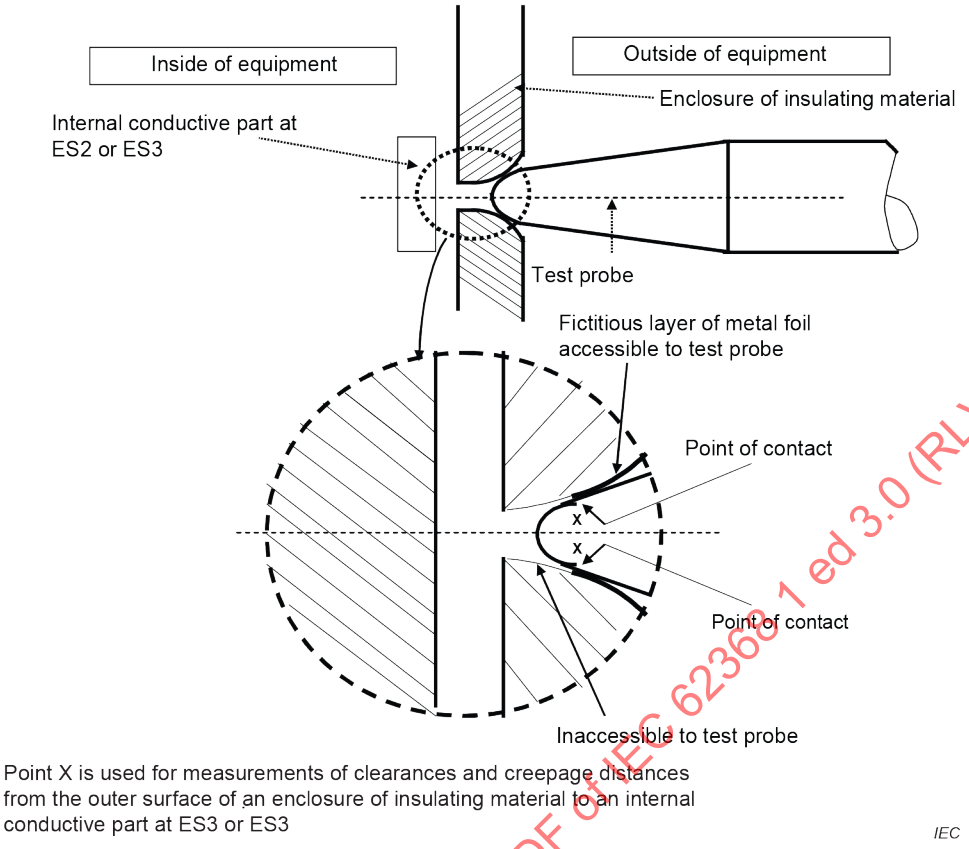


Figure O.13 – Example of measurements in an enclosure of insulating material

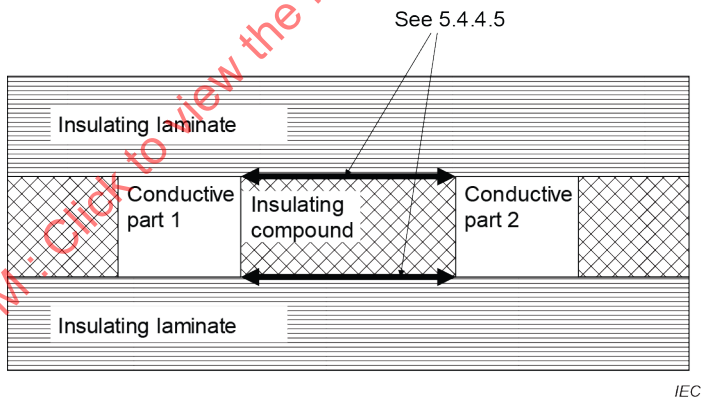


Figure O.14 – Cemented joints in multi-layer printed boards

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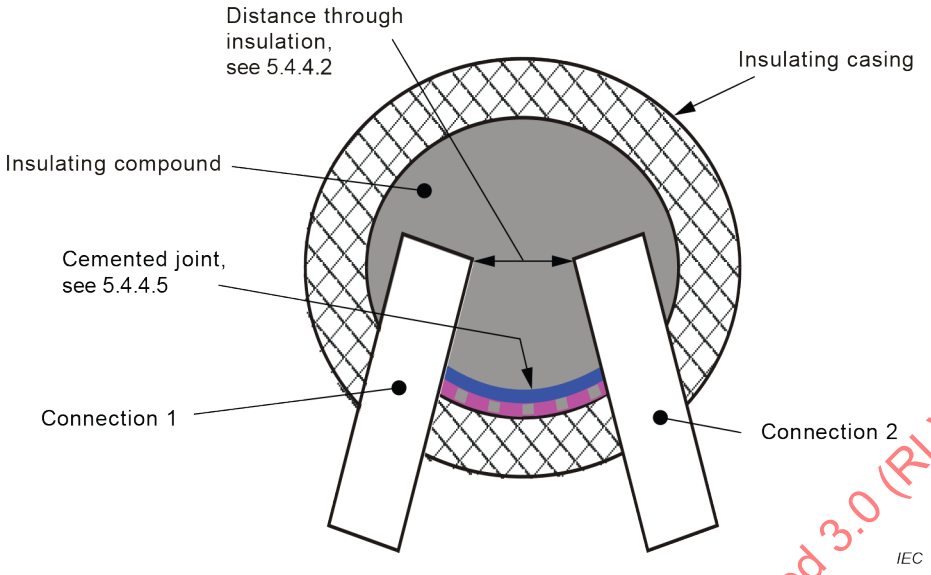


Figure O.15 – Device filled with insulating compound

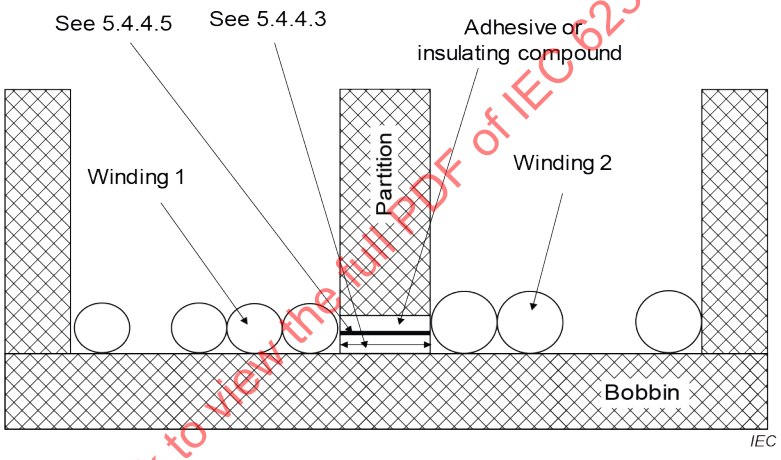


Figure O.16 – Partitioned bobbin

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Annex P
(normative)

Safeguards against conductive objects

P.1 General

This annex specifies **safeguards** to reduce the likelihood of fire, electric shock and adverse chemical reaction due to the entry of objects through top or side openings in the equipment, or due to spillage of internal liquids, or the failure of metallized coatings and adhesives securing conductive parts inside the equipment.

The **basic safeguard** against entry of a foreign object is that persons are not expected to insert a foreign object into the equipment. The **safeguards** specified in this annex are **supplementary safeguards**.

This annex does not apply to openings that are parts of connectors.

For equipment intended, according to the manufacturer's instructions, to be used in more than one orientation, the **safeguards** shall be effective for each such orientation.

For **transportable equipment**, the **safeguards** shall be effective for all orientations.

NOTE The examples of Figure P.1, Figure P.2 and Figure P.3 are not intended to be used as engineering drawings but are only shown to illustrate the intent of these requirements.

P.2 Safeguards against entry or consequences of entry of a foreign object

P.2.1 General

Equipment shall comply with the requirements of P.2.2 or with the requirements of P.2.3.

P.2.2 Safeguards against entry of a foreign object

Openings in the top and sides of an **accessible enclosure** shall be so located or constructed to reduce the likelihood that a foreign object will enter the openings.

Equipment openings shall comply with the requirements specified below when the doors, panels, and covers, etc., are closed or in place. These requirements do not apply to openings located behind doors, panels, covers, etc., even if they can be opened or removed by an **ordinary person**.

Any one of the following constructions are considered to comply:

– openings that do not exceed 5 mm in any dimension;
– openings that do not exceed 1 mm in width regardless of length;
– openings that meet the requirements of IP3X;
– top openings in which vertical entry is prevented (see Figure P.1 for examples);
– side openings provided with louvres that are shaped to deflect outwards an external vertically falling object (see Figure P.2 for examples);
– side openings without louvres where the **enclosure** thickness at the opening is not less than the vertical dimension of the opening.

Compliance is checked by inspection or measurement.

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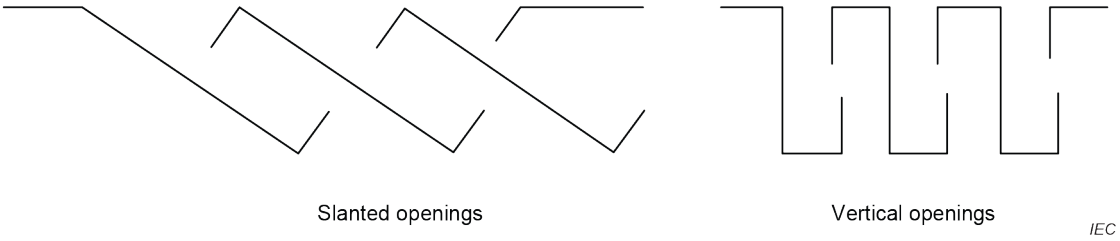


Figure P.1 – Examples of cross-sections of designs of top openings which prevent vertical entry

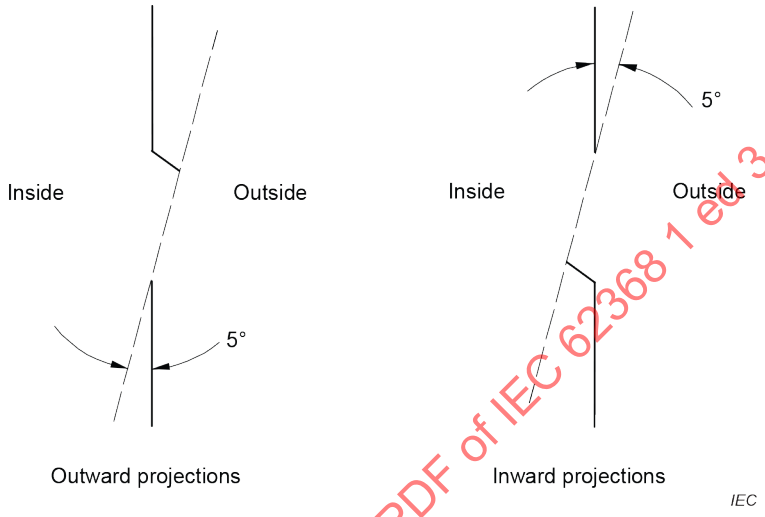


Figure P.2 – Examples of cross-sections of designs of side opening louvres which prevent vertical entry

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P.2.3 Safeguards against the consequences of entry of a foreign object

P.2.3.1 Safeguard requirements

The entry of a foreign object shall not defeat an **equipment supplementary safeguard** or an **equipment reinforced safeguard**. Furthermore, the object shall not create a **PIS**.

Safeguards against the consequences of entry of foreign objects include the following:

– an internal barrier that prevents a foreign object from defeating an **equipment safeguard** or creating a **PIS**;

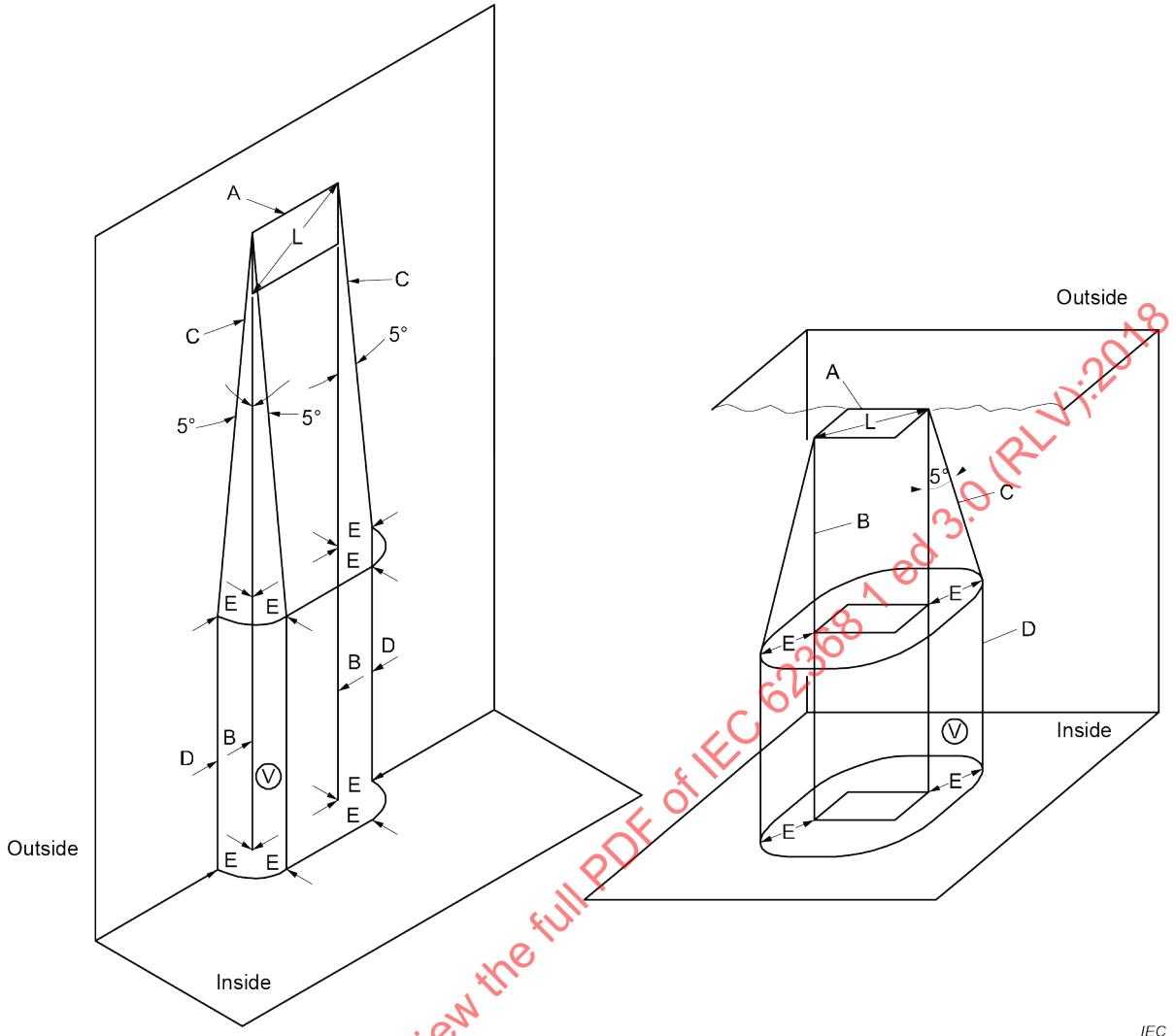
– within the projected volume as depicted in Figure P.3 there are

- no bare conductive parts of a **safeguard**, or
- no **PIS**, or
- no bare conductive parts of ES3 or PS3 circuits, or
- only conductive parts covered with conformal or other similar coatings;

NOTE 1 Conductive parts covered with conformal or other similar coatings are not considered to be bare conductive parts. A conformal coating is a dielectric material deposited on a printed circuit board and components in order to protect them against moisture, dust, corrosion and other environmental stresses.

– within the projected volume as depicted in Figure P.3, bare conductive parts at ES3 or PS3 subjected to the tests of P.2.3.2.

Other constructions shall be subject to the test of P.2.3.2.



Key

A **enclosure** opening

B vertical projection of the outer edges of the opening

C inclined lines that project at a 5° angle from the edges of the opening to points located E distance from B

D line that is projected straight downward in the same plane as the **enclosure** side wall

E projection of the outer edge of the opening (B) and the inclined line (C) (not to be greater than L)

L maximum dimension of the **enclosure** opening

V projected (keep-out) volume for **supplementary safeguards** or **reinforced safeguards**

Figure P.3 – Internal volume locus for foreign object entry

For **transportable equipment**, if the design does not prevent the entry of a foreign object, the object is considered to move to any place within the equipment. The ES3 and PS3 keep-out volume in Figure P.3 is not applicable to **transportable equipment**.

For **transportable equipment** with metallized plastic parts and the like, if the design does not prevent the entry of a foreign object, the distance between the metallized parts and all bare conductive parts of ES3 or PS3 shall be at least 13 mm. Alternatively, the metallized parts and the bare conductive parts shall be tested by shorting.

NOTE 2 Examples of metallized barriers or metallized **enclosures** include those made of conductive composite materials or materials that are electroplated, vacuum-deposited, foil lined or painted with metallic paint.

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Compliance is checked by inspection, measurement, and where necessary by the test of P.2.3.2.

P.2.3.2 Consequence of entry test

An attempt shall be made to short all bare conductive parts of ES3 or PS3 within volume V, Figure P.3, along a direct straight path to all other bare conductive parts and to all metallized parts within a 13 mm radius. The attempt of shorting is made by means of a straight metal object, 1 mm in diameter and having any length up to 13 mm, applied without appreciable force.

*For **transportable equipment**, the attempt of shorting shall be at all places where the foreign object could lodge.*

*During and after the tests, all **supplementary safeguards** and **reinforced safeguards** shall be effective, and no part shall become a **PIS**.*

P.3 Safeguards against spillage of internal liquids

P.3.1 General

The requirements specified below apply to equipment with internal liquids where that liquid may defeat any **equipment safeguard**.

These requirements do not apply to:

– liquids that are non-conductive, non-flammable, non-toxic, and non-corrosive, and are not in a pressurized container;

– electrolytic capacitors;

– liquids with viscosity of 1 Pa s or more; and

– **batteries** (see Annex M).

NOTE Viscosity of 1 Pa s is approximately equivalent to 60 weight motor oil.

P.3.2 Determination of spillage consequences

If the equipment is not **transportable equipment**, the equipment shall be energized, and the liquid shall be allowed to leak from piping connectors and similar joints in the liquid system.

If the equipment is **transportable equipment**, then, following introduction of the leak, the equipment shall be moved to all possible positions and then energized.

P.3.3 Spillage safeguards

If the spillage may result in a **single fault condition** not covered by Clause B.4, then:

– the vessel serving as a **basic safeguard** shall allow no spillage under **normal operating conditions**, and the **supplementary safeguard** (for example, a barrier or drip pan or supplementary containment vessel, etc.) shall effectively limit the spread of the spillage; or

– the liquid shall be contained in a vessel comprising a **reinforced safeguard**; or

– the containment vessel **safeguard** shall comprise a **double safeguard** or a **reinforced safeguard**.

If the liquid is conductive, flammable, toxic, or corrosive, then:

– the liquid shall be contained in a **double safeguard** or a **reinforced safeguard**; or

– following the spillage:

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- a toxic liquid shall not be **accessible** to **ordinary persons** or **instructed persons**, and
- a conductive liquid shall not bridge a **basic insulation**, a **supplementary insulation** or a **reinforced insulation**, and
- a flammable liquid (or its vapour) shall not contact any **PIS** or parts at a temperature that may ignite the liquid, and
- a corrosive liquid shall not contact any connection of a **protective conductor**.

A vessel that meets the relevant test requirements of Clause G.15 is considered to comprise a **reinforced safeguard**.

NOTE The following liquids are generally considered non-flammable:

– Oil or equivalent liquids used for lubrication or in a hydraulic system having a flash point of 149 °C or higher; or

– Replenishable liquids such as printing inks having a flash point of 60 °C or higher.

P.3.4 Compliance criteria

Compliance is checked by inspection or available data, and where necessary, by the relevant tests.

*During and after the tests, all **supplementary safeguards** and **reinforced safeguards** shall be effective, and no part shall become a **PIS**.*

P.4 Metallized coatings and adhesives securing parts

P.4.1 General

The metallized coating and adhesive shall have adequate bonding properties throughout the life of the equipment.

Compliance is checked by examination of the construction and of the available data. If such data is not available, compliance is checked by the tests of P.4.2.

*For metallized coatings, **clearances** and **creepage distances** for **pollution degree** 3 shall be maintained instead of the tests of P.4.2.*

P.4.2 Tests

A sample of the equipment or a subassembly of the equipment containing parts having metallized coating and the parts joined by adhesive is evaluated with the sample placed with the part secured by adhesive on the underside.

Condition the sample in an oven at a temperature T_C for the specified duration (eight weeks, three weeks or one week) as follows:

$$T_C = T_R + (T_A + 10 - T_S)$$

In case the value for $T_A + 10 - T_S$ is negative, the value will be replaced by zero.

where:

T_C *is the conditioning temperature;*

T_R *is the rated conditioning temperature value of (82 ± 2) °C for eight weeks; (90 ± 2) °C for three weeks; or (100 ± 2) °C (for one week) as applicable;*

T_A *is the temperature of the coating or the part under **normal operating conditions** (see B.2.6.1);*

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T_S = 82.

NOTE 1 For example for eight week conditioning, if the actual temperature is 70 °C, then the $T_A + 10 - T_S = 70 + 10 - 82 = -2$, then this -2 is ignored. The minimum conditioning temperature remains 82 °C. Also, for three week conditioning, if the actual temperature is 70 °C, then the $T_A + 10 - T_S = 70 + 10 - 82 = -2$, then this -2 is ignored. The minimum conditioning temperature remains 90 °C. Also, for one week conditioning, if the actual temperature is 70 °C, then the $T_A + 10 - T_S = 70 + 10 - 82 = -2$, then this -2 is ignored. The minimum conditioning temperature remains 100 °C.

NOTE 2 For example for eight week conditioning, if the actual temperature is 75 °C, then the $T_A + 10 - T_S = 75 + 10 - 82 = +3$, the minimum conditioning temperature becomes 82 + 3 = 85 °C. Also, for three week conditioning, if the actual temperature is 75 °C, then the $T_A + 10 - T_S = 75 + 10 - 82 = +3$, then the minimum conditioning temperature remains 90 + 3 = 93 °C. Also, for one week conditioning, if the actual temperature is 75 °C, then the $T_A + 10 - T_S = 75 + 10 - 82 = +3$, then the minimum conditioning temperature remains 100 + 3 = 103 °C.

NOTE 3 The table below gives the summary of the results in NOTE 1 and NOTE 2:

T_A	T_R	T_S	$T_A + 10 - T_S$	$T_C = T_R + T_A + 10 - T_S$
70	82 (8 weeks)	82	70 + 10 − 82 = −2	82 + 0 = 82
70	90 (3 weeks)	82	70 + 10 − 82 = −2	90 + 0 = 90
70	100 (1 week)	82	70 + 10 − 82 = −2	100 + 0 = 100
75	82 (8 weeks)	82	75 + 10 − 82 = +3	82 + 3 = 85
75	90 (3 weeks)	82	75 + 10 − 82 = +3	90 + 3 = 93
75	100 (1 week)	82	75 + 10 − 82 = +3	100 + 3 = 103

Upon completion of the temperature conditioning, subject the sample to the following:

- *remove the sample from oven and leave it at any convenient temperature between 20 °C and 30 °C for a minimum of 1 h;*
- *place the sample in a freezer at –40 °C ± 2 °C for a minimum of 4 h;*
- *remove and allow the sample to come to any convenient temperature between 20 °C and 30 °C for a minimum of 8 h;*
- *place the sample in a cabinet at 91 % to 95 % relative humidity for 72 h at any convenient temperature between 20 °C and 30 °C;*
- *remove the sample and leave it at any convenient temperature between 20 °C and 30 °C for a minimum of 1 h;*
- *place the sample in an oven at the temperature used for the temperature conditioning (T_C) for a minimum of 4 h; and*
- *remove the sample and allow it to reach any convenient temperature between 20 °C; and 30 °C for a minimum of 8 h.*

The sample is then immediately subjected to the tests of Annex T according to 4.4.3.

With the concurrence of the manufacturer, the above time durations may be extended.

After the above tests:

- *a metallized coating or a part secured by adhesive shall not fall off or partly dislodge;*
- *a metallized coating shall be subjected to the abrasion resistance test of G.13.6.2. After the abrasion resistance test, the coating shall have not loosened and no particles shall become loose from the coating; and*
- ***enclosure** parts serving as **safeguards** shall comply with all the applicable requirements for **enclosures**.*

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Annex Q
(normative)

Circuits intended for interconnection with building wiring

Q.1 Limited power source

Q.1.1 Requirements

A limited power source shall comply with one of the following:

a) the output is inherently limited in compliance with Table Q.1; or

b) linear or non-linear impedance limits the output in compliance with Table Q.1. If a PTC device is used, it shall:

   1) pass the tests specified in Clauses 15, 17, J.15 and J.17 of IEC 60730-1:2013; or

   2) meet the requirements of IEC 60730-1:2013 for a device providing Type 2.AL action;

c) a regulating network limits the output in compliance with Table Q.1, both with and without a simulated single fault (see Clause B.4), in the regulating network (open circuit or short-circuit); or

d) an overcurrent protective device is used and the output is limited in compliance with Table Q.2; or

e) an IC current limiter complying with Clause G.9.

Where an overcurrent protective device is used, it shall be a fuse or a non-adjustable, non-autoreset, electromechanical device.

Q.1.2 Test method and compliance criteria

Compliance is checked by inspection and measurement and, where appropriate, by examination of the manufacturer's data for ***batteries****.* ***Batteries*** *shall be fully charged when conducting the measurements for* U_{oc} *and* I_{sc} *according to Table Q.1 and Table Q.2. The maximum power shall be considered, such as from a* ***battery*** *and from a* ***mains*** *circuit.*

The non-capacitive load referenced in footnotes [b] *and* [c] *of Table Q.1 and Table Q.2 is adjusted to develop maximum current and maximum power transfer in turn.* ***Single fault conditions*** *are applied in a regulating network according to Clause Q.1.1, item c) while under these maximum current and power conditions.*

Table Q.1 – Limits for inherently limited power sources

Output voltage [a] U_{oc}		Output current [b d] I_{sc}	Apparent power [c d] S
V AC	V DC	A	VA
$U_{oc} \leq 30$	$U_{oc} \leq 30$	≤ 8,0	≤ 100
–	$30 < U_{oc} \leq 60$	$\leq 150/U_{oc}$	≤ 100

[a] U_{oc}: Output voltage measured in accordance with B.2.3 with all load circuits disconnected. Voltages are for substantially sinusoidal AC and ripple free DC For non-sinusoidal AC and DC with ripple greater than 10 % of the peak, the peak voltage shall not exceed 42,4 V.

[b] I_{sc}: Maximum output current with any non-capacitive load, including a short-circuit.

[c] S (VA): Maximum output VA with any non-capacitive load.

[d] Measurement of I_{sc} and S are made 5 s after application of the load if protection is by an electronic circuit and 60 s in case of a PTC device or in other cases.

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Table Q.2 – Limits for power sources not inherently limited (overcurrent protective device required)

Output voltage [a] U_{oc}		Output current [b d] I_{sc}	Apparent power [c d] S	Current rating of overcurrent protective device [e]
V AC	V DC	A	VA	A
≤ 20	≤ 20	≤ 1 000/U_{oc}	≤ 250	≤ 5,0
20 < U_{oc} ≤ 30	20 < U_{oc} ≤ 30			≤ 100/U_{oc}
–	30 < U_{oc} ≤ 60			≤ 100/U_{oc}

[a] U_{oc}: Output voltage measured in accordance with B.2.3 with all load circuits disconnected. Voltages are for substantially sinusoidal AC and ripple free DC For non-sinusoidal AC and for DC with ripple greater than 10 % of the peak, the peak voltage shall not exceed 42,4 V.

[b] I_{sc}: Maximum output current with any non-capacitive load, including a short-circuit, measured 60 s after application of the load.

[c] S (VA): Maximum output VA with any non-capacitive load measured 60 s after application of the load.

[d] Current limiting impedances in the equipment remain in the circuit during measurement, but overcurrent protective devices are bypassed.

The reason for making measurements with overcurrent protective devices bypassed is to determine the amount of energy that is available to cause possible overheating during the operating time of the overcurrent protective devices.

[e] The current ratings of overcurrent protective devices are based on fuses and circuit breakers that break the circuit within 120 s with a current equal to 210 % of the current rating specified in the table.

Q.2 Test for external circuits – paired conductor cable

*Equipment supplying power to an **external circuit** paired conductor cable intended to be connected to the building wire shall be checked as follows.*

If current limiting is due to the inherent impedance of the power source, the output current into any resistive load, including a short-circuit, is measured. The current limit shall not be exceeded after 60 s of test.

If current limiting is provided by an overcurrent protective device having a specified time/current characteristic:

– *the time/current characteristic shall show that a current equal to 110 % of the current limit will be interrupted within 60 min; and*

– *the output current into any resistive load, including a short-circuit, with the overcurrent protective device bypassed, measured after 60 s of test, shall not exceed 1 000/U where U is the output voltage measured in accordance with B.2.3 with all load circuits disconnected.*

If current limiting is provided by an overcurrent protective device that does not have a specified time/current characteristic:

– *the output current into any resistive load, including a short-circuit, shall not exceed the current limit after 60 s of test; and*

– *the output current into any resistive load, including a short-circuit, with the overcurrent protective device bypassed, measured after 60 s of test, shall not exceed 1 000/U, where U is the output voltage measured in accordance with B.2.3 with all load circuits disconnected.*

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Annex R
(normative)

Limited short-circuit test

R.1 General

This annex documents the test procedure and compliance criteria for the limited short-circuit test. This test demonstrates that a **protective bonding conductor**, used in circuits protected by a device having a rating not exceeding 25 A, is suitable for the fault current permitted by the overcurrent protective device, and in doing so, tests the integrity of a **supplementary safeguard**.

R.2 Test setup

*The source used to conduct the limited short-circuit test shall be short-circuited at its output terminals and the current measured to ensure that it can supply at least 1 500 A. This can be an AC wall socket, generator, power supply or **battery**.*

If the overcurrent protective device is provided in the equipment, then this is used for the test.

For AC sources where only one overcurrent protective device is provided in the equipment and the plug is non-polarised, the protective device in the building installation is used for the test and the internal overcurrent protective device is by-passed. The manufacturer shall specify the device used for the test in the equipment safety instructions.

Where there is no protective device present in the equipment, a suitable overcurrent protective device shall be chosen. This overcurrent protective device shall be such that it does not interrupt the fault current before half a cycle has passed. The overcurrent protective device in the building installation for AC sources, or that specified to be provided externally to the equipment for DC sources, is used for the test. The manufacturer shall then specify the device used to conduct the test in the equipment safety instructions.

R.3 Test method

*The source shall be applied to the EUT via the **mains** cord supplied or specified by the equipment manufacturer. Where there is no **mains** cord supplied or specified, a 1 m length of 2,5 mm^2 or 12 AWG shall be used. For DC sources, the cable shall be sized for the maximum **rated current** of the equipment.*

To conduct this test a short-circuit in the equipment to the earth connection of the equipment shall be introduced. The point at which this is done is depending on the equipment. After consideration of the equipment construction and circuit diagrams, the short-circuit shall be introduced between the phase conductor, at the point nearest to the input (the point of lowest impedance), and the protective bonding path under consideration. There may be more than one point at which this short-circuit may be applied to determine the worst case.

*The **protective bonding conductor** is connected to a source capable of supplying an AC or DC current, as appropriate to the EUT, of 1 500 A under short-circuit conditions, and using a source voltage equal to the **rated voltage** or any voltage within the **rated voltage range** of the equipment. In cases where the prospective short-circuit current seen by the equipment is known, then the source used for test shall be able to supply that current under short-circuit conditions. The manufacturer shall state the prospective short-circuit current that has been used in the evaluation in the safety instructions. The overcurrent protective device protecting the circuit under consideration (in accordance with Clause R.2) is kept in series with the*

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***protective bonding conductor**. The power supply cord, if provided or specified, shall remain connected when conducting the test.*

*The limited short-circuit test for **protective bonding conductors** in a potted or conformally coated assembly is conducted on a potted or coated sample.*

The test is conducted two more times (for a total of three times, on a different sample unless the manufacturer agrees to conduct the test on the same sample). The test is continued until the overcurrent protective device operates.

R.4 Compliance criteria

At the conclusion of the test, compliance is checked by inspection as follows.

There shall be

- *no damage to the **protective bonding conductor**;*
- *no damage to any **basic insulation**, **supplementary insulation**, or **reinforced insulation**;*
- *no reduction of **clearances**, **creepage distances** and distances through insulation; and*
- *no delamination of the printed board.*

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Annex S
(normative)

Tests for resistance to heat and fire

NOTE Toxic fumes are given off during the tests. The tests are usually carried out either under a ventilated hood or in a well-ventilated room, but free from draughts that could invalidate the tests.

S.1 Flammability test for fire enclosure and fire barrier materials of equipment where the steady state power does not exceed 4 000 W

Fire enclosure *and fire barrier materials are tested according to IEC 60695-11-5. The test is performed on three test specimens.*

The following additional requirements apply to the specified clauses of IEC 60695-11-5:2016.

Clause 6 of IEC 60695-11-5:2016 – Test specimen

For ***fire enclosures*** *and fire barriers, each test specimen consists of either a complete* ***fire enclosure*** *or fire barrier or a section of the* ***fire enclosure*** *or fire barrier representing the thinnest significant wall thickness and including any ventilation opening.*

Clause 7 of IEC 60695-11-5:2016 – Flame application times

The values of duration of application of the test flame are as follows:

– *the test flame is applied for 10 s;*
– *if flaming does not exceed 30 s, the test flame is immediately reapplied for 1 min at the same point;*
– *if again flaming does not exceed 30 s, the test flame is immediately reapplied for 2 min at the same point.*

Clause 8 of IEC 60695-11-5:2016 – Conditioning and test conditions

Prior to being tested, the specimens are conditioned in a circulating air oven for a period of 7 days (168 h), at a temperature 10 K higher than the maximum temperature of the part measured during the test of 5.4.1.4 or 70 °C, whichever is the higher, and then cooled to room temperature.

For printed boards, a preconditioning of 24 h at a temperature of 125 °C ± 2 °C in an air circulating oven and a subsequent cooling period of 4 h at room temperature in a desiccator over anhydrous calcium chloride is to be applied.

Subclause 9.3 of IEC 60695-11-5:2016 – Application of needle flame

The test flame is applied to an inside surface of the test specimen at a point judged to be likely to become ignited because of its proximity to a source of ignition.

If a vertical part is involved, the flame is applied at an angle of approximately 45° from the vertical.

If ventilation openings are involved, the flame is applied to an edge of an opening, otherwise to a solid surface. In all cases, the tip of the flame is to be in contact with the test specimen.

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The test is repeated on the remaining two test specimens. If any part being tested is near a source of ignition at more than one point, each test specimen is tested with the flame applied to a different point that is near a source of ignition.

Clause 11 of IEC 60695-11-5:2016 – Evaluation of test results

The existing text is replaced by the following.

The test specimens shall comply with all of the following:

– *after every application of the test flame, the test specimen shall not be consumed completely; and*
– *after any application of the test flame, any self-sustaining flame shall extinguish within 30 s; and*
– *no burning of the specified layer or **wrapping tissue** shall occur.*

S.2 Flammability test for fire enclosure and fire barrier integrity

*Compliance of **fire enclosure** and fire barrier integrity is checked according to IEC 60695-11-5. The test is performed on three test specimens.*

For the purpose of this document, the following additional requirements apply to the stated clauses of IEC 60695-11-5:2016.

Clause 6 of IEC 60695-11-5:2016 – Test specimen

*For **fire enclosures** and fire barriers, each test specimen consists of either a complete **fire enclosure** and fire barrier or a section of the **fire enclosure** and fire barrier representing the thinnest significant wall thickness and including any ventilation opening.*

Clause 7 of IEC 60695-11-5:2016 – Flame application times

The value of duration of application of the test flame is as follows:

– *the test flame is applied for 60 s. Top openings are covered with single layer of* **cheese cloth.**

Clause 8 of IEC 60695-11-5:2016 – Conditioning and test conditions

Prior to being tested, the specimens are conditioned in a circulating air oven for a period of 7 days (168 h), at a temperature 10 K higher than the maximum temperature of the part measured during the test of 5.4.1.4 or 70 °C, whichever is the higher, and then cooled to room temperature.

For printed boards, a preconditioning of 24 h at a temperature of 125 °C ± 2 °C in an air circulating oven and a subsequent cooling period of 4 h at room temperature in a desiccator over anhydrous calcium chloride is to be applied.

Subclause 9.3 of IEC 60695-11-5:2016 – Application of needle flame

*The test flame is applied at a distance measured from the closest point of a **PIS** to the closest surface point of the test specimen. The application of the flame is measured from the top of the needle flame burner to the closest surface point, see Figure S.1.*

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If a vertical part is involved or if the test specimen drips molten or flaming material during the application of the flame, the flame is applied at an angle of approximately 45° from the vertical.

The test is repeated on the remaining two test specimens. If any part being tested is near a source of ignition at more than one point, each test specimen is tested with the flame applied to a different point that is near a source of ignition. In case of openings having different dimensions, the test shall be conducted on one opening of each group of openings with the same dimensions.

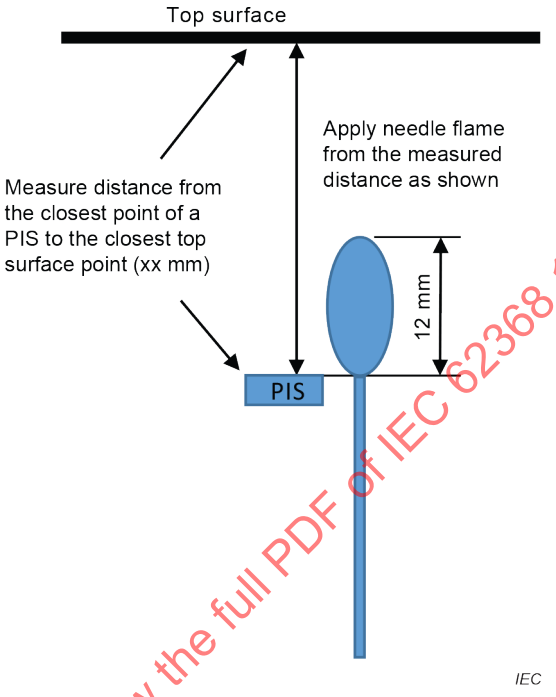


Figure S.1 – Top openings / surface of fire enclosure or fire barrier

Clause 11 of IEC 60695-11-5:2016 – Evaluation of test results

The existing text is replaced by the following.

*The **cheesecloth*** shall not ignite.

S.3 Flammability tests for the bottom of a fire enclosure

S.3.1 Mounting of samples

*A sample of the complete finished bottom of the **fire enclosure** is securely supported in a horizontal position. A **cheesecloth** is placed in one layer over a shallow, flat-bottomed pan approximately 50 mm below the sample, and is of sufficient size to cover completely the pattern of openings in the sample, but not large enough to catch any of the oil that runs over the edge of the sample or otherwise does not pass through the openings.*

*Use of a metal screen or a wired-glass **enclosure** surrounding the test area is recommended.*

S.3.2 Test method and compliance criteria

A small metal ladle (preferably no more than 65 mm in diameter), with a pouring lip and a long handle whose longitudinal axis remains horizontal during pouring, is partially filled with 10 ml

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of diesel fuel oil. The ladle containing the oil is heated and the oil ignited and allowed to burn for 1 min, at which time all of the hot flaming oil is poured at the rate of approximately 1 ml/s in a steady stream onto the centre of the pattern of openings, from a position approximately 100 mm above the openings.

NOTE "Diesel fuel oil" is regarded to be similar to a medium volatile distillate fuel oil having a mass per unit volume between 0,845 g/ml and 0,865 g/ml, a flash point between 43,5 °C and 93,5 °C and an average calorific value of 38 MJ/l.

*The test is repeated twice at 5 min intervals, using clean **cheesecloth**.*

*During these tests the **cheesecloth** shall not ignite.*

S.4 Flammability classification of materials

Materials are classified according to the burning behaviour and their ability to extinguish, if ignited. Tests are made with the material in the thinnest significant thickness used.

The hierarchies of the **material flammability classes** are given in Table S.1, Table S.2 and Table S.3.

Table S.1 – Foamed materials

Material flammability class	ISO standard
HF-1 regarded better than **HF-2**	ISO 9772
HF-2 regarded better than **HBF**	ISO 9772
HBF	ISO 9772

Table S.2 – Rigid materials

Material flammability class	IEC standard
5VA regarded better than **5VB**	IEC 60695-11-20
5VB regarded better than **V-0**	IEC 60695-11-20
V-0 regarded better than **V-1**	IEC 60695-11-10
V-1 regarded better than **V-2**	IEC 60695-11-10
V-2 regarded better than **HB40**	IEC 60695-11-10
HB40 regarded better than **HB75**	IEC 60695-11-10
HB75	IEC 60695-11-10

Table S.3 – Very thin materials

Material flammability class	ISO standard
VTM-0 regarded better than **VTM-1**	ISO 9773
VTM-1 regarded better than **VTM-2**	ISO 9773
VTM-2	ISO 9773

When VTM materials are used, relevant electrical and mechanical requirements should also be considered.

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Wood and wood-based material with a thickness of at least 6 mm is considered to fulfil the **V-1** requirement. Wood-based material is material in which the main ingredient is machined natural wood, coupled with a binder.

EXAMPLE Wood-based materials are materials incorporating ground or chipped wood, such as hard fibre board or chip board.

S.5 Flammability test for fire enclosure materials of equipment with a steady state power exceeding 4 000 W

Fire enclosure *materials are tested according to IEC 60695-11-20:2015, using the plate procedure of IEC 60695-11-20:2015, 8.3.*

For the purpose of this document, the following additional requirements apply to the specified clauses of IEC 60695-11-20:2015.

Clause 7 of IEC 60695-11-20:2015 – Test specimen

For ***fire enclosures****, each test specimen consists of either a complete* ***fire enclosure*** *or a section of the* ***fire enclosure*** *representing the thinnest significant wall thickness and including any ventilation opening (plate procedure).*

Subclause 8.1 of IEC 60695-11-20:2015 – Conditioning

Prior to being tested, the samples are conditioned in a circulating air oven for a period of 7 days (168 h), at a temperature 10 K higher than the maximum temperature of the part measured during the test of 5.4.1.4 or 70 °C, whichever is the higher, and then cooled to room temperature.

Subclause 8.3 of IEC 60695-11-20:2015 – Plate shaped test specimens

The test flame is applied to an inside surface of the test specimen at a point judged to be likely to become ignited because of its proximity to a source of ignition.

If a vertical part is involved, the flame is applied at an angle of approximately 20° from the vertical.

If ventilation openings are involved, the flame is applied to an edge of an opening, otherwise to a solid surface. In all cases, the tip of the flame is to be in contact with the test specimen.

The values of duration of application of the test flame are as follows:

– *the test flame is applied for 5 s and removed for 5 s;*
– *the test flame application and removal is repeated four more times at the same location (total of five flame applications).*

Subclause 8.4 of IEC 60695-11-20:2015 – Classification

The existing text is replaced by the following.

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The test specimens shall comply with all of the following:

– *after every application of the test flame, the test specimen shall not be consumed completely; and*

– *after the fifth application of the test flame, any flame shall extinguish within 1 min.*

No burning of the specified cotton indicator shall occur.

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Annex T
(normative)

Mechanical strength tests

T.1 General

In general, this annex describes a number of tests that are invoked by this document. Compliance criteria are specified in the clause that invokes a particular test.

No tests are applied to handles, levers, knobs, the face of CRTs or to transparent or translucent covers of indicating or measuring devices, unless parts at ES3 are **accessible** when the handle, lever, knob or cover is removed.

T.2 Steady force test, 10 N

A steady force of 10 N ± 1 N is applied to the component or part under consideration for a short time duration of approximately 5 s.

T.3 Steady force test, 30 N

The test is conducted by means of the straight unjointed version of the applicable test probe of Figure V.1 or Figure V.2, applied with a force of 30 N ± 3 N for a short time duration of approximately 5 s.

T.4 Steady force test, 100 N

*The test is conducted by subjecting the external **enclosure** to a steady force of 100 N ± 10 N over a circular plane surface 30 mm in diameter for a short time duration of approximately 5 s, applied in turn to the top, bottom, and sides.*

T.5 Steady force test, 250 N

*The test is conducted by subjecting the external **enclosures** to a steady force of 250 N ± 10 N over a circular plane surface 30 mm in diameter for a short time period of approximately 5 s, applied in turn to the top, bottom and sides.*

T.6 Enclosure impact test

*A sample consisting of the complete **enclosure** or a portion thereof, representing the largest unreinforced area is supported in its normal position. A solid, smooth, steel sphere of 50 mm ± 1 mm in diameter and with a mass of 500 g ± 25 g, is used to perform the following tests:*

- *on horizontal surfaces, the sphere is to fall freely from rest through a vertical distance of 1 300 mm ± 10 mm onto the sample (see Figure T.1); and*
- *on vertical surfaces, the sphere is suspended by a cord and swung as a pendulum in order to apply a horizontal impact, dropping through a vertical distance of 1 300 mm ± 10 mm onto the sample (see Figure T.1).*

*For evaluating a part that acts as a **fire enclosure** only, the test is done as above, but the vertical distance is 410 mm ± 10 mm.*

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Alternatively horizontal impacts may be simulated on vertical or sloping surfaces by mounting the sample at 90° to its normal position and applying the vertical impact test instead of the pendulum test.

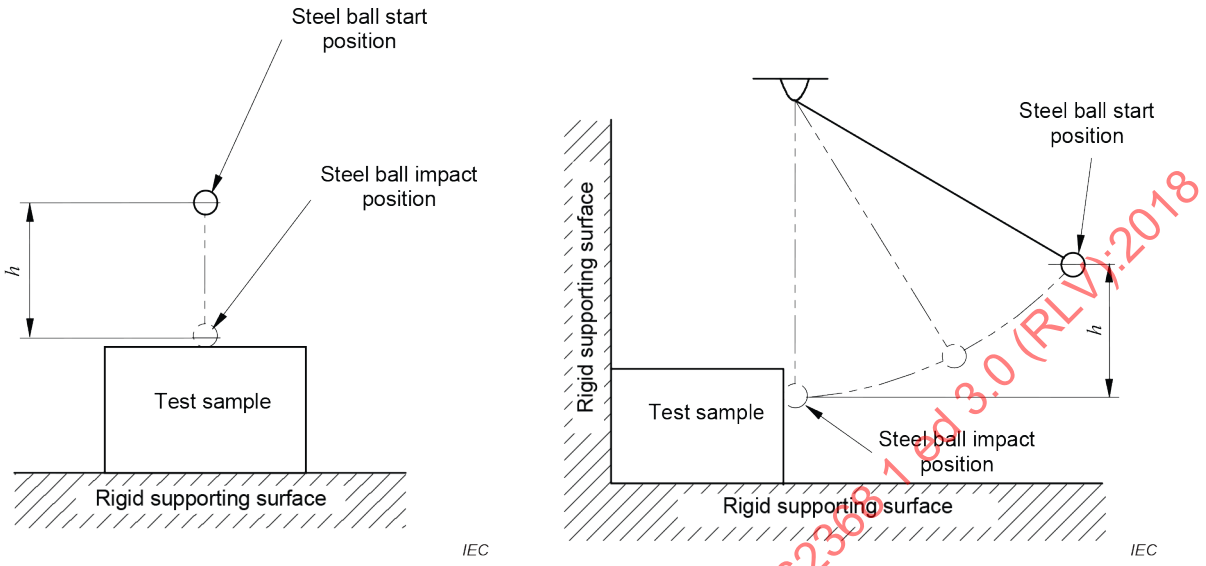


Figure T.1 – Impact test using sphere

T.7 Drop test

A sample of the complete equipment is subjected to three impacts that result from being dropped onto a horizontal surface in positions likely to produce the most adverse results.

The height of the drop shall be:

- *750 mm ± 10 mm for desk-top equipment and **movable equipment**;*
- *1 000 mm ± 10 mm for **hand-held equipment**, **direct plug-in equipment** and **transportable equipment**;*
- *350 mm ± 10 mm for a part acting as a **fire enclosure** only of desk-top equipment and **movable equipment**;*
- *500 mm ± 10 mm for a part acting as a **fire enclosure** only of **hand-held equipment**, **direct plug-in equipment** and **transportable equipment**.*

The horizontal surface consists of hardwood at least 13 mm thick, mounted on two layers of plywood each 18 mm ± 2 mm thick, all supported on a concrete or equivalent non-resilient floor.

T.8 Stress relief test

Stress relief is checked by the mould stress relief test of IEC 60695-10-3 or by the test procedure described below or by the inspection of the construction and the available data where appropriate.

*One sample consisting of the complete equipment, or of the complete **enclosure** together with any supporting framework, is placed in a circulating air oven at a temperature 10 K higher than the maximum temperature observed on the sample during the heating test of 5.4.1.4.2, but not less than 70 °C, for a period of 7 h, then cooled to room temperature.*

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*For large equipment where it is impractical to condition a complete **enclosure**, a portion of the **enclosure** representative of the complete assembly with regard to thickness and shape, including any mechanical support members, may be used.*

NOTE Relative humidity need not be maintained at a specific value during this test.

T.9 Glass impact test

The test sample is supported over its whole area and shall be subjected to a single impact, specified in Table T.1. The impact shall be applied in a location representing the centre of the glass.

The impact specified shall be caused by allowing a solid, smooth, steel ball of 50 mm ± 1 mm in diameter and with the mass of 500 g ± 25 g to fall freely from rest through a vertical distance not less than specified in Table T.1, as shown in Figure T.1, and strike the sample with the specified impact in a direction perpendicular to the surface of the sample.

Table T.1 – Impact force

Part	Safeguards against	Impact J	Height mm
Unless otherwise specified below, any glass used as a **safeguard** against class 3 energy sources except PS3	Exposure to class 3 energy sources	3,5	714
Glass on floor standing equipment	Skin-lacerations	3,5	714
Glass on all other equipment	Skin-lacerations	2	408
Laminated glass used as a **safeguard** against class 3 energy sources except PS 3	Exposure to class 3 energy sources	1	204
Glass lenses that are provided for the attenuation of UV radiation	Exposure to UV radiation	0,5	102
To apply the required impact, the height is calculated by $H = E / (g \times m)$ where: H is the vertical distance in metres with a tolerance of ±10 mm; E is the impact energy in joules; g is the gravitational acceleration of 9,81 m/s^2; m is the mass of the steel ball in kilograms.			

T.10 Glass fragmentation test

The test sample is supported over its whole area and precautions shall be taken to ensure that particles will not be scattered upon fragmentation. Then the test sample is shattered with a centre punch placed approximately 15 mm in from the midpoint of one of the longer edges of the test sample. After a maximum of 5 min of fracture, and without using any aid to vision, except spectacles if normally worn, the particles are counted in a square of 50 mm side located approximately at the centre of the area of coarsest fracture and excluding any area within 15 mm of any edge or hole.

The test sample shall fragment in such a way that the number of particles counted in a square with sides of 50 mm shall not be less than 45.

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T.11 Test for telescoping or rod antennas

The end piece of telescoping or rod antennas shall be subjected to a 20 N force along the major axis of the antenna for a period of 1 min. In addition, if the end piece is attached by screw threads, a loosening torque is to be applied to the end pieces of five additional samples. The torque is to be gradually applied with the rod fixed. When the specific torque is reached, it is to be maintained for no more than 15 s. The holding time for any one sample shall be not less than 5 s and the average holding time of the five samples shall be not less than 8 s.

The value of torque is given in Table T.2.

Table T.2 – Torque values for end-piece test

End-piece diameter mm	Torque Nm
< 8,0	0,3
≥ 8,0	0,6

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Annex U
(normative)

Mechanical strength of CRTs and protection against the effects of implosion

U.1 General

This annex specifies mechanical strength of CRTs, how to protect against the effects of implosion and how a protective screen can withstand mechanical forces.

CRTs with a maximum face dimension exceeding 160 mm shall be either intrinsically protected with respect to effects of implosion and to mechanical impact, or the **enclosure** of the equipment shall provide adequate protection against the effects of an implosion of the CRT.

The face of a non-intrinsically protected CRT shall be provided with an effective screen that cannot be removed by hand. If a separate screen of glass is used, it shall not contact the surface of the CRT.

The CRT, other than the face of an intrinsically protected CRT, shall not be **accessible** to an **ordinary person**.

A protective film attached to the faceplate of the picture tube as part of the implosion protection system shall be covered on all edges by the **enclosure** of the equipment.

If the equipment is provided with a CRT with protective film attached to the faceplate as part of the safety implosion system, an **instructional safeguard** shall be provided in accordance with Clause F.5:

– element 1a: not available
– element 2: “Warning” or equivalent word or text
– element 3: “Risk of injury” or equivalent text
– element 4: “The CRT in this equipment uses a protective film on the face. This film shall not be removed as it serves a safety function and removal will increase the risk of injury” or equivalent text

The **instructional safeguard** shall be provided in the instructions.

Compliance is checked by inspection, by measurement, and by the tests of:

– *IEC 61965 for intrinsically protected CRTs, including those having integral protective screens;*
– *Clauses U.2 and U.3 for equipment having non-intrinsically protected CRTs; and*
– *Annex V for application of probes for the **enclosure**.*

NOTE 1 A picture tube CRT is considered to be intrinsically protected with respect to the effects of implosion if, when it is correctly mounted, no additional protection is necessary.

NOTE 2 To facilitate the tests, the CRT manufacturer is requested to indicate the most vulnerable area on the CRTs to be tested.

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U.2 Test method and compliance criteria for non-intrinsically protected CRTs

The equipment, with the CRT and the protective screen in position, is placed on a horizontal support at a height of (750 ± 50) mm above the floor, or directly on the floor if the equipment is obviously intended to be positioned on the floor.

The CRT is imploded inside the ***enclosure*** *of the equipment by the following method.*

Cracks are propagated in the envelope of each CRT. An area on the side or on the face of each CRT is scratched with a diamond stylus and this area is repeatedly cooled with liquid nitrogen or the like until a fracture occurs. To prevent the cooling liquid from flowing away from the test area, a dam of modelling clay or the like should be used.

NOTE Suitable scratch patterns are found in Figure 6 of IEC 61965:2003.

After this test, within 5 s of the initial fracture, no particle (a single piece of glass having a mass greater than 0,025 g) shall have passed a 250 mm high barrier, placed on the floor, 500 mm from the projection of the front of the equipment.

U.3 Protective screen

A protective screen shall be adequately secured and resistant to mechanical forces.

Compliance is checked by the tests of Clause T.3, without cracking of the protective screen or loosening of its mounting.

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Annex V
(normative)

Determination of accessible parts

V.1 Accessible parts of equipment

V.1.1 General

An **accessible** part of an equipment is a part that can be touched by a body part. For the purposes of determining an **accessible** part, a body part is represented by one or more of the specified test probes.

Accessible parts of an equipment may include parts behind a door, panel, removable cover, etc. that can be opened without the use of a **tool**.

Accessible parts do not include those that become **accessible** when floor standing equipment having a mass exceeding 40 kg is tilted.

For equipment intended for building-in or rack-mounting, or for subassemblies and the like for incorporation in larger equipment, **accessible** parts do not include those that are not **accessible** when the equipment or subassembly is installed according to the method of mounting or installation specified in the installation instructions.

A part is considered **accessible** if the instructions or markings intended to be followed require that a person physically contacts that part. This applies without test and irrespective of whether a **tool** is required to gain access.

V.1.2 Test method 1 – Surfaces and openings tested with jointed test probes

For surfaces and openings, the following jointed test probe is applied, without appreciable force and in any possible position, to the surfaces and openings of the equipment:

– *the test probe of Figure V.1 for equipment that is likely to be **accessible** to children;*

NOTE 1 Equipment intended for use in homes, schools, public and similar locations is equipment generally considered to be **accessible** to children, see also Clause F.4.

– *the test probe of Figure V.2 for equipment that is not likely to be **accessible** to children.*

*Where entry behind a door, panel, removable cover, etc. is possible without the use of a **tool**, or entry is directed by manufacturer instructions or marking, with or without the use of a **tool**, the test probe is applied to surfaces and openings in those areas.*

*Where the entire probe passes through a large opening (allowing entry of an arm but not of a shoulder), the probe shall be applied to all parts within a hemisphere with radius of 762 mm. The probe handle shall point along a path towards the large opening to simulate the hand on the end of the arm extending through the large opening. The plane of the hemisphere shall be the outside plane of the opening. Any part outside the 762 mm radius hemisphere is deemed not **accessible**.*

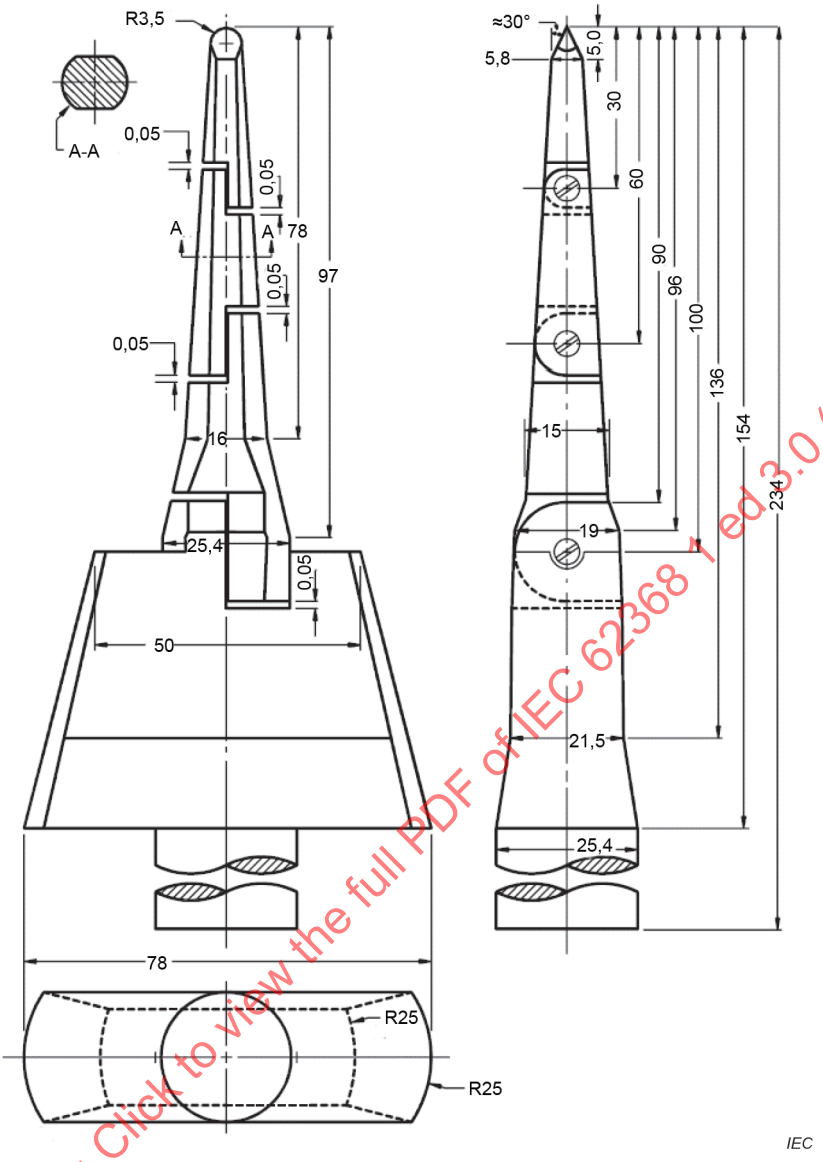
NOTE 2 The equipment can be dismantled to perform this test.

V.1.3 Test method 2 – Openings tested with straight unjointed test probes

Openings preventing access to a part by the applicable jointed test probe of Figure V.1 or Figure V.2 are further tested by means of a straight unjointed version of the respective test probe applied with a force of 30 N. If the unjointed probe enters the openings, test method 1 is repeated, except that the applicable jointed version of the test probe is pushed through the opening using any necessary force up to 30 N.

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Dimensions in millimetres



Tolerances on dimensions without specific tolerances:

angles: ± 15′

on radii: ± 0,1 mm

Tolerances on linear dimensions without specific tolerances:

≤ 15 mm: $^{0}_{-0,1}$ mm

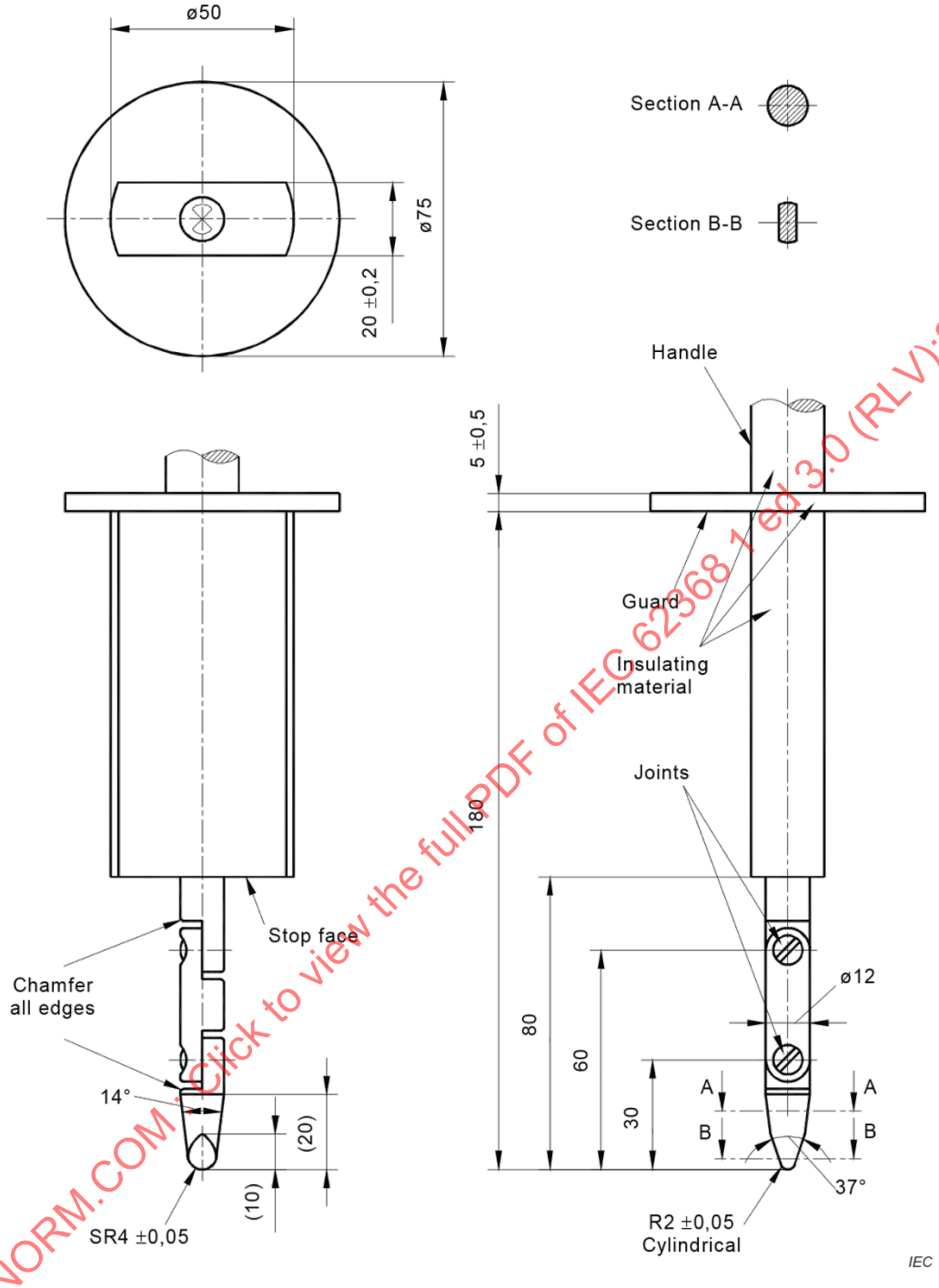
> 15 mm ≤ 25 mm: ± 0,1 mm

> 25 mm: ± 0,3 mm

Material of the test probe: heat-treated steel, for example.

Figure V.1 – Jointed test probe for equipment likely to be accessible to children

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Linear dimensions in millimetres

Tolerances on dimensions without specific tolerances:

14° and 37° angles: ± 15′

on radii: ± 0,1 mm

on linear dimensions:

≤ 15 mm: $^{0}_{-0,1}$ mm

> 15 mm ≤ 25 mm: ± 0,1 mm

> 25 mm: ± 0,3 mm

NOTE This jointed test probe is taken from Figure 2, test probe B of IEC 61032:1997.

Figure V.2 – Jointed test probe for equipment not likely to be accessible to children

V.1.4 Test method 3 – Plugs, jacks, connectors

The blunt probe of Figure V.3 is applied without appreciable force and in any possible position to specified parts.

Dimensions in millimetres

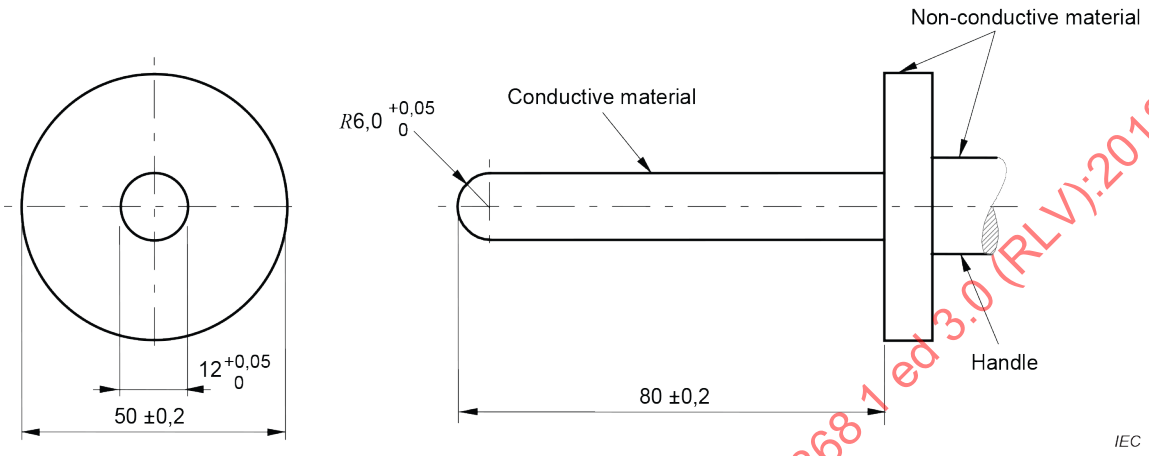


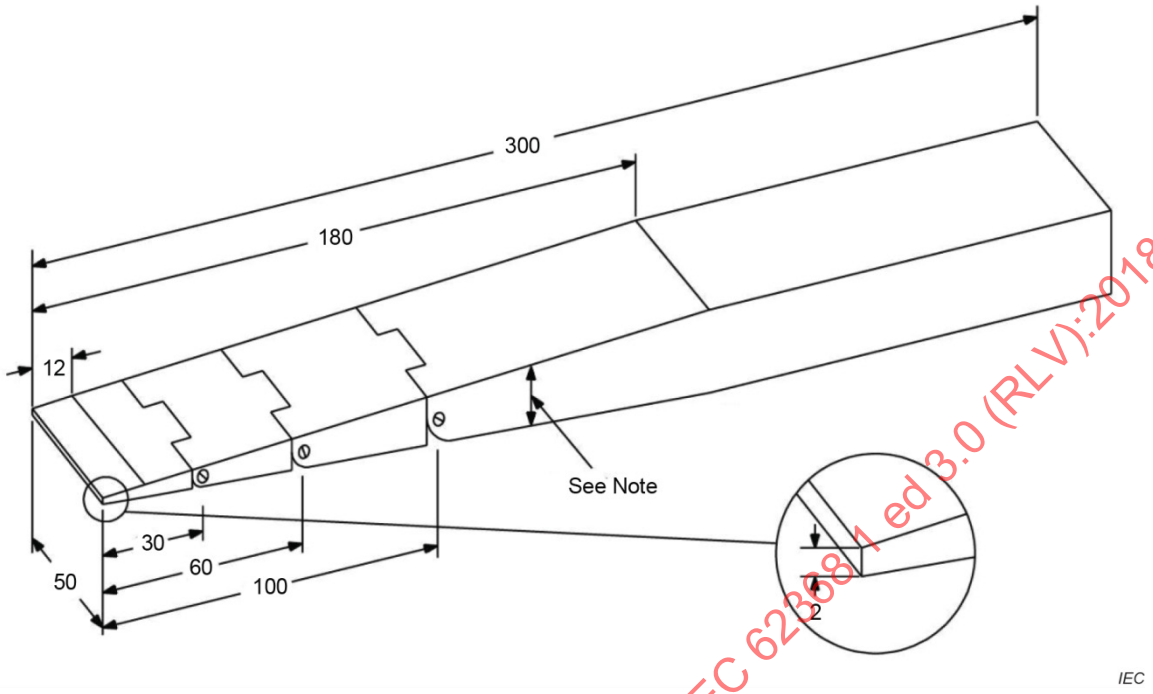
Figure V.3 – Blunt probe

V.1.5 Test method 4 – Slot openings

The wedge probe of Figure V.4 is applied as specified.

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Dimensions in millimetres



Tolerances on linear dimensions without specific tolerances:

≤ 25 mm: ± 0,13 mm

> 25 mm: ± 0,3 mm

NOTE The thickness of the probe varies linearly, with slope changes at the following points along the probe:

Distance from probe tip mm	Probe thickness mm
0	2
12	4
180	24

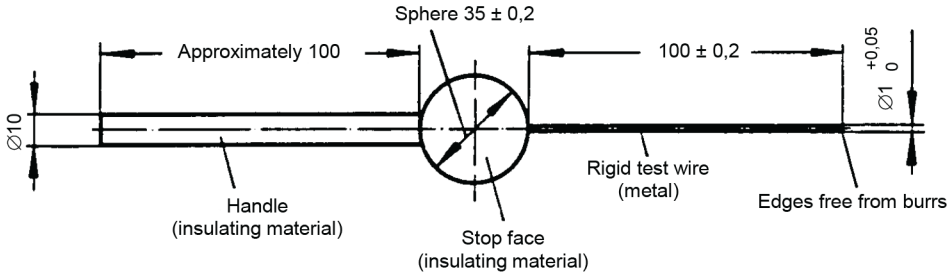
Figure V.4 – Wedge probe

V.1.6 Test method 5 – Terminals intended to be used by an ordinary person

The rigid test wire of the test probe of Figure V.5 is inserted into the applicable opening with a force up to 1 N ± 0,1 N and with the length limited to 20 mm ± 0,2 mm. While inserted, the probe is moved in any angle with minimal force.

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Dimensions in millimetres



NOTE This probe is taken from Figure 4 of IEC 61032:1997.

Figure V.5 – Terminal probe

V.2 Accessible part criterion

*If a part can be touched by the specified probe, then the part is **accessible**.*

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Annex W
(informative)

Comparison of terms introduced in this document

W.1 General

This document introduces new safety terms associated with the new safety concepts.

This annex identifies the relevant terms in this document and, where different, compare them to the equivalent IEC/TC 64 [3] basic safety publications and other relevant safety publications.

Terms not in the tables below are either the same or substantially the same as in other IEC standards.

W.2 Comparison of terms

In the Tables W.1 to W.6 below, the text quoted from an IEC standard is in normal font. Remarks about IEC 62368-1 are in italic font.

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3 IEC/TC 64: Electrical installations and protection against electric shock. Click on the IEC website for a list of publications issued by TC 64.

Table W.1 – Comparison of terms and definitions in IEC 60664-1:2007 and IEC 62368-1

IEC 60664-1:2007	IEC 62368-1
3.2 **clearance** shortest distance in air between two conductive parts	**3.3.12.1** **clearance** shortest distance in air between two conductive parts
3.3 **creepage distance** shortest distance along the surface of a solid insulating material between two conductive parts	**3.3.12.2** **creepage distance** shortest distance along the surface of an insulating material between two conductive parts
3.4 **solid insulation** solid insulating material interposed between two conductive parts	**3.3.5.6** **solid insulation** insulation consisting entirely of solid material
3.5 **working voltage** highest RMS value of the AC or DC voltage across any particular insulation which can occur when the equipment is supplied at rated voltage	**3.3.14.8** **working voltage** highest voltage across any particular insulation that can occur when the equipment is supplied at **rated voltage** or any voltage in the **rated voltage range** under **normal operating conditions**
3.9 **rated voltage** value of voltage assigned by the manufacturer, to a component, device or equipment and to which operation and performance characteristics are referred	**3.3.10.4** **rated voltage** value of voltage assigned by the manufacturer to a component, device or equipment and to which operation and performance characteristics are referred
3.13 **pollution degree** numeral characterizing the expected pollution of the micro-environment	**3.3.6.8** **pollution degree** numeral characterising the expected pollution of the micro-environment
3.19.1 **type test** test of one or more devices made to a certain design to show that the design meets certain specifications	**3.3.6.15** **type test** test on a representative sample with the objective of determining if, as designed and manufactured, it can meet the requirements of this document
3.9.2 **rated impulse voltage** impulse withstand voltage value assigned by the manufacturer to the equipment or to a part of it, characterizing the specified withstand capability of its insulation against transient overvoltages	**3.3.14.2** **mains transient voltage** highest peak voltage expected at the **mains** input to the equipment, arising from external transients

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IEC 60664-1:2007	IEC 62368-1
3.17.1 **functional insulation** insulation between conductive parts which is necessary only for the proper functioning of the equipment	**3.3.5.3** **functional insulation** insulation between conductive parts which is necessary only for the proper functioning of the equipment
3.17.2 **basic insulation** insulation of hazardous-live-parts which provides basic protection	**3.3.5.1** **basic insulation** insulation to provide a **basic safeguard** against electric shock
3.17.3 **supplementary insulation** independent insulation applied in addition to basic insulation for fault protection	**3.3.5.7** **supplementary insulation** independent insulation applied in addition to **basic insulation** to provide **supplementary safeguard** for fault protection against electric shock
3.17.4 **double insulation** insulation comprising both basic insulation and supplementary insulation	**3.3.5.2** **double insulation** insulation comprising both **basic insulation** and **supplementary insulation**
3.17.5 **reinforced insulation** insulation of hazardous-live-parts which provides a degree of protection against electric shock equivalent to double insulation	**3.3.5.5** **reinforced insulation** single insulation system that provides a degree of protection against electric shock equivalent to **double insulation**
3.19.2 **routine test** test to which each individual device is subjected during or after manufacture to ascertain whether it complies with certain criteria	**3.3.6.10** **routine test** test to which each individual device is subjected during or after manufacture to ascertain whether it complies with certain criteria
3.19.3 **sampling test** test on a number of devices taken at random from a batch	**3.3.6.11** **sampling test** test on a number of devices taken at random from a batch

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Table W.2 – Comparison of terms and definitions in IEC 61140:2016 and IEC 62368-1

IEC 61140:2016 terms	IEC 62368-1 terms
	*For consistency throughout the document the term "**safeguard**" is used to describe the device or scheme that provides protection against an energy source.*
3.1.1 **basic protection** protection against electric shock under fault-free conditions	**3.3.11.2** **basic safeguard** **safeguard** that provides protection under **normal operating conditions** and under **abnormal operating conditions** whenever an energy source capable of causing pain or injury is present in the equipment
3.10.2 **supplementary insulation** Independent insulation applied in addition to basic insulation, for fault protection	**3.3.11.17** **supplementary safeguard** **safeguard** applied in addition to the **basic safeguard** that is or becomes operational in the event of failure of the **basic safeguard**
3.4 **live part** conductor or conductive part intended to be energized in normal operation, including a neutral conductor, but by convention not a PEN conductor or PEM conductor or PEL conductor Note 1 to entry: This concept does not necessarily imply a risk of electric shock. Note 2 to entry: For definitions of PEM and PEL see IEV 195-02-13 and 195-02-14.	*The term **live part** is not used.* *In accordance with the IEC 61140 definition, ES1, ES2 and ES3 are all live parts*
3.5 **hazardous-live-part** live part that, under certain conditions, can give a harmful electric shock Note 1 to entry: In case of high voltage, a hazardous voltage may be present on the surface of solid insulation. In such a case the surface is considered to be a hazardous-live-part.	*The term **hazardous-live-part** is not used.* *In accordance with the IEC 61140 definition, an ES3 source is a hazardous-live-part.*
3.26 **extra-low-voltage (ELV)** any voltage not exceeding the relevant voltage limit specified in IEC TS 61201	*No equivalent term. See ES1.*
3.26.1 **SELV system** an electrical system in which the voltage cannot exceed ELV: – under normal conditions; and – under single-fault conditions, including earth faults in other circuits	**ES1** ES1 is a voltage not exceeding the relevant voltage limit specified in IEC TS 61201 or a current not exceeding the relevant current limit specified in IEC TS 60479-1 – under normal conditions; and – under **single fault conditions**

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IEC 61140:2016 terms	IEC 62368-1 terms
3.28 **limited-current-source** device supplying electrical energy in an electric circuit – with protective-separation from hazardous-live-parts, and – that ensures that the steady state touch current and charge are limited to non-hazardous levels, under normal and fault conditions	**ES1** ES1 is a voltage not exceeding the relevant voltage limit specified in IEC TS 61201 or a current not exceeding the relevant current limit specified in IEC TS 60479-1 – under normal conditions; and – under **single fault conditions**.
5.1.6 **Limitation of steady state touch current and charge** Limitation of steady state touch current and charge shall prevent persons or animals from being subjected to values of steady state touch current and charge liable to be hazardous or perceptible. Note 1 to entry: For persons, the following values (AC values for frequencies up to 100 Hz) are given as guidance: – A steady state current flowing between simultaneously accessible conductive parts through a pure resistance of 2 000 Ω not exceeding the threshold of perception, AC 0,5 mA or DC 2 mA are recommended. – Values not exceeding the threshold of pain AC 3,5 mA or DC 10 mA may be specified.	*ES1 current limit is 0,5 mA AC and 2 mA DC* *ES2 current limit is 5 mA AC, 25 mA DC (these values are taken from IEC TS 60479-1)*
No equivalent term	**3.3.11.12** **safeguard** physical part or system or instruction specifically provided to reduce the likelihood of injury, or, for fire, to reduce the likelihood of ignition or spread of fire
No equivalent term. Based on double insulation	**3.3.11.2** **double safeguard** **safeguard** comprising both a **basic safeguard** and a **supplementary safeguard**
No equivalent term. Based on reinforced insulation	**3.3.11.12** **reinforced safeguard** single **safeguard** that is provides protection under – **normal operating conditions**, – **abnormal operating conditions**, and – **single fault conditions**.
No equivalent term. Roughly equivalent to a warning	**3.3.11.5** **instructional safeguard** an instruction invoking specified behaviour

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IEC 61140:2016 terms	IEC 62368-1 terms
No equivalent term	**3.3.11.7** **precautionary safeguard** **instructed person** behaviour to avoid contact with or exposure to a class 2 energy source based on supervision or instructions given by a **skilled person**
No equivalent term	**3.3.11.14** **skill safeguard** **skilled person** behaviour to avoid contact with or exposure to a class 2 or class 3 energy source based on education and experience
The term normal condition is used in IEC 61140, but not defined	**3.3.7.4** **normal operating condition** mode of operation that represents as closely as possible the range of normal use that can reasonably be expected
No equivalent term	**3.3.7.1** **abnormal operating condition** temporary operating condition that is not a **normal operating condition** and is not a **single fault condition** of the equipment itself
The term single fault is used in IEC 61140, but not defined	**3.3.7.9** **single fault condition** fault under **normal operating condition** of a single **safeguard** (but not a **reinforced safeguard**) or of a single component or a device

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Table W.3 – Comparison of terms and definitions in IEC 60950-1:2005 and IEC 62368-1

IEC 60950-1:2005 terms	IEC 62368-1 terms
1.2.8.8 **SELV circuit** secondary circuit that is so designed and protected that under normal operating conditions and single fault conditions, its voltages do not exceed a safe value	**5.2.1.1** **ES1** ES1 is a class 1 electrical energy source with **touch current** or **prospective touch voltage** levels – not exceeding ES1 limits under • **normal operating conditions**, and • **abnormal operating conditions**, and • **single fault conditions** of a component, device or insulation not serving as a **safeguard**; and not exceeding ES2 limits under **single fault conditions** of a **basic safeguard** or of a **supplementary safeguard**.
1.2.8.11 **TNV circuit** circuit that is in the equipment and to which the accessible area of contact is limited and that is so designed and protected that, under normal operating conditions and single fault conditions (see 1.4.14 of IEC 60950-1:2005), the voltages do not exceed specified limit values A TNV circuit is considered to be a secondary circuit in the meaning of this document.	*See detailed TNV classes for comparison.*
1.2.8.12 **TNV-1 circuit** TNV circuit – whose normal operating voltages do not exceed the limits for an SELV circuit under normal operating conditions and – On which overvoltages from telecommunication networks and cable distribution systems are possible	ES 1 on which transients according to Table 13, ID numbers 1, 2 and 3 are possible NOTE The electrical characteristics are not identical to TNV circuits but will give equivalent level of safety.

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IEC 60950-1:2005 terms	IEC 62368-1 terms
1.2.8.13 **TNV-2 circuit** TNV circuit – whose normal operating voltages exceed the limits for an SELV circuit under normal operating conditions and – which is not subject to overvoltages from telecommunication networks	ES2 ES2 is a class 2 electrical energy source where – both the **prospective touch voltage** and the **touch current** exceed the limits for ES1; and – under • **normal operating conditions**, and • **abnormal operating conditions**, and • **single fault conditions**, either the **prospective touch voltage** or the **touch current** does not exceed the limit for ES2. NOTE The electrical characteristics are not identical to TNV circuits but will give equivalent level of safety.
1.2.8.14 **TNV-3 circuit** TNV circuit – whose normal operating voltages exceed the limits for an SELV circuit under normal operating conditions and – on which overvoltages from telecommunication networks and cable distribution systems are possible	ES 2 on which transients according to Table 13, ID numbers 1, 2 and 3 are possible NOTE The electrical characteristics are not identical to TNV circuits but will give equivalent level of safety.
1.2.13.6 **USER** any person, other than a service person *The term user in this document is the same as the term operator and the two terms can be interchanged*	**3.3.8.2** **ordinary person** person who is neither a **skilled person** nor an **instructed person**
1.2.13.7 **operator** see **user** (1.2.13.6 of IEC 60950-1:2005)	**See 3.3.8.2**

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IEC 60950-1:2005 terms	IEC 62368-1 terms
1.2.13.8 **telecommunication network** metallically terminated transmission medium intended for communication between equipment that may be located in separate buildings, excluding: – the mains system for supply, transmission and distribution of electrical power, if used as a telecommunication transmission medium; – cable distribution systems; – SELV circuits connecting units of information technology equipment Note 1 to entry: The term telecommunication network is defined in terms of its functionality, not its electrical characteristics. a telecommunication network is not itself defined as being either an SELV circuit or a TNV circuit. Only the circuits in the equipment are so classified. Note 2 to entry: A telecommunication network may be: – publicly or privately owned: – subject to transient overvoltages due to atmospheric discharges and faults in power distribution systems: – subject to longitudinal (common mode) voltages induced from nearby power lines or electric traction lines. Note 3 to entry: Examples of telecommunication networks are: – a public switched telephone network: – a public data network: – an integrated Services Digital Network (ISDN); – a private network with electrical interface characteristics similar to the above.	**3.3.1.1** **external circuit** electrical circuit that is external to the equipment and is not **mains** Note 1 to entry: An **external circuit** is classified as ES1, ES2 or ES3, and PS1, PS2, or PS3.
None	**3.3.8.1** **instructed person** person instructed or supervised by a **skilled person** as to energy sources and who can responsibly use equipment **safeguards** and **precautionary safeguards** with respect to those energy sources

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IEC 60950-1:2005 terms	IEC 62368-1 terms
1.2.13.5 **service person** person having appropriate technical training and experience necessary to be aware of hazards to which that person may be exposed in performing a task and of measures to minimize the risks to that person or other persons	**3.3.8.3** **skilled person** person with relevant education or experience to enable him or her to identify hazards and to take appropriate actions to reduce the likelihood of risks of injury to themselves and others
1.2.13.14 **cable distribution system** metallically terminated transmission medium using coaxial cable, mainly intended for transmission of video and/or audio signals between separate buildings or between outdoor antennas and buildings, excluding: – the mains system for supply, transmission and distribution of electric power, if used as a communication transmission medium; – telecommunication networks; – SELV circuits connecting units of information technology equipment Note 1 to entry: Examples Of cable distribution systems are: – local area cable networks, community antenna television systems and master antenna television systems providing video and audio signal distribution; – outdoor antennas including satellite dishes, receiving antennas, and other similar devices. Note 2 to entry: Cable distribution systems may be subjected to greater transients than telecommunication networks.	**3.3.1.1** **external circuit** electrical circuit that is external to the equipment and is not **mains** Note 1 to entry: The relevant **external circuits** are identified in Table 13.

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Table W.4 – Comparison of terms and definitions in IEC 60728-11:2016 and IEC 62368-1

IEC 60728-11:2016 terms	IEC 62368-1 terms
3.1.4 **cable networks <for television signals, sound signals and interactive services>** regional and local broadband cable networks, extended satellite and terrestrial television distribution networks or systems and individual satellite and terrestrial television receiving systems Note 1 to entry: These networks and systems can be used in downstream and upstream directions. **3.1.5** **CATV network or community antenna television network** regional and local broadband cable networks designed to provide sound and television signals as well as signals for interactive services to a regional or local area Note 1 to entry: Originally defined as Community Antenna Television network. **3.1.31** **MATV network or master antenna television network** extended terrestrial television distribution networks or systems designed to provide sound and television signals received by terrestrial receiving antenna to households in one or more buildings Note 1 to entry: Originally defined as master antenna television network. Note 2 to entry: This kind of network or system can possibly be combined with a satellite antenna for the additional reception of TV and/or radio signals via satellite networks. Note 3 to entry: This kind of network or system can also carry other signals for special transmission systems (e.g. MoCA or WiFi) in the return path direction.	**3.3.1.1** **external circuit** electrical circuit that is external to the equipment and is not **mains** Note 1 to entry: The relevant **external circuits** are identified in Table 13.

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IEC 60728-11:2016 terms	IEC 62368-1 terms
3.1.44 **SMATV network or satellite master antenna television network** extended distribution networks or systems designed to provide sound and television signals received by satellite receiving antenna to households in one or more buildings Note 1 to entry: Originally defined as satellite master antenna television network Note 2 to entry: This kind of network or system can possibly be combined with terrestrial antennas for the additional reception of TV and/or radio signals via terrestrial networks. Note 3 to entry: This kind of network or system can also carry control signals for satellite switched systems or other signals for special transmission systems (e.g. MoCA or WiFi) in the return path direction.	

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Table W.5 – Comparison of terms and definitions in IEC 62151:2000 and IEC 62368-1

IEC 62151:2000 terms	IEC 62368-1 terms
3.1.3 **telecommunication network** a metallically terminated transmission medium intended for communication between equipments that may be located in separate buildings, excluding: – the mains systems for supply, transmission and distribution of electrical power, if used as a telecommunication transmission medium; – television distribution systems using cable Note 1 to entry: The term telecommunication network is defined in terms of its functionality, not its electrical characteristics. a telecommunication networK is not itself defined as being a TNV circuit. Only the circuits in equipment are so classified. Note 2 to entry: A telecommunication network may be – publicly or privately owned; – subject to transient overvoltages due to atmospheric discharges and faults in power distribution systems; – subject to permanent longitudinal (common mode) voltages induced from nearby power lines or electric traction lines. Note 3 to entry: Examples of telecommunication networks are – a public switched telephone network; – a public data network; – an ISDN network; – a private network with electrical interface characteristics similar to the above.	**3.3.1.1** **external circuit** electrical circuit that is external to the equipment and is not **mains** Note 1 to entry: The relevant **external circuits** are identified in Table 13.
3.5.4 **TNV-0 circuit** a TNV circuit: – whose normal operating voltages do not exceed a safe value under normal operating conditions and under single fault conditions; – which is not subject to overvoltages from telecommunication networks Note 1 to entry: The limiting values of voltage under normal operating and single fault conditions are specified in 4.1.	**5.2.1.1** **ES1** ES1 is a class 1 electrical energy source with **touch current** or **prospective touch voltage** levels – not exceeding ES1 limits under • **normal operating conditions**, and • **abnormal operating conditions**, and • **single fault conditions** of a component, device or insulation not serving as a **safeguard**; and not exceeding ES2 limits under **single fault conditions** of a **basic safeguard** or of a **supplementary safeguard**.

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IEC 62151:2000 terms	IEC 62368-1 terms
3.5.3 **TNV circuit** a circuit which is in the equipment and to which the accessible area of contact is limited (except for a TNV-0 circuit) and that is so designed and protected that, under normal operating and single fault conditions, the voltages do not exceed specified limiting values A TNV circuit is considered to be a secondary circuit in the meaning of this document. Note 1 to entry: The voltage relationships between TNV CIRCUITS are shown in table 1.	**5.2.1.2** **ES2** ES2 is a class 2 electrical energy source where – both the **prospective touch voltage** and the **touch current** exceed the limits for ES1; and – under • **normal operating conditions**, and • **abnormal operating conditions**, and • **single fault conditions**. either the **prospective touch voltage** or the **touch current** does not exceed the limit for ES2.

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Table W.6 – Comparison of terms and definitions in IEC 60065:2014 and IEC 62368-1

IEC 60065:2014 terms	IEC 62368-1 terms
2.2.12 **professional apparatus** apparatus for use in trades, professions or industries and which is not intended for sale to the general public Note 1 to entry: The designation should be specified by the manufacturer.	**3.3.3.8** **professional equipment** equipment for use in trades, professions or industries and which is not intended for sale to the general public
2.4.3 **directly connected to the mains** electrical connection with the mains in such a way that a connection to either pole of the mains causes in that connection a permanent current equal to or greater than 9 A, protective devices in the apparatus being not short-circuited Note 1 to entry: A current of 9 A is chosen as the minimum breaking current of a 6 A fuse.	*No equivalent term.* *In accordance with the IEC 60065 definition, an ES3 source would be considered directly connected to the **mains**.*
2.4.4 **conductively connected to the mains** electrical connection with the mains in such a way that a connection through a resistance of 2 000 Ω to either pole of the mains causes in that resistance a permanent current greater than 0,7 mA (peak), the apparatus not being connected to earth	*No equivalent term.* *In accordance with the IEC 60065 definition, an ES3 or ES2 source could be considered conductively connected to the **mains**.*

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IEC 60065:2014 terms	IEC 62368-1 terms
2.4.7 **telecommunication network** metallically-terminated transmission medium intended for communication between apparatus that may be located in separate buildings, excluding: – the mains systems for supply, transmission and distribution of electrical power, if used as a telecommunication transmission medium; – television – distribution systems using cable Note 1 to entry: The term telecommunication network is defined in terms of its functionality, not its electrical characteristics. a telecommunication network is not itself defined as being either a TNV circuit. Only the circuits in the apparatus are so classified. Note 2 to entry: A telecommunication network may be: – publicly or privately owned: – subject to transient overvoltages due to atmospheric discharges and faults in power distribution systems: – subject to longitudinal (common mode) voltages induced from nearby power lines or electric traction lines. Note 3 to entry: Examples of telecommunication networks are: – a public switched telephone network; – a public data network; – an ISDN network; – a private network with electrical interface characteristics similar to the above.	**3.3.1.1** **external circuit** electrical circuit that is external to the equipment and is not **mains** Note 1 to entry: The relevant **external circuits** are identified in Table 13.
2.6.10 **hazardous live** electrical condition of an object from which a hazardous touch current (electric shock) could be drawn (see 9.1.1)	*The term hazardous-live is not used.* *In accordance with the IEC 60065 definition, an ES3 source is hazardous live.*
2.8.6 **instructed person** person adequately advised or supervised by skilled persons to enable him or her to avoid dangers and to prevent risks which electricity may create	**3.3.8.1** **instructed person** person instructed or supervised by a skilled person as to energy sources and who can responsibly uses **equipment safeguards** and **precautionary safeguards** with respect to those energy sources Note 1 to entry: Supervised, as used in the definition, means having the direction and oversight of the performance of others. [SOURCE: IEV 826-18-02, modified]

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IEC 60065:2014 terms	IEC 62368-1 terms
2.8.11 **potential ignition source** possible fault which can start a fire if the open-circuit voltage measured across an interruption or faulty contact exceeds a value of 50 V (peak) AC or DC and the product of the peak value of this voltage and the measured RMS current under normal operating conditions exceeds 15 VA. Such a faulty contact or interruption in an electrical connection includes those which may occur in conductive patterns on printed boards. Note 1 to entry: An electronic protection circuit may be used to prevent such a fault from becoming a potential ignition source.	**3.3.9.2** **arcing PIS** **PIS** where an arc may occur due to the opening of a conductor or contact Note 1 to entry: An electronic protection circuit or additional constructional measures may be used to prevent a location from becoming an **arcing PIS**. Note 2 to entry: A faulty contact or interruption in an electric connection that may occur in conductive patterns on printed boards is considered to be within the scope of this definition.

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Annex X
(normative)

Alternative method for determining clearances for insulation in circuits connected to an AC mains not exceeding 420 V peak (300 V RMS)

For an AC **mains** not exceeding 420 V peak (300 V RMS):

– if the peak of the **working voltage** does not exceed the peak value of the AC **mains** supply voltage, the alternate minimum **clearance** is determined from Table X.1;

– if the peak of the **working voltage** exceeds the peak value of the AC **mains** supply voltage, the alternate minimum **clearance** is the sum of the following two values:

- the **clearance** from Table X.1, and
- the appropriate additional **clearance** from Table X.2.

NOTE A **clearance** obtained by the use of Table X.1 lies between the values required for homogeneous and inhomogeneous fields. As a result, it may not pass the appropriate electric strength test if the field is substantially inhomogeneous.

Table X.1 – Alternative minimum clearances for insulation in circuits connected to ac mains not exceeding 420 V peak (300 V RMS)

Clearances in mm

Voltage up to and including V	**Mains transient voltage**							
	1 500 V [a]				**2 500 V [a]**			
	Pollution degree							
	1 and 2		**3**		**1 and 2**		**3**	
	B/S	**R**	**B/S**	**R**	**B/S**	**R**	**B/S**	**R**
71	1,0	2,0	1,3	2,6	2,0	4,0	2,0	4,0
210	1,0	2,0	1,3	2,6	2,0	4,0	2,0	4,0
420	B/S 2,0 R 4,0							
If the peak of the **working voltage** exceeds the peak value of the AC **mains** supply voltage, linear interpolation is permitted between the nearest two points, the calculated minimum **clearance** being rounded up to the next higher 0,1 mm increment.								
[a] The relationship between **mains transient voltage** and AC **mains** supply voltage is given in Table 12.								

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Table X.2 – Additional clearances for insulation in circuits connected to ac mains not exceeding 420 V peak (300 V RMS)

Clearances in mm

Mains transient voltage						
1 500 V [a]				2 500 V [a]		
Voltage up to and including V		Basic or supplementary insulation	Reinforced insulation	Voltage up to and including V	Basic or supplementary insulation	Reinforced insulation
Pollution degrees 1 and 2	Pollution degree 3			Pollution degrees 1, 2 and 3		
210	210	0,0	0,0	420	0,0	0,0
298	294	0,1	0,2	493	0,1	0,2
386	379	0,2	0,4	567	0,2	0,4
474	463	0,3	0,6	640	0,3	0,6
562	547	0,4	0,8	713	0,4	0,8
650	632	0,5	1,0	787	0,5	1,0
738	715	0,6	1,2	860	0,6	1,2
826	800	0,7	1,4	933	0,7	1,4
914	885	0,8	1,6	1 006	0,8	1,6
1 002	970	0,9	1,8	1 080	0,9	1,8
1 090	1 055	1,0	2,0	1 153	1,0	2,0
1 178	1 140	1,1	2,2	1 226	1,1	2,2
1 266	1 225	1,2	2,4	1 300	1,2	2,4
1 354	1 310	1,3	2,6	1 374	1,3	2,6

For voltages above the peak value of the **working voltage** given in the table, linear extrapolation is permitted.

For voltages within the peak value of the **working voltage** given in the table, linear interpolation is permitted between the nearest two points, the calculated minimum additional **clearance** being rounded up to the next higher 0,1 mm increment.

[a] The relationship between **mains transient voltage** and AC **mains** supply voltage is given in Table 12.

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Annex Y
(normative)

Construction requirements for outdoor enclosures

Y.1 General

Protection against corrosion shall be provided by the use of suitable materials or by the application of a protective coating applied to the exposed surface, taking into account the intended conditions of use.

Parts, such as dials or connectors, that serve as a functional part of an **outdoor enclosure** shall comply with the same environmental protection requirements as for the **outdoor enclosure**.

NOTE 1 Aspects affecting safety that influence the integrity of the **outdoor enclosure** through the life of the product include:

– continued protection against access to class 2 and class 3 energy sources, including after mechanical strength tests;

– continued protection against ingress of dust and water; and

– continued provision of earth continuity.

An **outdoor enclosure** shall not be used to carry current during normal operation if this could cause corrosion that would impair safety. This does not preclude connection of a conductive part of an **outdoor enclosure** to **protective earthing** for the purpose of carrying fault currents.

NOTE 2 The action of a current flowing through a joint can increase corrosion under wet conditions.

Where a conductive part of an **outdoor enclosure** is connected to **protective earthing** for the purpose of carrying fault currents, the resulting connection shall meet the requirements of 5.6, after the appropriate weather conditioning tests, see Clause Y.3.

Compliance is checked by inspection and, if necessary, by the tests of 5.6 after the tests of Clause Y.3.

Y.2 Resistance to UV radiation

Non-metallic parts of an **outdoor enclosure** required for compliance with this document shall be sufficiently resistant to degradation by UV radiation.

*Compliance is checked by examination of the construction and of available data regarding the UV resistance characteristics of the **outdoor enclosure** material and any associated protective coating. If such data is not available, Annex C applies.*

Y.3 Resistance to corrosion

Y.3.1 General

Metallic parts of **outdoor enclosures**, with or without protective coatings, shall be resistant to the effects of water-borne contaminants.

Compliance is checked by either:

– *inspection and by evaluation of data provided by the manufacturer; or*

– *the tests and criteria as specified in Y.3.2 through Y.3.5; or*

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– *the applicable performance level (A1, A2 or A3) of IEC 61587-1.*

Y.3.2 Test apparatus

The apparatus for the salt spray test shall consist of a test chamber and spraying devices as described in IEC 60068-2-11.

The apparatus for the test in a water-saturated sulphur dioxide atmosphere shall consist of an inert, hermetically sealed, chamber containing a water-saturated sulphur dioxide atmosphere in which the test specimens and their supports are held. The chamber shall be as described in ISO 3231.

Y.3.3 Water – saturated sulphur dioxide atmosphere

If the test chamber has an internal volume of 300 l ± 30 l the water-saturated sulphur dioxide atmosphere is created by the introduction of 0,2 l of sulphur dioxide with a concentration of 0,067 % by volume into the closed test chamber. The sulphur dioxide can either be introduced from a gas cylinder or by creating a specific reaction within the chamber. For test chambers having a different internal volume the quantity of sulphur dioxide is varied accordingly.

Sulphur dioxide can be formed inside the test apparatus by treating sodium pyrosulphite ($Na_2S_2O_5$) with a relatively strong acid, sulphamic acid (HSO_3NH_2).

NOTE 1 The method consists of dissolving excess sodium pyrosulphite in water, giving the reaction:

$$Na_2S_2O_5 + H_2O \rightarrow 2\ NaHSO_3$$

A stoichiometric quantity of sulphamic acid is then added giving the reaction:

$$NaHSO_3 + HSO_3NH_2 \rightarrow NaSO_3NH_2 + H_2O + SO_2$$

The resulting overall reaction is:

$$Na_2S_2O_5 + 2\ HSO_3NH_2 \rightarrow 2\ NaSO_3NH_2 + H_2O + 2\ SO_2$$

To obtain 1 l of SO_2 under normal conditions of 0 °C temperature and 1,013 3 × 105 Pa, air pressure, 4,24 g sodium pyrosulphite and 4,33 g sulphamic acid are needed.

NOTE 2 Sulphamic acid is the only solid mineral acid that is easy to conserve.

NOTE 3 The above description is taken from 8.2.11.3.1 and 8.2.11.3.2 of IEC 61439-5:2014.

Y.3.4 Test procedure

The test shall consist of two identical and successive 12 day periods.

Each 12 day period consists of test a) followed by test b):

test a) 168 h of exposure to the salt spray atmosphere. The concentration of the saline solution forming the salt spray atmosphere is 5 % ± 1 % by weight and the temperature of the test chamber is maintained at 35 °C ± 2 °C.

test b) 5 exposure cycles each consisting of an 8 h exposure to a water-saturated sulphur dioxide-rich atmosphere (see Y.3.3), during which the temperature of the test chamber is maintained at 40 °C ± 3 °C , followed by 16 h at rest with the test chamber door open.

After each 12 day period, the test specimens are washed with demineralized water.

Alternatively, the test procedures as described in the following standards may be used to show compliance:

– *ISO 21207 Method B; or*

– *ISO 14993; or*

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– *any other equivalent standard.*

Y.3.5 Compliance criteria

*Compliance is checked by visual inspection. The **outdoor enclosure** shall not show rust or oxidation of the protective coating, cracking or other deterioration that will jeopardize the safety aspects as follows:*

– *continued protection against access to class 2 and class 3 energy sources, including after mechanical strength tests; and*

– *continued protection against ingress of dust and water; and*

– *continued provision of earth continuity.*

However, surface corrosion of the protective coating is disregarded.

Y.4 Gaskets

Y.4.1 General

When gaskets are used as the method providing protection against the ingress of potential contaminants, Y.4.2 through Y.4.6 shall apply as appropriate.

NOTE In Canada and the United States, **enclosure** types are specified in the Canadian Electrical Code and the U.S. National Electrical Code.

Joints for all devices closing openings into the equipment cavity of an **outdoor enclosure** subjected to splashing or seepage of oil, as well as any door or cover for such an **outdoor enclosure**, shall include a gasket in the full length of the joint.

A gasket of elastomeric or thermoplastic material, or a composition gasket utilizing an elastomeric material that is provided on an **outdoor enclosure** subjected to water or dust, shall meet requirements of this document.

Compliance is checked by inspection and by applying the relevant tests of Y.4.2 through Y.4.6.

Y.4.2 Gasket tests

The relevant tests specified in Y.4.3 or Y.4.4, depending on the type of gasket material used, are applicable to gaskets employed on an **outdoor enclosure** subjected to water or dust. The additional test of Y.4.5 is applicable to gaskets employed on an **outdoor enclosure** subjected to oil or coolant. A set of three specimens of the gasket material shall be subjected to the relevant tests.

Y.4.3 Tensile strength and elongation tests

This test is applicable to gaskets, which can stretch (such as O-rings). Gasket material shall be of such quality that samples subjected to a temperature of 69 °C to 70 °C in circulating air for 168 h have a tensile strength of not less than 75 % and an elongation of not less than 60 % of values determined for unaged samples. At the conclusion of the temperature conditioning, there shall be no visible deterioration, deformation, melting, or cracking of the material and the material shall not harden as determined by normal hand flexing.

As an alternative, the tensile strength and elongation tests as given in ISO 37, ISO 1798, ASTM D412 or ASTM D3574 may be used.

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Y.4.4 Compression test

This test is applicable to gaskets with closed cell construction. The set of specimens of gasket material shall be tested to the requirements of a), b) and c) (see Figure Y.1). On completion of each test, the specimens shall not show signs of deterioration or cracks that can be seen with normal or corrected vision.

a) A cylindrical weight sufficient to apply 69 kPa shall be placed on the middle portion of each specimen for a period of 2 h. At the end of that time the weight shall be removed and the specimen allowed to rest at a room temperature of 25 °C ± 3 °C for 30 min. The thickness of the gasket shall then be determined and compared with a measurement obtained before the application of the weight. The compression set shall not exceed 50 % of the initial thickness of the specimen.

b) Following the test specified in a), the same specimens shall be suspended in an air oven at a temperature of 70° C for a period of 5 days. The specimens shall then be tested for compliance with a), approximately 24 h after removal from the oven.

c) Following the test specified in b), the same specimens shall be cooled for a period of 24 h to the minimum temperature specified by the manufacturer or -33 °C if no minimum ambient temperature is specified and then subjected to an impact from a hammer of 1,35 kg mass falling from a height of 150 mm upon removal from the cold chamber. The hammer head shall be steel, 28,6 mm in diameter and have a flat striking surface, 25,4 mm in diameter with slightly rounded edges. The specimens being tested shall be placed on short lengths of 50 mm by 100 mm minimum wooden pieces (clear spruce) when being impacted. Following the impact the specimens shall be examined for evidence of cracking or other adverse effects. The test shall be continued and the specimens impacted every 24 h for two more days. The specimens shall then be removed from the cold chamber, allowed to rest at a room temperature of 25 °C ± 3 °C for approximately 24 h, and then again tested for compliance with a).

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Dimensions in millimetres

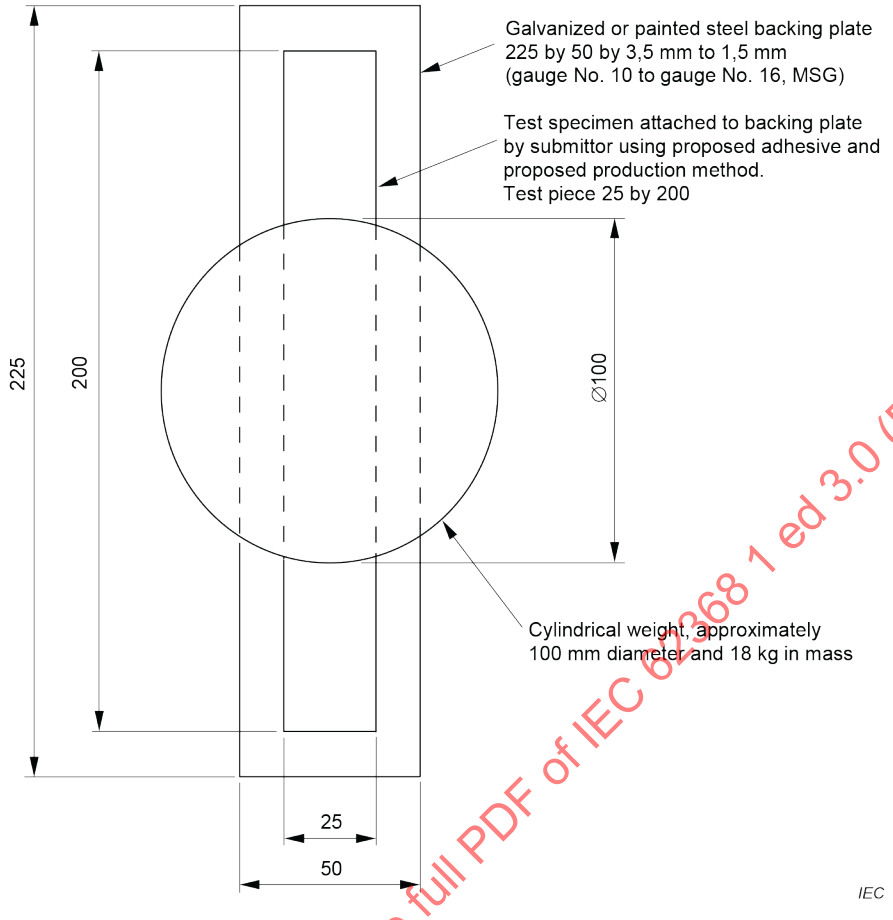


Figure Y.1 – Gasket test

Y.4.5 Oil resistance

A gasket provided on an **outdoor enclosure** subjected to oil or coolant shall be oil resistant.

Compliance is checked by inspection and by the following oil immersion test.

Gasket material shall not swell more than 25 % or shrink more than 1 % as a result of immersion in oil for 70 h at a room temperature of 25 °C ± 3 °C. Specifications are provided in ISO 1817:2015 or ASTM D471-98.

NOTE In Canada and United States, IRM Immersion Oil No. 903 is accepted.

Y.4.6 Securing means

A gasket shall be secured with adhesive or by mechanical means. The gasket and its securing means shall not be damaged when the joint is opened.

Where a gasket is secured by adhesive alone without mechanical securement, and the specific part(s) associated with the gasket may be subjected to opening or similar movement on a periodic basis, the gasket and adhesive shall be subjected to the testing in Clause P.4.Compliance is checked by inspection and available manufacturer's data. If data is not available, then the tests according to Clause P.4 are conducted, as applicable.

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Y.5 Protection of equipment within an outdoor enclosure

Y.5.1 General

Equipment within an **outdoor enclosure** shall have adequate protection from the effects of moisture and excessive dust.

See Table Y.1 for examples for provisions of **pollution degree** environments. To establish a **pollution degree**, both considerations shall be met.

Table Y.1 – Examples of the provision of pollution degree environments

Pollution degree	Method of achievement Dust (Y.5.5)	Method of achievement Moisture (Y.5.1 to Y.5.3)
Pollution degree 3	Default	The use of an **enclosure** meeting IPX4 or the requirements of Y.5.3 relating to the ingress of water is considered to provide a **pollution degree** 3 environment within the **outdoor enclosure**.
Reduction of **pollution degree** 3 to **pollution degree** 2	Reduction of **pollution degree** 3 to **pollution degree** 2 can be accomplished by either: – providing continuous energization of the enclosed equipment; or – providing separate climate conditioning which prevents condensation within the **outdoor equipment** or **outdoor enclosure**; or – IP5X – IP6X – Y.5.5.2 – Y.5.5.3 equivalent (for, example NEMA).	Reduction of the **pollution degree** 3 environment to **pollution degree** 2 can be accomplished by either: – providing continuous energization of the enclosed equipment; or – providing separate climate conditioning which prevents condensation within the **outdoor equipment** or **outdoor enclosure**; or – the use of an **enclosure** meeting IPX4.
Reduction to **pollution degree** 1	See 5.4.1.5.2, Test for **pollution degree** 1 environment and for an insulating compound.	Control of the environment at the insulation surface to **pollution degree** 1 can be accomplished for example by, encapsulation, potting or coating.

Compliance is checked by inspection of the construction, available data and, if necessary, by the tests in Y.5.2 to Y.5.5.

Y.5.2 Protection from moisture

The **outdoor enclosure** shall provide adequate protection from the effect of moisture on the enclosed equipment.

NOTE 1 This does not preclude **outdoor enclosure** or **outdoor equipment** being constructed with segmented volumes, each providing a different **pollution degree**.

NOTE 2 For consideration of the effects of the presence of conductive pollution, as opposed to non-conductive pollution which can become conductive only due to the presence of moisture, see the relevant requirements in IEC 60529.

Where necessary, the **outdoor enclosure** shall be provided with drain holes to control the accumulation of moisture due to:

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– entrance of water through openings; and
– condensation, when this is likely to occur (for example, keeping the equipment energized or separately heating the equipment is considered to keep it free of condensation).

The provision of drain holes and their location shall be taken into consideration when determining the IP rating.

Compliance is checked by inspection and, if necessary, by the relevant tests of IEC 60529 or Y.5.3.

Prior to testing, the equipment shall be mounted, so far as is reasonably practicable, according to the manufacturer's installation instructions. If fans or other means for ventilation are provided, which could affect the ingress of water, the test shall be conducted with the ventilation means both on and off unless it is evident that one of the modes of operation will produce the more onerous result.

At the conclusion of the test the following conditions shall exist:

– For **outdoor enclosures**, no water shall have entered the **outdoor enclosure**.
– For **outdoor equipment**, water is permitted to enter the **outdoor enclosure** provided it does not:
  - deposit on insulation where it could lead to tracking along the **creepage distance**,
  - deposit on bare live parts or bare wiring, or on windings not designed to operate when wet, or
  - enter any supply wiring space, see G.7.6.

Y.5.3 Water spray test

*The water-spray test apparatus, using fresh water, is to consist of three spray heads mounted in a water supply pipe rack as shown in Figure Y.2. Spray heads are to be constructed in accordance with the details shown in Figure Y.3. The **outdoor enclosure** is to be positioned in the focal area of the spray heads so that the greatest quantity of water is likely to enter the **outdoor enclosure**. The water pressure is to be maintained at 34,5 kPa at each spray head. The **outdoor enclosure** is to be exposed to the water spray for 1 h.*

*Unless the construction is such that a test on one side of the **outdoor enclosure** is representative of a test on another side, the test is to be repeated on other sides of the **outdoor enclosure** as necessary.*

*The water spray is to produce a uniform spray over the surface or surfaces under test. The various vertical surfaces of an **outdoor enclosure** may be tested separately or collectively, provided that a uniform spray is applied.*

*The top surface of the **outdoor enclosure** shall be tested by applying a uniform spray from nozzles located at proper heights (see the focal point in Figure Y.2), if*

– *there are openings in the top surface; or*
– *from an examination of the construction, it is determined that run-off from the top surface could cause water ingress at a vertical surface which would not be detected by the test of the vertical surface.*

*If there are openings in a vertical surface, located less than 250 mm above ground level, such that water ingress from rain bouncing upwards from the ground surface might occur, a test shall be performed, spraying water on the ground surface in front of such openings, over such distance necessary to cause the deflected spray to reach the **outdoor enclosure**. This test is not carried out if, from an examination of the construction, it is determined that the test of the vertical surface adequately assures compliance.*

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Dimensions in millimetres, unless indicated otherwise

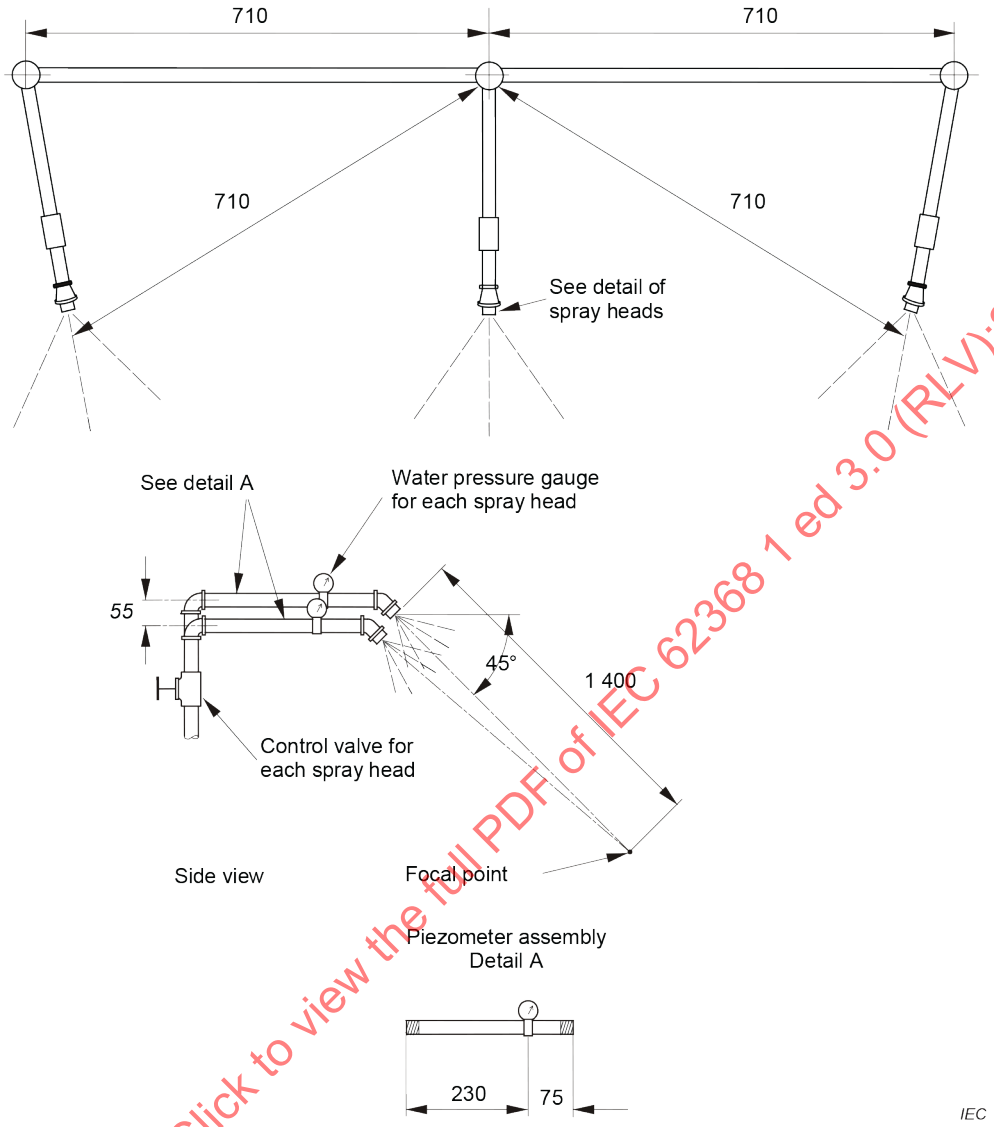


Figure Y.2 – Water-spray test spray-head piping

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Dimensions in millimetres, unless indicated otherwise

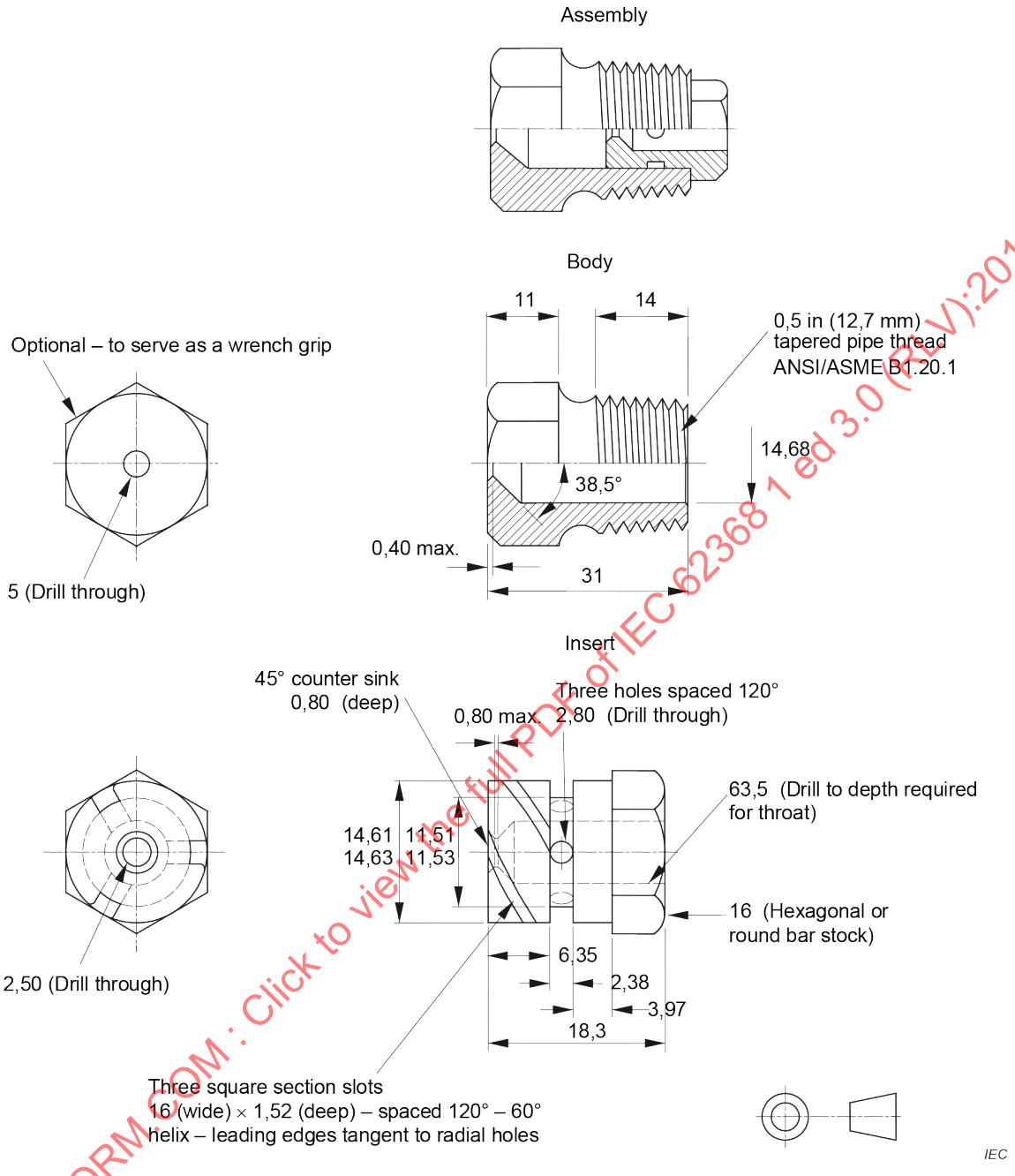


Figure Y.3 – Water-spray test spray head

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Y.5.4 Protection from plants and vermin

If entry by plants and vermin is a consideration, **outdoor equipment** shall have adequate protection.

NOTE For protection against plants and vermin, see IEC 61969-3.

Compliance is checked by inspection.

Y.5.5 Protection from excessive dust

Y.5.5.1 General

Unless the **clearances** and **creepage distances** comply with the requirements as given in 5.4 for **pollution degree** 3, **outdoor equipment** shall have adequate protection against the ingress of the dust through the use of an appropriately rated IP5X or IP6X **enclosure**, or equivalent (for example, an equivalent NEMA rated **enclosure**).

NOTE Dust from road vehicles is not considered to be conductive.

Compliance is checked by inspection and, if necessary, by the relevant tests of IEC 60529 or alternatively, by the tests of Y.5.5.2 or Y.5.5.3 using the acceptance conditions of IEC 60529:1989, Clause 5, 13.5.2 and 13.6.2.

*If the **enclosure** complies with the dust chamber test for IP5X or IP6X, the examination for spherical objects mentioned in the note of 13.3 of IEC 60529:1989 can be considered done and complied with.*

Y.5.5.2 IP5X equipment

Dust-proof equipment (first characteristic IP numeral 5) shall be tested in a dust chamber similar to that shown in Figure 2 of IEC 60529:1989, in which talcum powder is maintained in suspension by an air current. The chamber shall contain 2 kg of powder for every cubic meter of its volume. The talcum powder used shall be able to pass through a square-meshed sieve whose nominal wire diameter is 50 μm and whose nominal free distance between wires is 75 μm. It shall not have been used for more than 20 tests.

The test shall proceed as follows:

*a) The equipment is suspended outside the dust chamber and operated at **rated voltage** until operating temperature is achieved.*

b) The equipment, whilst still operating, is placed with the minimum disturbance in the dust chamber.

c) The door of the dust chamber is closed.

d) The fan/blower causing the talcum powder to be in suspension is switched on.

e) After 1 min, the equipment is disconnected and allowed to cool for 3 h whilst the talcum powder remains in suspension.

NOTE The 1 min interval between switching on the fan/blower and switching off the equipment is to ensure that the talcum powder is properly in suspension around the equipment during initial cooling, which is most important with smaller equipment. The equipment is operated initially as in item a) to ensure the test chamber is not overheated.

Y.5.5.3 IP6X equipment

Dust-tight equipment (first characteristic IP numeral 6) shall be tested in accordance with Y.5.5.2.

Y.6 Mechanical strength of enclosures

Y.6.1 General

Outdoor enclosures and **outdoor equipment** shall have adequate mechanical strength and shall provide protection against access to class 3 energy sources within the equipment throughout the intended ambient operating range.

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Compliance is checked by the inspection of the construction and available data and, if necessary, by the test of Y.6.2. After the test, the level of protection shall remain in accordance with Y.5.5.1,

Y.6.2 Impact test

*For equipment with an **outdoor enclosure** made of polymeric material, the **outdoor enclosure** of the equipment should be subjected to the low temperature conditioning before the impact test. Subsequently **outdoor enclosures** and **outdoor equipment** are to be subjected to the impact test of Clause T.6. Where the **outdoor enclosure** is made of polymeric material, the test is carried out at an ambient temperature equal to the minimum ambient temperature specified by the manufacturer or –33 °C if no minimum ambient temperature is specified, for 24 h. The test can be applied to a portion of the **enclosure** representing the largest unreinforced area, supported in its normal position.*

The impacts are applied to doors, covers, seams and the like which could affect the ingress of dust and moisture. The test is performed whether or not failure would give direct access to class 3 energy sources. The impacts are applied within 2 min of removal from the climatic chamber.

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SOMMAIRE

AVANT-PROPOS 393
INTRODUCTION 396
0 Principes de la présente norme relative à la sécurité des produits 396
0.1 Objectif 396
0.2 Personnes 396
0.2.1 Généralités 396
0.2.2 Personne ordinaire 396
0.2.3 Personne avertie 396
0.2.4 Personne qualifiée 396
0.3 Modèle pour les douleurs et les blessures 397
0.4 Sources d'énergie 398
0.5 Protections 399
0.5.1 Généralités 399
0.5.2 Protection de l'équipement 400
0.5.3 Protection de l'installation 400
0.5.4 Protection individuelle 400
0.5.5 Protections de comportement 400
0.5.6 Protection dans des conditions d'entretien par une personne ordinaire ou avertie 401
0.5.7 Protections dans des conditions d'entretien par une personne qualifiée 401
0.5.8 Exemples de caractéristiques de protection 402
0.6 Douleurs ou blessures dues à l'électricité (choc électrique) 403
0.6.1 Modèles pour des douleurs ou blessures dues à l'électricité 403
0.6.2 Modèles pour se protéger contre les douleurs ou blessures dues à l'électricité 403
0.7 Incendie d'origine électrique 404
0.7.1 Modèles pour les incendies d'origine électrique 404
0.7.2 Modèles pour se protéger contre les incendies d'origine électrique 405
0.8 Blessures dues à des substances dangereuses 406
0.9 Blessures dues à un choc mécanique 406
0.10 Blessures dues à la chaleur (brûlure de la peau) 407
0.10.1 Modèles pour les blessures dues à la chaleur 407
0.10.2 Modèles pour se protéger contre les douleurs ou blessures dues à la chaleur 408
0.11 Blessures dues à des rayonnements 409
1 Domaine d'application 410
2 Références normatives 412
3 Termes, définitions et abréviations 419
3.1 Abréviations des sources d'énergie 419
3.2 Autres abréviations 419
3.3 Termes et définitions 420
3.3.1 Termes relatifs aux circuits 424
3.3.2 Termes relatifs à l'enveloppe 424
3.3.3 Termes relatifs à l'équipement 425
3.3.4 Termes relatifs à l'inflammabilité 426
3.3.5 Isolation électrique 428

IECNORM.COM : Click to view the full PDF of IEC 62368-1 ed 3.0 (RLV):2018

3.3.6 Divers 428
3.3.7 Conditions de fonctionnement et de défaut 430
3.3.8 Personnes 432
3.3.9 Sources potentielles d'incendie 432
3.3.10 Caractéristiques assignées 433
3.3.11 Protections 433
3.3.12 Distances 435
3.3.13 Températures et commandes 435
3.3.14 Tensions et courants 436
3.3.15 Classes d'équipement par rapport à la protection contre les chocs électriques 437
3.3.16 Termes relatifs aux éléments chimiques 437
3.3.17 Batteries 438
3.3.18 Termes relatifs aux fils de bobinage totalement isolés 439
3.3.19 exposition au bruit 439
4 Exigences générales 440
4.1 Généralités 440
4.1.1 Application des exigences d'acceptation des matériaux, composants et sous-ensembles 440
4.1.2 Utilisation de composants 440
4.1.3 Conception et construction de l'équipement 441
4.1.4 Installation de l'équipement 441
4.1.5 Aspects relatifs aux constructions et composants non traités spécifiquement 442
4.1.6 Orientation lors du transport et de l'utilisation 442
4.1.7 Choix de critères 442
4.1.8 Liquides et composants remplis de liquide (LFC) 442
4.1.9 Instruments de mesure électriques 442
4.1.10 Mesures de température 443
4.1.11 Conditions stables 443
4.1.12 Hiérarchie des protections 443
4.1.13 Exemples mentionnés dans le présent document 443
4.1.14 Essais sur des parties ou des échantillons autres que sur le produit fini 443
4.1.15 Marquages et instructions 443
4.2 Classification des sources d'énergie 444
4.2.1 Source d'énergie de classe 1 444
4.2.2 Source d'énergie de classe 2 444
4.2.3 Source d'énergie de classe 3 444
4.2.4 Classification des sources d'énergie selon un mode déclaratif 444
4.3 Protection contre les sources d'énergie 444
4.3.1 Généralités 444
4.3.2 Protections destinées à protéger une personne ordinaire 445
4.3.3 Protections d'une personne avertie 446
4.3.4 Protection d'une personne qualifiée 447
4.3.5 Protections dans une zone à accès limité 448
4.4 Protections 448
4.4.1 Matériaux ou composants équivalents 448
4.4.2 Composition d'une protection 449
4.4.3 Robustesse de la protection 449

IECNORM.COM : Click to view the full PDF of IEC 62368-1:2018 ed 3.0 (RLV):2018

4.4.4 Déplacement d'une protection par un isolant liquide 451
4.4.5 Verrouillages de sécurité 451
4.5 Explosion 452
4.5.1 Généralités 452
4.5.2 Exigences 452
4.6 Fixation des conducteurs 452
4.6.1 Exigences 452
4.6.2 Critères de conformité 453
4.7 Équipement pour insertion directe dans des socles d'alimentation 453
4.7.1 Généralités 453
4.7.2 Exigences 453
4.7.3 Critères de conformité 453
4.8 Équipement contenant des piles ou accumulateurs boutons 453
4.8.1 Généralités 453
4.8.2 Protection par instructions 454
4.8.3 Construction 454
4.8.4 Essais 454
4.8.5 Critères de conformité 455
4.9 Probabilité d'incendie ou de choc dû à l'entrée d'objets conducteurs 456
4.10 Exigences sur les composants 456
4.10.1 Dispositif de déconnexion 456
4.10.2 Interrupteurs et relais 456
5 Blessure due à un choc électrique 457
5.1 Généralités 457
5.2 Classification et limites des sources d'énergie électrique 457
5.2.1 Classifications des sources d'énergie électrique 457
5.2.2 Limites des sources d'énergie électrique ES1 et ES2 457
5.3 Protection contre les sources d'énergie électrique 464
5.3.1 Généralités 464
5.3.2 Accessibilité des sources d'énergie électrique et des protections 464
5.4 Matériaux isolants et exigences 467
5.4.1 Généralités 467
5.4.2 Distances dans l'air 473
5.4.3 Lignes de fuite 485
5.4.4 Isolation solide 488
5.4.5 Isolation des dispositifs de connexion extérieure d'antenne 498
5.4.6 Isolation du câblage interne en tant que partie d'une protection supplémentaire 499
5.4.7 Essais pour les composants à semi-conducteurs et pour les joints scellés 499
5.4.8 Épreuve hygroscopique 500
5.4.9 Essai de rigidité diélectrique 500
5.4.10 Protections contre les tensions transitoires des circuits externes 504
5.4.11 Séparation entre des circuits externes et la terre 506
5.4.12 Isolant liquide 507
5.5 Composants comme protections 508
5.5.1 Généralités 508
5.5.2 Condensateurs et cellules RC 508
5.5.3 Transformateurs 510

IECNORM.COM : Click to view the full PDF of IEC 62368-1:ed 3.0 (RLV):2018

5.5.4 Optocoupleurs 510
5.5.5 Relais 510
5.5.6 Résistances 510
5.5.7 Dispositifs de protection contre les surtensions (SPD) 511
5.5.8 Isolation entre le réseau d'alimentation et un circuit externe composé d'un câble coaxial 512
5.5.9 Protection des socles de prise de courant d'un matériel pour installation extérieure 512
5.6 Conducteur de protection 512
5.6.1 Généralités 512
5.6.2 Exigences relatives aux conducteurs de protection 513
5.6.3 Exigences relatives aux conducteurs de mise à la terre de protection 513
5.6.4 Exigences relatives aux conducteurs de liaison de protection 514
5.6.5 Bornes des conducteurs de protection 517
5.6.6 Résistance du système de liaison de protection 518
5.6.7 Connexion fiable d'un conducteur de mise à la terre de protection 520
5.6.8 Mise à la terre pour des raisons fonctionnelles 520
5.7 Tension de contact présumée, courant de contact et courant du conducteur de protection 521
5.7.1 Généralités 521
5.7.2 Dispositifs de mesure et réseaux 521
5.7.3 Montage de l'équipement, connexions d'alimentation et connexions de mise à la terre 521
5.7.4 Parties accessibles non mises à la terre 522
5.7.5 Parties conductrices accessibles mises à la terre 522
5.7.6 Exigences lorsque le courant de contact dépasse les limites de ES2 522
5.7.7 Tension de contact présumée et courant de contact associés aux circuits externes 523
5.7.8 Somme des courants de contact provenant de circuits externes 525
5.8 Protection contre le retour de tension en entrée dans les alimentations de secours par batterie 526
6 Incendie d'origine électrique 527
6.1 Généralités 527
6.2 Classification des sources de puissance (PS) et des sources potentielles d'incendie (PIS) 527
6.2.1 Généralités 527
6.2.2 Classifications du circuit de source de puissance 528
6.2.3 Classification des sources potentielles d'incendie 531
6.3 Protections contre les incendies dans les conditions normales de fonctionnement et les conditions anormales de fonctionnement 532
6.3.1 Exigences 532
6.3.2 Critères de conformité 533
6.4 Protections contre les incendies dans les conditions de premier défaut 533
6.4.1 Généralités 533
6.4.2 Réduction de la probabilité d'inflammation en conditions de premier défaut dans les circuits PS1 533
6.4.3 Réduction de la probabilité d'inflammation en conditions de premier défaut dans les circuits PS2 et PS3 534
6.4.4 Contrôle de la propagation du feu dans les circuits PS1 535
6.4.5 Contrôle de la propagation du feu dans les circuits PS2 535
6.4.6 Contrôle de la propagation du feu dans un circuit PS3 536

IECNORM.COM : Click to view the full PDF of IEC 62368-1 ed 3.0 (RLV):2018

6.4.7 Séparation des matériaux combustibles d'une PIS 537
6.4.8 Enveloppes ignifuges (contre le feu) et barrières contre le feu 540
6.4.9 Inflammabilité d'un isolant liquide 546
6.5 Câblage interne et externe 546
6.5.1 Exigences générales 546
6.5.2 Exigences relatives à l'interconnexion avec le câblage du bâtiment 547
6.5.3 Câblage interne des socles d'alimentation 547
6.6 Protections contre les incendies dus à la connexion des équipements supplémentaires 547
7 Blessures dues à des substances dangereuses 548
7.1 Généralités 548
7.2 Réduction de l'exposition aux substances dangereuses 548
7.3 Exposition à l'ozone 548
7.4 Utilisation d'un équipement de protection individuelle (EPI) 548
7.5 Utilisation de protections par instructions et des instructions d'utilisation 548
7.6 Batteries et leurs circuits de protection 549
8 Blessures dues à un choc mécanique 549
8.1 Généralités 549
8.2 Classification des sources d'énergie mécanique 549
8.2.1 Classification générale 549
8.2.2 MS1 552
8.2.3 MS2 552
8.2.4 MS3 552
8.3 Protection contre les sources d'énergie mécanique 552
8.4 Protections contre les parties avec arêtes vives et angles vifs 552
8.4.1 Exigences 552
8.4.2 Critères de conformité 553
8.5 Protections contre les parties mobiles 553
8.5.1 Exigences 553
8.5.2 Exigences relatives à la protection par instructions 554
8.5.3 Critères de conformité 554
8.5.4 Catégories spéciales d'équipements comprenant des parties mobiles 555
8.5.5 Lampes à haute pression 560
8.6 Stabilité de l'équipement 561
8.6.1 Exigences 561
8.6.2 Stabilité statique 563
8.6.3 Stabilité en mouvement 564
8.6.4 Essai de lame de verre 565
8.6.5 Essai de force horizontale et critères de conformité 565
8.7 Équipements montés au mur, au plafond ou sur une autre structure 565
8.7.1 Exigences 565
8.7.2 Méthodes d'essai 566
8.7.3 Critères de conformité 567
8.8 Rigidité des poignées 567
8.8.1 Généralités 567
8.8.2 Méthode d'essai 567
8.9 Exigences relatives aux attaches des roues ou des roulettes 568
8.9.1 Généralités 568
8.9.2 Méthode d'essai 568

IECNORM.COM : Click to view the full PDF of IEC 62368-1:2018 Ed 3.0 (RLV):2018

8.10 Chariots, supports et éléments de support semblables 568
8.10.1 Généralités 568
8.10.2 Marquage et instructions 569
8.10.3 Essai de chargement de chariot, de support ou élément de support et critères de conformité 569
8.10.4 Essai de choc sur chariot, support ou élément de support 570
8.10.5 Stabilité mécanique 570
8.10.6 Stabilité en température des matériaux thermoplastiques 570
8.11 Dispositifs de montage des équipements montés sur rail de glissière (SRME – *slide-rail mounted equipment*)) 571
8.11.1 Généralités 571
8.11.2 Exigences 571
8.11.3 Essai de résistance mécanique 572
8.11.4 Critères de conformité 573
8.12 Antennes télescopiques ou fouets 573
9 Brûlure thermique 573
9.1 Généralités 573
9.2 Classifications des sources d'énergie thermique 573
9.2.1 TS1 573
9.2.2 TS2 573
9.2.3 TS3 574
9.3 Limites de température de contact 574
9.3.1 Exigences 574
9.3.2 Méthode d'essai et critères de conformité 574
9.4 Protection contre les sources d'énergie thermique 576
9.5 Exigences pour les protections 576
9.5.1 Protection de l'équipement 576
9.5.2 Protection par instructions 576
9.6 Exigences relatives aux émetteurs de puissance sans fil 577
9.6.1 Généralités 577
9.6.2 Spécification des objets étrangers 577
9.6.3 Méthode d'essai et critères de conformité 579
10 Rayonnements 580
10.1 Généralités 580
10.2 Classifications des sources d'énergie de rayonnement 580
10.2.1 Classification générale 580
10.2.2 RS1 581
10.2.3 RS2 582
10.2.4 RS3 582
10.3 Protections contre le rayonnement laser 582
10.4 Protection contre les rayonnements optiques des lampes et systèmes de lampes (y compris à LED) 583
10.4.1 Exigences générales 583
10.4.2 Exigences relatives aux enveloppes 584
10.4.3 Protection par instructions 584
10.4.4 Critères de conformité 586
10.5 Protections contre les rayons X 586
10.5.1 Exigences 586
10.5.2 Critères de conformité 586

IECNORM.COM : Click to view the full PDF of IEC 62368-1 ed 3.0 (RLV):2018

10.5.3 Méthode d'essai 586
10.6 Protections contre les sources d'énergie acoustique 587
10.6.1 Généralités 587
10.6.2 Classification 588
10.6.3 Exigences relatives aux systèmes basés sur la dose 589
10.6.4 Méthodes de mesure 590
10.6.5 Protection des personnes 590
10.6.6 Exigences relatives aux dispositifs d'écoute (casques, écouteurs, etc.) 591
Annexe A (informative) Exemples d'équipements relevant du domaine d'application du présent document 592
Annexe B (normative) Essais en conditions normales de fonctionnement, essais en conditions anormales de fonctionnement et essais en condition de premier défaut 593
B.1 Généralités 593
B.1.1 Applicabilité de l'essai 593
B.1.2 Type d'essai 593
B.1.3 Échantillons pour essai 593
B.1.4 Conformité par examen des données pertinentes 593
B.1.5 Conditions de mesure de la température 593
B.2 Conditions normales de fonctionnement 594
B.2.1 Généralités 594
B.2.2 Fréquence d'alimentation 594
B.2.3 Tension d'alimentation 594
B.2.4 Tensions normales de fonctionnement 595
B.2.5 Essai à l'entrée du circuit 595
B.2.6 Conditions de mesure de la température de fonctionnement 596
B.2.7 Charge et décharge de la batterie dans les conditions normales de fonctionnement 597
B.3 Simulation de conditions anormales de fonctionnement 597
B.3.1 Généralités 597
B.3.2 Couverture des ouvertures de ventilation 597
B.3.3 Essai de polarité sur les réseaux d'alimentation en courant continu 598
B.3.4 Réglage du sélecteur de tension 598
B.3.5 Charge maximale aux bornes de sortie 598
B.3.6 Polarité de batterie inversée 598
B.3.7 Conditions anormales de fonctionnement des amplificateurs audio 598
B.3.8 Critères de conformité pendant et après des conditions anormales de fonctionnement 599
B.4 Simulation des conditions de premier défaut 599
B.4.1 Généralités 599
B.4.2 Dispositif de contrôle de la température 599
B.4.3 Essais moteur 600
B.4.4 Isolation fonctionnelle 600
B.4.5 Court-circuit et interruption des électrodes dans les tubes et les semi-conducteurs 600
B.4.6 Court-circuit ou déconnexion des composants passifs 600
B.4.7 Fonctionnement en continu des composants 601
B.4.8 Critères de conformité pendant et après des conditions de premier défaut 601
B.4.9 Charge et décharge de la batterie dans les conditions de premier défaut 602
Annexe C (normative) Rayonnement ultraviolet (UV) 603

IECNORM.COM : Click to view the full PDF of IEC 62368-1:2018 ed 3.0 (RLV)

C.1 Protection des matériaux des équipements contre le rayonnement ultraviolet 603
C.1.1 Généralités 603
C.1.2 Exigences 603
C.1.3 Méthode d'essai et critères de conformité 603
C.2 Essai de conditionnement à la lumière ultraviolette 604
C.2.1 Appareillage d'essai 604
C.2.2 Montage des échantillons pour essai 604
C.2.3 Essai d'exposition à la lumière sous une lampe à arc au carbone 604
C.2.4 Essai d'exposition à la lumière sous une lampe à arc au xénon 604
Annexe D (normative) Générateurs d'essai 605
D.1 Générateurs d'impulsions d'essai 605
D.2 Générateur d'essai de l'interface d'antenne 606
D.3 Générateur d'impulsions électronique 607
Annexe E (normative) Conditions d'essai pour les équipements comprenant des amplificateurs audio 608
E.1 Classification des sources d'énergie électrique pour les signaux audio 608
E.2 Conditions normales de fonctionnement des amplificateurs audio 608
E.3 Conditions anormales de fonctionnement des amplificateurs audio 610
Annexe F (normative) Marquages des équipements, instructions et protections par instructions 611
F.1 Généralités 611
F.2 Symboles littéraux et symboles graphiques 611
F.2.1 Symboles littéraux 611
F.2.2 Symboles graphiques 611
F.2.3 Critères de conformité 611
F.3 Marquages des équipements 611
F.3.1 Emplacements du marquage d'équipement 611
F.3.2 Marquages d'identification des équipements 612
F.3.3 Marquages de caractéristiques assignées des équipements 612
F.3.4 Dispositif de réglage de la tension 615
F.3.5 Marquages des bornes et dispositifs de fonctionnement 615
F.3.6 Marquages d'équipements liés à leur classification 616
F.3.7 Marquage de l'indice IP de l'équipement 617
F.3.8 Marquage de la sortie de l'alimentation électrique externe 617
F.3.9 Durabilité, lisibilité et permanence des marquages 617
F.3.10 Essai déterminant la permanence des marquages 618
F.4 Instructions 618
F.5 Protections par instructions 619
Annexe G (normative) Composants 622
G.1 Interrupteurs 622
G.1.1 Généralités 622
G.1.2 Exigences 622
G.1.3 Méthode d'essai et critères de conformité 623
G.2 Relais 623
G.2.1 Exigences 623
G.2.2 Essai de surcharge 624
G.2.3 Relais contrôlant les socles de raccordement d'autres équipements 624
G.2.4 Méthode d'essai et critères de conformité 624
G.3 Dispositifs de protection 624

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G.3.1 Disjoncteurs thermiques 624
G.3.2 Coupe-circuit thermiques 626
G.3.3 Thermistances CTP 627
G.3.4 Dispositifs de protection contre les surintensités 627
G.3.5 Dispositifs de protection non mentionnés de G.3.1 à G.3.4 627
G.4 Connecteurs 628
G.4.1 Exigences relatives aux distances dans l'air et aux lignes de fuite 628
G.4.2 Connecteurs du réseau d'alimentation 628
G.4.3 Connecteurs autres que les connecteurs de réseau d'alimentation 628
G.5 Composants bobinés 628
G.5.1 Isolation des fils dans des composants bobinés 628
G.5.2 Essai d'endurance 629
G.5.3 Transformateurs 631
G.5.4 Moteurs 640
G.6 Isolation des fils 645
G.6.1 Généralités 645
G.6.2 Isolation de fil de bobinage en émail 646
G.7 Câbles d'alimentation réseau 646
G.7.1 Généralités 646
G.7.2 Section 647
G.7.3 Dispositifs d'arrêt de traction et de relâchement des contraintes pour les câbles d'alimentation fixés à demeure 649
G.7.4 Point d'entrée du câble/cordon 650
G.7.5 Protection des câbles fixés à demeure contre les courbures 650
G.7.6 Espace pour l'installation des câbles d'alimentation 651
G.8 Varistances 653
G.8.1 Généralités 653
G.8.2 Protections contre l'incendie 654
G.9 Limiteurs de courant sur circuit intégré 655
G.9.1 Exigences 655
G.9.2 Programme d'essai 656
G.9.3 Critères de conformité 657
G.10 Résistances 657
G.10.1 Généralités 657
G.10.2 Conditionnement 657
G.10.3 Essai de résistance 657
G.10.4 Essai de tension de choc 657
G.10.5 Essai de choc 658
G.10.6 Essai de surcharge 658
G.11 Condensateurs et cellules RC 658
G.11.1 Généralités 658
G.11.2 Conditionnement des condensateurs et des cellules RC 658
G.11.3 Règles à appliquer pour sélectionner des condensateurs 658
G.12 Optocoupleurs 659
G.13 Cartes imprimées 659
G.13.1 Généralités 659
G.13.2 Cartes imprimées sans revêtement 660
G.13.3 Cartes imprimées avec revêtement 660
G.13.4 Isolation entre des conducteurs situés sur la même surface interne 661

IECNORM.COM : Click to view the full PDF of IEC 62368-1 ed 3.0 (RLV):2018

G.13.5 Isolation entre des conducteurs se trouvant sur des surfaces différentes 662
G.13.6 Essais sur des cartes imprimées avec revêtement 662
G.14 Revêtements sur les bornes des composants 664
G.14.1 Exigences 664
G.14.2 Méthode d'essai et critères de conformité 664
G.15 Composants remplis de liquide sous pression (LFC) 665
G.15.1 Exigences 665
G.15.2 Méthodes d'essai et critères de conformité 665
G.15.3 Critères de conformité 666
G.16 IC qui inclut une fonction de décharge de condensateur (ICX) 666
G.16.1 Exigences 666
G.16.2 Essais 667
G.16.3 Critères de conformité 667
Annexe H (normative) Critères applicables aux signaux de sonnerie de téléphone 668
H.1 Généralités 668
H.2 Méthode A 668
H.3 Méthode B 671
H.3.1 Signal de sonnerie 671
H.3.2 Dispositif de déclenchement et tension de surveillance 671
Annexe I (informative) Catégories de surtension (voir l'IEC 60364-4-44) 673
Annexe J (normative) Fils de bobinage isolés destinés à une utilisation sans isolation intercouche 674
J.1 Généralités 674
J.2 Essais de type 674
J.2.1 Généralités 674
J.2.2 Rigidité diélectrique 674
J.2.3 Flexibilité et adhérence 675
J.2.4 Choc thermique 675
J.2.5 Rétention de la rigidité diélectrique après courbure 676
J.3 Essai en cours de production 676
J.3.1 Généralités 676
J.3.2 Essai d'étincelles 677
J.3.3 Essai sur prélèvement 677
Annexe K (normative) Verrouillages de sécurité 678
K.1 Généralités 678
K.1.1 Exigences générales 678
K.1.2 Méthode d'essai et critères de conformité 678
K.2 Composants du mécanisme de protection du verrouillage de sécurité 679
K.3 Modification par inadvertance du mode de fonctionnement 679
K.4 Réenclenchement forcé de la protection du verrouillage 679
K.5 Fonctionnement sans défaillance 679
K.5.1 Exigence 679
K.5.2 Méthode d'essai et critères de conformité 679
K.6 Verrouillages de sécurité à fonctionnement mécanique 680
K.6.1 Exigence d'endurance 680
K.6.2 Méthode d'essai et critères de conformité 680
K.7 Isolation des circuits de verrouillage 680
K.7.1 Distances de séparation pour les distances d'ouverture des contacts et les éléments des circuits de verrouillage 680

IECNORM.COM : Click to view the full PDF of IEC 62368-1:2018 ed 3.0 (RLV)

K.7.2 Essai de surcharge 681
K.7.3 Essai d'endurance 681
K.7.4 Essai de rigidité diélectrique 681
Annexe L (normative) Dispositifs de déconnexion 682
L.1 Exigences générales 682
L.2 Équipement relié en permanence 682
L.3 Parties restant alimentées 682
L.4 Équipement monophasé 683
L.5 Équipement triphasé 683
L.6 Interrupteurs servant de dispositifs de déconnexion 683
L.7 Fiches servant de dispositifs de déconnexion 683
L.8 Sources d'alimentation multiples 683
L.9 Critères de conformité 684
Annexe M (normative) Équipements contenant des piles ou batteries et leurs circuits de protection 685
M.1 Exigences générales 685
M.2 Sécurité des piles et batteries et leurs éléments 685
M.2.1 Exigences 685
M.2.2 Critères de conformité 685
M.3 Circuits de protection des batteries fournis dans l'équipement 685
M.3.1 Exigences 685
M.3.2 Méthode d'essai 686
M.3.3 Critères de conformité 687
M.4 Protections supplémentaires pour les équipements contenant des accumulateurs au lithium portables 687
M.4.1 Généralités 687
M.4.2 Protections de charge 687
M.4.3 Enveloppe ignifuge (contre le feu) 689
M.4.4 Essai de chute de l'équipement contenant un accumulateur au lithium 689
M.5 Risque de brûlure provoqué par un court-circuit pendant le transport 690
M.5.1 Exigences 690
M.5.2 Méthode d'essai et critères de conformité 690
M.6 Protections contre les courts-circuits 690
M.6.1 Exigences 690
M.6.2 Critères de conformité 691
M.7 Risque d'explosion des batteries d'accumulateurs au plomb-acide et au nickel-cadmium 691
M.7.1 Ventilation empêchant la concentration en gaz explosif 691
M.7.2 Méthode d'essai et critères de conformité 692
M.7.3 Essais de ventilation 695
M.7.4 Exigences en matière de marquage 696
M.8 Protection contre une inflammation interne à partir des sources d'étincelles externes des batteries à électrolyte aqueux 696
M.8.1 Généralités 696
M.8.2 Méthode d'essai 697
M.9 Prévention contre l'écoulement d'électrolyte 699
M.9.1 Prévention contre l'écoulement d'électrolyte 699
M.9.2 Réceptacle pour la prévention contre l'écoulement d'électrolyte 699
M.10 Instructions destinées à éviter tout mauvais usage raisonnablement prévisible 700

IECNORM.COM : Click to view the full PDF of IEC 62368-1:2018 ed 3.0 (RLV):2018

Annexe N (normative) Potentiels électrochimiques (V) 701
Annexe O (normative) Mesure des lignes de fuite et des distances dans l'air 703
Annexe P (normative) Protections contre les objets conducteurs 710
P.1 Généralités 710
P.2 Protections contre l'entrée ou les conséquences de l'entrée de corps étrangers 710
P.2.1 Généralités 710
P.2.2 Protections contre l'entrée de corps étrangers 710
P.2.3 Protections contre les conséquences de l'entrée d'un objet étranger 711
P.3 Protections contre l'écoulement de liquides internes 713
P.3.1 Généralités 713
P.3.2 Détermination des conséquences d'un écoulement 713
P.3.3 Protections contre l'écoulement 714
P.3.4 Critères de conformité 714
P.4 Revêtements métallisés et pièces de fixation adhésives 714
P.4.1 Généralités 714
P.4.2 Essais 715
Annexe Q (normative) Circuits destinés à l'interconnexion avec le câblage du bâtiment 717
Q.1 Source à puissance limitée 717
Q.1.1 Exigences 717
Q.1.2 Méthode d'essai et critères de conformité 717
Q.2 Essai des circuits externes – câble conducteur à paires 718
Annexe R (normative) Essai de court-circuit limité 720
R.1 Généralités 720
R.2 Montage d'essai 720
R.3 Méthode d'essai 720
R.4 Critères de conformité 721
Annexe S (normative) Essais de résistance à la chaleur et au feu 722
S.1 Essai d'inflammabilité de l'enveloppe ignifuge et des matériaux de barrières ignifuges des équipements où la puissance en régime constant ne dépasse pas 4 000 W 722
S.2 Essai d'inflammabilité pour vérifier l'intégrité de l'enveloppe ignifuge et de la barrière ignifuge 723
S.3 Essais d'inflammabilité du fond d'une enveloppe ignifuge (contre le feu) 724
S.3.1 Montage des échantillons 724
S.3.2 Méthode d'essai et critères de conformité 725
S.4 Classe d'inflammabilité des matériaux 725
S.5 Essai d'inflammabilité des matériaux d'enveloppes ignifuges (contre le feu) de l'équipement avec une puissance en régime constant qui dépasse 4 000 W 726
Annexe T (normative) Essais de résistance mécanique 728
T.1 Généralités 728
T.2 Essai de force constante, 10 N 728
T.3 Essai de force constante, 30 N 728
T.4 Essai de force constante, 100 N 728
T.5 Essai de force constante, 250 N 728
T.6 Essai de choc sur l'enveloppe 728
T.7 Essai de chute 729
T.8 Essai de relâchement des contraintes 729

IECNORM.COM : Click to view the full PDF of IEC 62368-1 ed 3.0 (RLV):2018

T.9 Essais de choc sur le verre 730
T.10 Essai de fragmentation du verre 730
T.11 Essai pour les antennes télescopiques ou les antennes fouets 731
Annexe U (normative) Résistance mécanique des tubes cathodiques et protection contre les effets d'implosion 732
U.1 Généralités 732
U.2 Méthode d'essai et critères de conformité pour les tubes cathodiques non intrinsèquement protégés 733
U.3 Écran de protection 733
Annexe V (normative) Détermination des parties accessibles 734
V.1 Parties accessibles de l'équipement 734
V.1.1 Généralités 734
V.1.2 Méthode d'essai 1 – Surfaces et ouvertures soumises à l'essai avec sondes d'essai articulées 734
V.1.3 Méthode d'essai 2 – Ouvertures soumises à l'essai avec sondes d'essai droites et inarticulées 735
V.1.4 Méthode d'essai 3 – Fiches, jacks, connecteurs 738
V.1.5 Méthode d'essai 4 – Ouvertures fentes 738
V.1.6 Méthode d'essai 5 – Dispositifs de connexion extérieure conçus pour être utilisés par une personne ordinaire 739
V.2 Critère de la partie accessible 740
Annexe W (informative) Comparaison des termes présentés dans le présent document 741
W.1 Généralités 741
W.2 Comparaison des termes 741
Annexe X (normative) Autre méthode de détermination des distances dans l'air pour l'isolation dans les circuits connectés à un réseau d'alimentation en courant alternatif ne dépassant pas 420 V crête (300 V en valeur efficace) 759
Annexe Y (normative) Exigences de construction des enveloppes extérieures 761
Y.1 Généralités 761
Y.2 Résistance aux rayonnements UV 761
Y.3 Résistance à la corrosion 761
Y.3.1 Généralités 761
Y.3.2 Appareillage d'essai 762
Y.3.3 Atmosphère contenant du dioxyde de soufre saturée d'eau 762
Y.3.4 Procédure d'essai 762
Y.3.5 Critères de conformité 763
Y.4 Joints d'étanchéité 763
Y.4.1 Généralités 763
Y.4.2 Essais de joint d'étanchéité 763
Y.4.3 Essais de résistance à la traction et d'allongement 763
Y.4.4 Essai de compression 764
Y.4.5 Résistance à l'huile 765
Y.4.6 Moyens de fixation 765
Y.5 Protection des équipements à l'intérieur d'une enveloppe extérieure 766
Y.5.1 Généralités 766
Y.5.2 Protection contre l'humidité 766
Y.5.3 Essai d'arrosage à l'eau 767
Y.5.4 Protection contre les végétaux et les animaux nuisibles 769
Y.5.5 Protection contre l'excès de poussière 770
Y.6 Résistance mécanique des enveloppes 770

IECNORM.COM : Click to view the full PDF of IEC 62368-1 ed 3.0 (RLV):2018

Y.6.1 Généralités 770
Y.6.2 Essai de choc 771
Bibliographie 772

Figure 1 – Modèle en trois blocs pour les douleurs et les blessures 397
Figure 2 – Modèle en trois blocs pour la sécurité 399
Figure 3 – Schéma et modèle pour les douleurs ou les blessures dues à l'électricié 403
Figure 4 – Modèle pour se protéger contre les douleurs ou blessures dues à l'électricité 404
Figure 5 – Modèles pour les incendies d'origine électrique 405
Figure 6 – Modèles pour se protéger contre les incendies 405
Figure 7 – Schéma et modèle pour les blessures dues à la chaleur 408
Figure 8 – Modèle pour se protéger contre les blessures dues à la chaleur 408
Figure 9 – Modèle pour protéger une personne ordinaire contre une source d'énergie de classe 1 445
Figure 10 – Modèle pour protéger une personne ordinaire contre une source d'énergie de classe 2 445
Figure 11 – Modèle pour protéger une personne ordinaire contre une source d'énergie de classe 2 dans les conditions d'entretien par une personne ordinaire 446
Figure 12 – Modèle pour protéger une personne ordinaire contre une source d'énergie de classe 3 446
Figure 13 – Modèle pour protéger une personne avertie contre une source d'énergie de classe 1 446
Figure 14 – Modèle pour protéger une personne avertie contre une source d'énergie de classe 2 447
Figure 15 – Modèle pour protéger une personne avertie contre une source d'énergie de classe 3 447
Figure 16 – Modèle pour protéger une personne qualifiée contre une source d'énergie de classe 1 447
Figure 17 – Modèle pour protéger une personne qualifiée contre une source d'énergie de classe 2 448
Figure 18 – Modèle pour protéger une personne qualifiée contre une source d'énergie de classe 3 448
Figure 19 – Modèle pour protéger une personne qualifiée contre des sources d'énergie de classe 3 dans les conditions d'entretien de l'équipement 448
Figure 20 – Crochet d'essai 456
Figure 21 – Représentation des limites ES pour la tension et le courant 458
Figure 22 – Valeurs maximales pour les courants alternatif et continu combinés 460
Figure 23 – Valeurs maximales pour les tensions alternative et continue combinées 461
Figure 24 – Exigences en matière de contact avec des parties conductrices internes nues 465
Figure 25 – Mandrin 493
Figure 26 – Position initiale du mandrin 493
Figure 27 – Position finale du mandrin 493
Figure 28 – Position de la feuille métallique sur le matériau isolant 494
Figure 29 – Exemple d'instrument d'essai de rigidité diélectrique pour une isolation solide 503
Figure 30 – Points d'application de la tension d'essai 504

IECNORM.COM : Click to view the full PDF of IEC 62368-1:2018 ed 3.0 (RLV)

Figure 31 – Essai de séparation entre un circuit externe et la terre 507
Figure 32 – Circuit d'essai pour le courant de contact d'équipement monophasé 524
Figure 33 – Circuit d'essai pour le courant de contact d'équipement triphasé 525
Figure 34 – Mesure de la puissance dans le cas de défaut de charge le plus défavorable 529
Figure 35 – Mesure de la puissance dans le cas de défaut le plus défavorable de la source de puissance 530
Figure 36 – Représentation de la classification des sources de puissance 531
Figure 37 – Exigences minimales de séparation d'une source potentielle d'incendie (PIS) 538
Figure 38 – Exigences étendues de séparation d'une source potentielle d'incendie (PIS) 538
Figure 39 – Exigences sur la déviation de la barrière par rapport à une source potentielle d'incendie lorsqu'une barrière contre le feu est utilisée 539
Figure 40 – Détermination des ouvertures sur le dessus, dans le fond et latérales 541
Figure 41 – Ouvertures sur le dessus 542
Figure 42 – Ouvertures dans le fond 543
Figure 43 – Construction avec plaque écran 544
Figure 44 – Trajectoire vers le bas de la source potentielle d'incendie 545
Figure 45 – Limites pour les pales mobiles de ventilateurs en matériaux autres que le plastique 551
Figure 46 – Limites pour les pales mobiles de ventilateurs en matériaux plastiques 551
Figure 47 – Disque en acier 577
Figure 48 – Bague en aluminium 578
Figure 49 – Feuille d'aluminium 579
Figure 50 – Exemple d'étiquette de mise en garde pour une lampe avec plusieurs zones dangereuses du spectre 586
Figure D.1 – Générateur de tension de choc de 1,2/50 µs et 10/700 µs 605
Figure D.2 – Circuit du générateur d'essai pour interface d'antenne 606
Figure D.3 – Exemple de générateur d'impulsions électronique 607
Figure E.1 – Filtre passe-bande pour la mesure du bruit en bande large 609
Figure F.1 – Exemple de protection par instructions 620
Figure G.1 – Détermination de la moyenne arithmétique des températures 634
Figure G.2 – Tensions d'essai 640
Figure G.3 – Durée de vieillissement thermique 663
Figure G.4 – Essai de résistance à l'abrasion pour couches de revêtement 664
Figure H.1 – Définition d'une période de sonnerie et d'un cycle de cadence 669
Figure H.2 – Courbe de limite I_{TS1} du signal de sonnerie cadencée 670
Figure H.3 – Courants crête et crête à crête 670
Figure H.4 – Critères de déclenchement de la tension de sonnerie 672
Figure M.1 – Distance d en fonction de la capacité assignée pour des courants de charge divers I (mA/Ah) 699
Figure O.1 – Encoche étroite 703
Figure O.2 – Encoche large 704
Figure O.3 – Encoche en forme de V 704

IECNORM.COM : Click to view the full PDF of IEC 62368-1:2018 Ed 3.0 (RLV):2018

Figure O.4 – Partie conductrice non connectée intercalée 704
Figure O.5 – Nervure 704
Figure O.6 – Joint non scellé avec encoche étroite 705
Figure O.7 – Joint non scellé avec encoche large 705
Figure O.8 – Joint non scellé avec encoches large et étroite 705
Figure O.9 – Faible retrait 706
Figure O.10 – Large retrait 706
Figure O.11 – Revêtement autour des bornes 707
Figure O.12 – Revêtement sur circuit imprimé 707
Figure O.13 – Exemple de mesures dans une enveloppe en matériau isolant 708
Figure O.14 – Joints scellés sur cartes de circuit imprimé multicouches 708
Figure O.15 – Composant rempli d'isolant 709
Figure O.16 – Bobine cloisonnée 709
Figure P.1 – Exemples de sections transversales de constructions d'ouvertures sur le dessus empêchant l'entrée d'objets tombant verticalement 711
Figure P.2 – Exemples de sections transversales de constructions d'ouvertures latérales avec volets en grille-écran empêchant l'entrée d'objets tombant verticalement 711
Figure P.3 – Volume interne destiné à empêcher l'entrée d'objets étrangers 712
Figure S.1 – Ouvertures supérieures / surface de l'enveloppe ignifuge ou de la barrière contre le feu 724
Figure T.1 – Essai de choc utilisant une sphère 729
Figure V.1 – Sonde d'essai articulée pour équipements susceptibles d'être accessibles aux enfants 736
Figure V.2 – Sonde d'essai articulée pour équipements qui ne sont pas susceptibles d'être accessibles aux enfants 737
Figure V.3 – Calibre d'essai 738
Figure V.4 – Sonde en coin 739
Figure V.5 – Sonde de dispositif de connexion extérieure 740
Figure Y.1 – Essai du joint d'étanchéité 765
Figure Y.2 – Tuyau de tête d'arrosage pour l'essai d'arrosage à l'eau 768
Figure Y.3 – Tête d'arrosage pour l'essai d'arrosage à l'eau 769

Tableau 1 – Réponse à la classe d'énergie 397
Tableau 2 – Exemples de réactions du corps humain ou de dommages matériels liés aux sources d'énergie 398
Tableau 3 – Exemples de caractéristiques de protection 402
Tableau 4 – Limites de sources d'énergie électrique pour les sources d'énergie ES1 et ES2 stables 459
Tableau 5 – Limites de sources d'énergie électrique pour un condensateur chargé 462
Tableau 6 – Limites de tension pour les impulsions uniques 463
Tableau 7 – Limites de courant pour les impulsions uniques 463
Tableau 8 – Distance d'entrefer minimale 466
Tableau 9 – Limites de températures des matériaux, composants et systèmes 469
Tableau 10 – Distances dans l'air minimales pour des tensions avec des fréquences jusqu'à 30 kHz 475

IECNORM.COM : Click to view the full PDF of IEC 62368-1:2018 Ed 3.0 (RLV):2018

Tableau 11 – Distances dans l'air minimales pour des tensions avec des fréquences supérieures à 30 kHz 476
Tableau 12 – Tensions transitoires du réseau d'alimentation 478
Tableau 13 – Tensions transitoires du circuit externe 480
Tableau 14 – Distances dans l'air minimales avec la tension de tenue exigée 482
Tableau 15 – Tensions d'essai de rigidité diélectrique 483
Tableau 16 – Facteurs de multiplication pour les distances dans l'air et les tensions d'essai 484
Tableau 17 – Lignes de fuite minimales pour une isolation principale et une isolation supplémentaire, en mm 487
Tableau 18 – Lignes de fuite minimales pour des fréquences supérieures à 30 kHz et jusqu'à 400 kHz en mm 488
Tableau 19 – Essais pour l'isolation dans des couches non séparables 492
Tableau 20 – Résistance du champ électrique E_P pour quelques matériaux couramment utilisés 496
Tableau 21 – Facteurs de réduction pour la valeur de la résistance du champ électrique de rupture E_P à des fréquences plus élevées 497
Tableau 22 – Facteurs de réduction pour la valeur de la résistance du champ électrique de rupture E_P à des fréquences plus élevées pour les matériaux fins 497
Tableau 23 – Valeurs pour la résistance d'isolement 498
Tableau 24 – Distance à travers l'isolation du câblage interne 499
Tableau 25 – Tensions d'essai pour les essais de rigidité diélectrique basés sur les tensions transitoires 501
Tableau 26 – Tensions d'essai pour les essais de rigidité diélectrique basés sur les valeurs crêtes des tensions de service et des tensions crêtes récurrentes 502
Tableau 27 – Tensions d'essai pour les essais de rigidité diélectrique basés sur les surtensions temporaires 502
Tableau 28 – Valeurs pour les essais de rigidité diélectrique 505
Tableau 29 – Présentation des essais pour les applications utilisant des résistances 511
Tableau 30 – Dimensions des conducteurs de mise à la terre de protection des protections renforcées pour les équipements reliés en permanence 514
Tableau 31 – Dimensions minimales du conducteur de liaison de protection des conducteurs en cuivre 515
Tableau 32 – Dimensions des bornes pour les conducteurs de protection 518
Tableau 33 – Durée de l'essai, équipements connectés au réseau d'alimentation 519
Tableau 34 – Liste des normes IEC applicables relatives aux isolants liquides 546
Tableau 35 – Classification des différentes catégories de sources d'énergie mécanique 550
Tableau 36 – Présentation des exigences et essais 562
Tableau 37 – Couple à appliquer aux vis 567
Tableau 38 – Limites de température de contact pour parties accessibles 575
Tableau 39 – Classifications des sources d'énergie de rayonnement 580
Tableau 40 – Niveau de rayonnement admis conformément à l'IEC 62471 (toutes les parties) pour chaque type de danger 583
Tableau 41 – Marquage de l'équipement en fonction du groupe de risque lié au danger 585
Tableau 42 – Explication des informations de marquage et recommandations sur les mesures de contrôle 585
Tableau C.1 – Limites minimales de rétention des propriétés après exposition au rayonnement UV 603

IECNORM.COM : Click to view the full PDF of IEC 62368-1 ed3.0 (RLV):2018

Tableau D.1 – Valeurs des composants pour la Figure D.1 et la Figure D.2 606
Tableau E.1 – Classes et protections de la source d'énergie électrique des signaux audio 608
Tableau F.1 – Description et exemples d'éléments de protection mise en place sous forme d'instructions 620
Tableau F.2 – Exemples de marquages, d'instructions et de protections mises en place sous forme d'instructions 621
Tableau G.1 – Courant de surcharge crête 623
Tableau G.2 – Température d'essai et durée d'essai (jours) par cycle 630
Tableau G.3 – Limites de température pour les enroulements de transformateurs et de moteurs (à l'exception de l'essai de surcharge sur moteur en marche) 633
Tableau G.4 – Tensions d'essai pour les essais de rigidité diélectrique basés sur les valeurs crête de la tension de service 635
Tableau G.5 – Valeurs des fils FIW d'un diamètre total maximal et de tensions d'essai minimales en fonction de l'augmentation de l'émail 638
Tableau G.6 – Limites de température pour les essais de surcharge en fonctionnement 641
Tableau G.7 – Tailles des conducteurs 648
Tableau G.8 – Force d'essai de relâchement des contraintes 649
Tableau G.9 – Plage des tailles des conducteurs acceptées par les bornes 652
Tableau G.10 – Essai de surcharge de varistance et de surtension temporaire 654
Tableau G.11 – Programme d'essai de performance des limiteurs de courant sur circuit intégré 656
Tableau G.12 – Caractéristiques assignées des condensateurs selon l'IEC 60384-14 659
Tableau G.13 – Distances de séparation minimales pour les cartes imprimées avec revêtement 661
Tableau G.14 – Isolation dans les cartes imprimées 662
Tableau I.1 – Catégories de surtension 673
Tableau J.1 – Diamètre du mandrin 675
Tableau J.2 – Température du four 676
Tableau M.1 – Valeurs du courant I_{flottant} et $I_{\text{charge rapide}}$, facteurs f_g et f_s, et tensions U_{flottant} et $U_{\text{charge rapide}}$ 694
Tableau O.1 – Valeur de X 703
Tableau Q.1 – Limites pour les sources à puissance limitée par construction 718
Tableau Q.2 – Limites pour les sources à puissance non limitée par construction (nécessité d'un dispositif de protection contre les surintensités) 718
Tableau S.1 – Matériaux plastiques cellulaires 725
Tableau S.2 – Matériaux rigides 725
Tableau S.3 – Matériaux très fins 726
Tableau T.1 – Force de l'impact 730
Tableau T.2 – Valeurs du couple pour l'essai des pièces d'extrémité 731
Tableau W.1 – Comparaison des termes et définitions de l'IEC 60664-1:2007 et de l'IEC 62368-1 742
Tableau W.2 – Comparaison des termes et définitions de l'IEC 61140:2016 et de l'IEC 62368-1 744
Tableau W.3 – Comparaison des termes et définitions de l'IEC 60950-1:2005 et de l'IEC 62368-1 748

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Tableau W.4 – Comparaison des termes et définitions de l'IEC 60728-11:2016 et de l'IEC 62368-1 752
Tableau W.5 – Comparaison des termes et définitions de l'IEC 62151:2000 et de l'IEC 62368-1 754
Tableau W.6 – Comparaison des termes et définitions de l'IEC 60065:2014 et de l'IEC 62368-1 756
Tableau X.1 – Autres distances dans l'air minimales pour l'isolation dans les circuits connectés à un réseau d'alimentation en courant alternatif ne dépassant pas 420 V crête (300 V en valeur efficace) 759
Tableau X.2 – Distances dans l'air supplémentaires pour l'isolation dans les circuits connectés à un réseau d'alimentation en courant alternatif ne dépassant pas 420 V crête (300 V en valeur efficace) 760
Tableau Y.1 – Exemples de dispositions des environnements de degré de pollution 766

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COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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ÉQUIPEMENTS DES TECHNOLOGIES DE L'AUDIO/VIDÉO, DE L'INFORMATION ET DE LA COMMUNICATION –

Partie 1: Exigences de sécurité

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La Norme internationale IEC 62368-1 a été établie par le comité d'études 108: Sécurité des appareils électroniques dans le domaine de l'audio, de la vidéo, du traitement de l'information et des technologies de la communication.

Cette troisième édition annule et remplace la deuxième édition parue en 2014. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

– ajout des exigences relatives au matériel pour installation extérieure;
– nouvelles exigences relatives au rayonnement optique;
– ajout des exigences relatives à l'isolant liquide;

– ajout des exigences relatives aux cellules de travail;
– ajout d'exigences relatives aux émetteurs de puissance sans fil;
– ajout d'exigences relatives aux fils de bobinage totalement isolés (FIW, *fully insulated winding wire*);
– méthode alternative de détermination des ouvertures supérieures, inférieures et latérales des enveloppes ignifuges;
– autres exigences relatives à la pression acoustique.

Le texte de ce document est issu des documents suivants:

FDIS	Rapport de vote
108/701/FDIS	108/707/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette Norme internationale.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

Une liste de toutes les parties de la série IEC 62368, publiées sous le titre général *Équipements des technologies de l'audio/vidéo, de l'information et de la communication*, peut être consultée sur le site web de l'IEC.

Les notes indiquant "dans certains pays" relatives aux différentes pratiques nationales sont contenues dans les articles, paragraphes et tableaux suivants:

0.2.1, Article 1, 3.3.8.1, 3.3.8.3, 4.1.15, 4.7.3, 5.2.2.2, 5.4.2.3.2.4, 5.4.2.5, 5.4.5.1, 5.4.10.2.1, 5.4.10.2.2, 5.4.10.2.3, 5.5.2.1, 5.5.6, 5.6.4.2.1, 5.6.8, 5.7.6, 5.7.7.1, 8.5.4.2.3, 10.5.3, 10.6.1, 10.6.2.1, F.3.3.6, Y.4.1, Y.4.5, Tableau 12, Tableau 13 et Tableau 39.

Dans le présent document, les caractères d'imprimerie ou formats suivants sont utilisés:

– exigences proprement dites et annexes normatives: caractères romains;
– déclarations de conformité et spécifications d'essai: *caractères italiques*;
– notes/commentaires: petits caractères romains;
– conditions normatives à l'intérieur des tableaux: petits caractères romains;
– termes définis en 3.3: **gras**.

Dans les figures et les tableaux, si la couleur est disponible:

– le vert indique une source d'énergie de classe 1;
– le jaune indique une source d'énergie de classe 2;
– le rouge indique une source d'énergie de classe 3.

Une comparaison des termes présentés dans le présent document qui sont différents de ceux des documents existants de l'IEC est proposée à l'Annexe W.

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- remplacé par une édition révisée, ou
- amendé.

NOTE Des informations explicatives relatives à l'IEC 62368-1 sont données dans l'IEC TR 62368-2. Celle-ci comporte les justifications, ainsi que les informations explicatives relatives au présent document.

IMPORTANT – Le logo *"colour inside"* qui se trouve sur la page de couverture de cette publication indique qu'elle contient des couleurs qui sont considérées comme utiles à une bonne compréhension de son contenu. Les utilisateurs devraient, par conséquent, imprimer cette publication en utilisant une imprimante couleur.

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INTRODUCTION

0 Principes de la présente norme relative à la sécurité des produits

0.1 Objectif

La présente partie de l'IEC 62368 est une norme relative à la sécurité des produits qui classifie les sources d'énergie, spécifie des **protections** contre ces sources d'énergie, et fournit des recommandations concernant leur application et leurs exigences.

Les **protections** spécifiées sont prévues pour réduire la probabilité de douleur, blessure et, en cas d'incendie, de dommage matériel.

L'INTRODUCTION a pour objectif de permettre aux concepteurs de comprendre les principes de sécurité sous-jacents pour concevoir des équipements sûrs. Ces principes sont informatifs et ne constituent pas une alternative aux exigences détaillées du présent document.

0.2 Personnes

0.2.1 Généralités

Le présent document décrit des **protections** pour trois types de personnes: les **personnes ordinaires**, les **personnes averties** et les **personnes qualifiées**. Sauf spécification contraire, les exigences relatives aux **personnes ordinaires** s'appliquent. Le présent document part du principe qu'une personne ne crée jamais volontairement des conditions ou des situations susceptibles de provoquer une douleur ou une blessure.

NOTE 1 En Australie, les opérations effectuées par une **personne avertie** ou par une **personne qualifiée** peuvent nécessiter une licence formelle de la part des autorités de réglementation.

NOTE 2 En Allemagne, une personne peut uniquement être considérée comme une **personne avertie** ou une **personne qualifiée** si certaines exigences légales sont satisfaites.

0.2.2 Personne ordinaire

Personne ordinaire est le terme appliqué à toutes les personnes qui ne sont ni des **personnes averties** ni des **personnes qualifiées**. **Personnes ordinaires** comprend non seulement les utilisateurs de l'équipement, mais également toutes les personnes qui peuvent avoir accès à l'équipement ou se trouver à proximité de l'équipement. Dans les **conditions normales de fonctionnement** ou des **conditions anormales de fonctionnement**, il convient que les **personnes ordinaires** ne soient pas exposées aux parties comprenant des sources d'énergie pouvant provoquer des douleurs ou des blessures. Dans une **condition de premier défaut**, il convient que les **personnes ordinaires** ne soient pas exposées aux parties comprenant des sources d'énergie pouvant provoquer des blessures.

0.2.3 Personne avertie

Personne avertie est un terme appliqué aux personnes qui ont été formées et entraînées par une **personne qualifiée**, ou qui sont supervisées par une **personne qualifiée**, pour identifier les sources d'énergie pouvant provoquer des douleurs (voir le Tableau 1) et pour prendre des précautions afin d'éviter tout contact involontaire avec ou exposition à ces sources d'énergie. Dans les **conditions normales de fonctionnement**, des **conditions anormales de fonctionnement** ou des **conditions de premier défaut**, il convient que les **personnes averties** ne soient pas exposées aux parties comprenant des sources d'énergie pouvant provoquer des blessures.

0.2.4 Personne qualifiée

Personne qualifiée est un terme appliqué aux personnes qui disposent d'une formation ou d'une expérience dans les technologies d'équipement, notamment dans la connaissance des

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différentes énergies et des amplitudes d'énergie utilisées dans l'équipement. Une **personne qualifiée** est censée utiliser sa formation et son expérience pour reconnaître les sources d'énergie pouvant provoquer des douleurs ou des blessures et pour mettre en œuvre une action de protection contre les blessures dues à ces énergies. Il convient que les **personnes qualifiées** soient également protégées contre le contact ou l'exposition involontaires aux sources d'énergie pouvant provoquer des blessures.

0.3 Modèle pour les douleurs et les blessures

Une source d'énergie qui provoque une douleur ou une blessure le fait par l'intermédiaire du transfert d'une forme d'énergie depuis ou vers une partie du corps.

Ce concept est représenté par un modèle en trois blocs (voir la Figure 1).

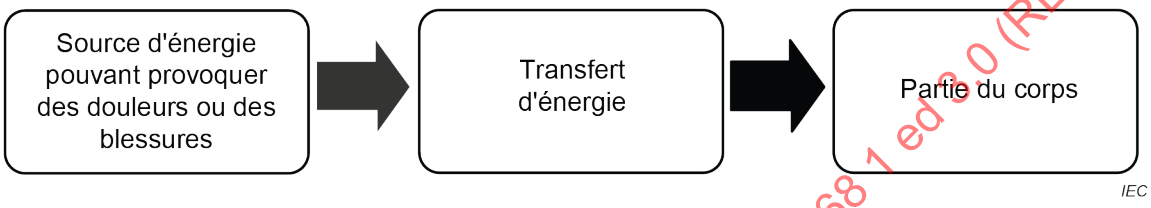


Figure 1 – Modèle en trois blocs pour les douleurs et les blessures

Cette norme relative à la sécurité spécifie trois classes de sources d'énergie définies par des amplitudes et des durées des paramètres des sources relatifs aux réponses du corps à ces sources d'énergie électrique ou thermique (voir le Tableau 1). Les paramètres des sources relatifs aux réponses à des **matériaux combustibles**, aux sources d'énergie mécanique et aux sources d'énergie de rayonnement sont spécifiés en fonction de l'expérience et des normes fondamentales en matière de sécurité.

Tableau 1 – Réponse à la classe d'énergie

Source d'énergie	Effet sur le corps	Effets sur les matériaux combustibles
Classe 1	Non douloureux, mais peut être détectable	Inflammation non probable
Classe 2	Douloureux, mais ne constitue pas une blessure	Inflammation possible, mais développement et propagation du feu limités
Classe 3	Blessure	Inflammation probable, développement et propagation rapides du feu

Le seuil d'énergie pour la douleur ou les blessures n'est pas constant au sein de la population. Par exemple, pour certaines sources d'énergie, le seuil est fonction de la masse du corps: plus la masse est faible, plus le seuil est bas, et inversement. D'autres variables du corps sont l'âge, l'état de santé, les émotions, les effets de médicaments, les caractéristiques de la peau, etc. De plus, même lorsque les apparences extérieures semblent identiques, les individus ne présentent pas le même seuil de sensibilité à la même source d'énergie.

L'effet de la durée du transfert d'énergie dépend de la forme d'énergie spécifique. Par exemple, la durée d'une douleur ou d'une blessure due à une énergie thermique peut être très courte (1 s) sur une peau à température élevée, ou très longue (plusieurs heures) sur une peau à basse température.

En outre, une douleur ou une blessure peut survenir longtemps après le transfert d'énergie vers une partie du corps. Par exemple, une douleur ou une blessure due à une réaction chimique ou physiologique peut ne pas se manifester pendant des jours, des semaines, des mois ou des années.

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0.4 Sources d'énergie

Les sources d'énergie sont traitées par le présent document avec les douleurs ou les blessures qui découlent d'un transfert de ces énergies vers le corps, ainsi que la probabilité de dommage matériel provoqué par le feu s'échappant de l'équipement.

Un produit électrique est connecté à une source d'énergie électrique (par exemple, le **réseau d'alimentation**), une alimentation externe ou une **batterie**. Un produit électrique utilise l'énergie électrique pour remplir ses fonctions prévues.

Au cours du processus d'utilisation d'énergie électrique, le produit transforme l'énergie électrique en d'autres formes d'énergie (par exemple, en énergie thermique, en énergie cinétique, en énergie optique, en énergie audio, en énergie électromagnétique, etc.). Certaines transformations d'énergie peuvent constituer une part délibérée de la fonction du produit (par exemple, des parties mobiles d'une imprimante, des images sur un écran d'affichage visuel, du son provenant d'un haut-parleur, etc.). Certaines transformations d'énergie peuvent être un sous-produit de la fonction du produit (par exemple, de la chaleur dissipée par des circuits fonctionnels, un rayonnement X provenant d'un tube cathodique, etc.).

Certains produits peuvent utiliser des sources d'énergie non électrique telles que des parties mobiles ou des produits chimiques. L'énergie située dans ces autres sources peut être transférée vers ou depuis une partie du corps ou être transformée en d'autres formes d'énergie (par exemple, l'énergie chimique peut être convertie en énergie électrique par le biais d'une batterie, ou une partie du corps mobile transfère son énergie cinétique vers une arête vive).

Des exemples des types de formes d'énergie et des blessures et dommages matériels associés traités dans le présent document figurent au Tableau 2.

Tableau 2 – Exemples de réactions du corps humain ou de dommages matériels liés aux sources d'énergie

Formes d'énergie	Exemples de réactions du corps humain ou de dommages matériels	Article
Énergie électrique (par exemple, parties conductrices alimentées)	Douleur, fibrillation, arrêt cardiaque, arrêt respiratoire, brûlure de la peau, ou brûlure d'un organe interne	5
Énergie thermique (par exemple, inflammation électrique et propagation du feu)	Incendie d'origine électrique provoquant une douleur ou une blessure liée à une brûlure ou un dommage matériel	6
Réaction chimique (par exemple, électrolyte, poison)	Endommagement de la peau, d'autres organes, ou empoisonnement	7
Énergie cinétique (par exemple, parties mobiles de l'équipement, ou une partie du corps mobile contre une partie de l'équipement)	Lacération, perforation, abrasion, contusion, écrasement, amputation ou perte d'un membre, d'un œil, d'une oreille, etc.	8
Énergie thermique (par exemple, parties **accessibles** chaudes)	Brûlure de la peau	9
Énergie rayonnée (par exemple, énergie électromagnétique, énergie optique, énergie acoustique)	Perte de la vue, brûlure de la peau ou perte de l'ouïe	10

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0.5 Protections

0.5.1 Généralités

De nombreux produits utilisent systématiquement de l'énergie pouvant provoquer des douleurs ou des blessures. La conception du produit ne peut pas empêcher l'utilisation de ce type d'énergie. En conséquence, il convient que ces produits suivent un plan qui réduit la probabilité que des énergies de ce type soient transférées vers une partie du corps. Le plan qui réduit la probabilité d'un transfert d'énergie vers une partie du corps s'appelle une **protection** (voir la Figure 2).



Figure 2 – Modèle en trois blocs pour la sécurité

Une **protection** est un dispositif, un plan ou un système qui

– est interposé entre une source d'énergie pouvant provoquer une douleur ou des blessures et une partie du corps, et

– réduit la probabilité d'un transfert d'énergie pouvant entraîner une douleur ou une blessure sur une partie du corps.

NOTE Les mécanismes de **protection** contre un transfert d'énergie pouvant entraîner une douleur ou une blessure consistent à:

– atténuer l'énergie (limiter la valeur de l'énergie), ou

– freiner l'énergie (réduire le débit du transfert d'énergie), ou

– dévier l'énergie (changer la direction de l'énergie), ou

– déconnecter, suspendre ou désactiver la source d'énergie, ou

– envelopper la source d'énergie (diminuer la probabilité que l'énergie s'échappe), ou

– interposer une barrière entre une partie du corps et la source d'énergie.

Une **protection** peut s'appliquer à l'équipement, à l'installation locale, à une personne ou peut consister en un comportement appris ou dirigé (par exemple, dans le cas d'une **protection par instructions**) visant à réduire la probabilité d'un transfert d'énergie pouvant provoquer une douleur ou des blessures. Une **protection** peut être un élément unique ou correspondre à un ensemble d'éléments.

Généralement, le présent document utilise l'ordre de préférence suivant pour présenter des **protections** en fonction des exigences de l'ISO/IEC Guide 51:

– **protections de l'équipement**: sont toujours utiles dans la mesure où elles n'exigent aucune connaissance ou action de la part des personnes en contact avec l'équipement;

– **protections de l'installation**: sont utiles lorsqu'une caractéristique de sécurité ne peut être assurée qu'après l'installation (par exemple, l'équipement doit être boulonné au sol pour des raisons de stabilité);

– **protections** de comportement: sont utiles lorsque l'équipement exige qu'une source d'énergie soit **accessible**.

En pratique, le choix d'une **protection** prend en compte la nature de la source d'énergie, l'utilisateur prévu, les exigences fonctionnelles de l'équipement, et des considérations du même ordre.

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0.5.2 Protection de l'équipement

Une **protection de l'équipement** peut être une **protection principale**, une **protection supplémentaire**, une **protection double** ou une **protection renforcée**.

0.5.3 Protection de l'installation

Les **protections de l'installation** ne sont pas contrôlées par le fabricant de l'équipement, bien que dans certains cas, des **protections de l'installation** puissent être spécifiées dans les instructions d'installation de l'équipement.

En général, pour l'équipement, une **protection d'installation** est une **protection supplémentaire**.

NOTE Par exemple, la **protection supplémentaire** fournissant la mise à la **terre de protection** est située en partie dans l'équipement et en partie dans l'installation. La **protection supplémentaire** fournissant la mise à la **terre de protection** n'est pas effective tant que l'équipement n'est pas connecté à la **mise à la terre de protection** de l'installation.

Les exigences relatives aux **protections de l'installation** ne sont pas traitées dans le présent document. Cependant, le présent document part du principe que certaines **protections de l'installation**, comme la mise à la **terre de protection**, sont en place et effectives.

0.5.4 Protection individuelle

Une **protection individuelle** peut être une **protection principale**, une **protection supplémentaire** ou une **protection renforcée**

Les exigences relatives aux **protections individuelles** ne sont pas traitées dans le présent document. Cependant, ce document part du principe que les **protections individuelles** sont disponibles pour une utilisation telle que spécifiée par le fabricant.

0.5.5 Protections de comportement

0.5.5.1 Introduction aux protections de comportement

En l'absence d'une protection de l'équipement, de l'installation ou **individuelle**, une personne peut adopter un comportement particulier comme **protection** pour éviter le transfert d'énergie et les blessures qui en résultent. Une **protection** de comportement est un comportement volontaire ou averti destiné à réduire la probabilité de transfert d'énergie à une partie du corps.

Le présent document spécifie trois types de **protections** de comportement. Chaque type de **protection** de comportement est associé à un type particulier de personne. Une **protection par instructions** concerne généralement une **personne ordinaire**, mais elle peut également concerner une **personne avertie** ou une **personne qualifiée**. Une **protection de précaution** est employée par une **personne avertie**. Une **protection mise en place grâce à l'expérience acquise** est utilisée par une **personne qualifiée**.

0.5.5.2 Protection par instructions

Une **protection par instructions** est un moyen de fournir des informations, décrivant l'existence et l'emplacement d'une source d'énergie pouvant provoquer une douleur ou une blessure, et visant à solliciter un comportement spécifique de la part d'une personne afin de réduire la probabilité d'un transfert d'énergie vers une partie du corps (voir l'Annexe F).

Une **protection par instructions** peut être une indication visuelle (symboles, mots ou les deux) ou un message sonore, selon le cas applicable pour l'utilisation prévue du produit.

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Une **protection par instructions** peut être considérée comme une protection acceptable pour contourner une **protection de l'équipement** lors de l'accès à des emplacements où l'équipement nécessite d'être alimenté pour effectuer une activité d'entretien, de telle sorte que la personne sache comment éviter un contact avec la source d'énergie de classe 2 ou de classe 3.

Si les **protections de l'équipement** nuisent ou empêchent son fonctionnement, une **protection par instructions** peut remplacer les **protections de l'équipement**.

Si l'exposition à une source d'énergie pouvant provoquer une douleur ou une blessure est essentielle au bon fonctionnement de l'équipement, une **protection par instructions** peut être utilisée pour assurer la protection des personnes plutôt que d'avoir recours à une autre **protection**. Il convient de considérer le fait de savoir s'il convient d'utiliser ou non une **protection individuelle** pour la **protection par instructions**.

La mise à disposition d'une **protection par instructions** ne fait pas d'une **personne ordinaire** une **personne avertie** (voir 0.5.5.3).

0.5.5.3 Protection de précaution (utilisée par une personne avertie)

Une **protection de précaution** consiste en la formation et l'expérience ou l'encadrement d'une **personne avertie** par une **personne qualifiée** en vue de l'utilisation de précautions pour protéger la **personne avertie** contre les sources d'énergie de classe 2. Les **protections de précaution** ne sont pas spécifiquement précisées dans le présent document mais sont considérées comme effectives lorsque le terme **personne avertie** est utilisé.

Pendant l'entretien de l'équipement, une **personne avertie** peut avoir besoin d'ôter ou de détruire une **protection de l'équipement**. Dans ce cas, une **personne avertie** est sensée alors utiliser son expérience comme **protection** pour éviter les expositions aux sources d'énergie de classe 2.

0.5.5.4 Protection mise en place grâce à l'expérience acquise (utilisée par une personne qualifiée)

Une **protection mise en place grâce à l'expérience acquise** consiste en l'utilisation de l'éducation, de la formation, des connaissances et de l'expérience de la **personne qualifiée** pour protéger cette même **personne** contre les sources d'énergie de classe 2 et de classe 3. Les **protections mises en place grâce à l'expérience acquise** ne sont pas spécifiquement précisées dans le présent document mais sont considérées comme effectives lorsque le terme **personne qualifiée** est utilisé.

Pendant l'entretien de l'équipement, une **personne qualifiée** peut avoir besoin d'ôter ou de détruire une **protection de l'équipement**. Dans ce cas, une **personne qualifiée** est sensée alors utiliser son expérience comme **protection** pour éviter les blessures.

0.5.6 Protection dans des conditions d'entretien par une personne ordinaire ou avertie

Dans des conditions d'entretien par une **personne ordinaire** ou par une **personne avertie**, des **protections** pour ces personnes peuvent se révéler nécessaires. Ces **protections** peuvent être des **protections de l'équipement**, des **protections individuelles** ou des **protections par instructions**.

0.5.7 Protections dans des conditions d'entretien par une personne qualifiée

Dans des conditions d'entretien par une **personne qualifiée**, il convient que des **protections de l'équipement** soient prévues contre les effets d'une réaction involontaire du corps (par exemple, un sursaut) susceptible d'entraîner un contact involontaire avec une source d'énergie de classe 3 située hors du champ de vision de la **personne qualifiée**.

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NOTE Cette **protection** s'applique généralement aux équipements de grande taille, dans lesquels la **personne qualifiée** a besoin de s'introduire en partie ou entièrement, entre au moins deux emplacements de source d'énergie de classe 3, au cours de l'entretien.

0.5.8 Exemples de caractéristiques de protection

Le Tableau 3 donne quelques exemples de caractéristiques de **protection**.

Tableau 3 – Exemples de caractéristiques de protection

Protection	Protection principale	Protection supplémentaire	Protection renforcée
Protection de l'équipement: partie physique d'un équipement	Effective dans les **conditions normales de fonctionnement**	Effective dans le cas d'un dysfonctionnement de la **protection principale**	Effective dans les **conditions normales de fonctionnement** et dans le cas d'une **condition de premier défaut** dans une autre partie de l'équipement
	Exemple: **isolation principale**	Exemple: **isolation supplémentaire**	Exemple: **isolation renforcée**
	Exemple: températures normales inférieures aux températures d'inflammation	Exemple: **enveloppe ignifuge**	Non applicable
Protection de l'installation: partie physique d'une installation réalisée par l'homme	Effective dans les **conditions normales de fonctionnement**	Effective dans le cas d'un dysfonctionnement d'une **protection principale** de l'équipement	Effective dans les **conditions normales de fonctionnement** et dans le cas d'une **condition de premier défaut** dans une autre partie de l'équipement
	Exemple: dimensions du fil	Exemple: dispositif de protection contre les surintensités	Exemple: socle de prise de courant
Protection individuelle: dispositif physique porté sur le corps	En l'absence de toute **protection de l'équipement**, effective dans les **conditions normales de fonctionnement**	Effective dans le cas d'un dysfonctionnement d'une **protection principale** de l'équipement	En l'absence de toute **protection de l'équipement**, effective dans les **conditions normales de fonctionnement** et dans le cas d'une **condition de premier défaut** dans une autre partie de l'équipement
	Exemple: des gants	Exemple: tapis de sol isolant	Exemple: gant isolé électriquement permettant de manipuler des conducteurs alimentés
Protection par instructions comportement volontaire ou averti destiné à réduire la probabilité de transfert d'énergie à une partie du corps	En l'absence de toute **protection de l'équipement**, effective dans les **conditions normales de fonctionnement**	Effective dans le cas d'un dysfonctionnement d'une **protection principale** de l'équipement	Effective uniquement de manière exceptionnelle, dans le cas où toutes les **protections** appropriées empêchent le fonctionnement prévu de l'équipement
	Exemple: **protection par instructions** permettant de déconnecter le câble de télécommunication avant de soulever le couvercle	Exemple: après l'ouverture d'une porte, **protection par instructions** contre les parties chaudes	Exemple: **protection par instructions** des parties chaudes dans une photocopieuse de bureau, ou d'un massicot à rouleau continu sur une imprimante du commerce

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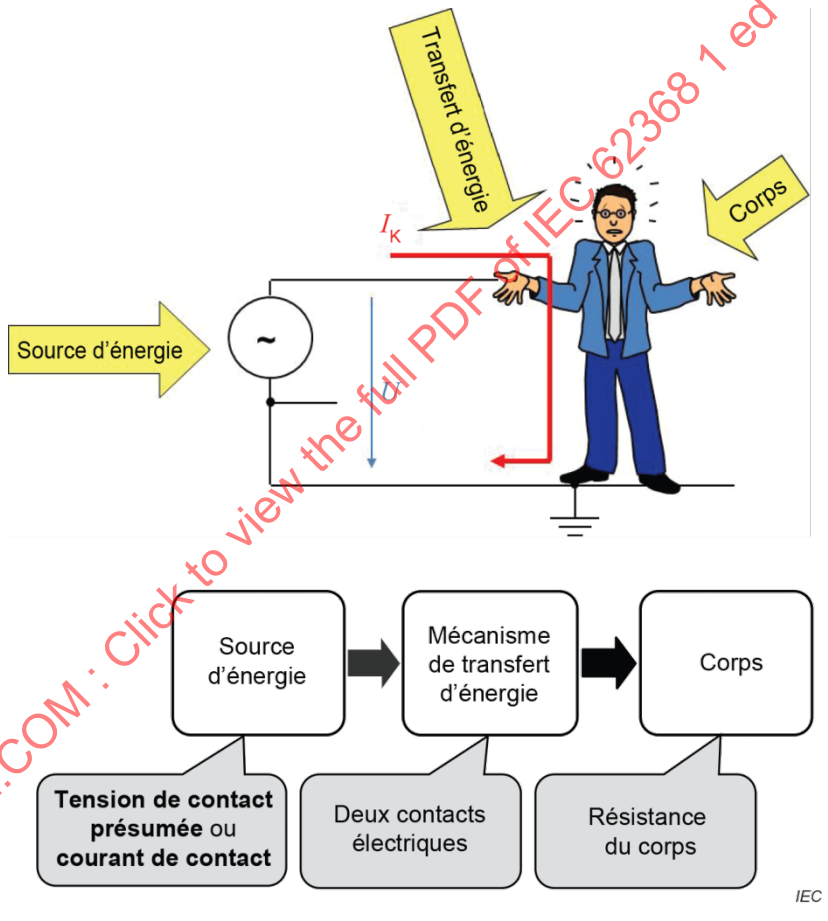
0.6 Douleurs ou blessures dues à l'électricité (choc électrique)

0.6.1 Modèles pour des douleurs ou blessures dues à l'électricité

Une douleur ou une blessure due à l'électricité peut survenir quand une énergie électrique susceptible de provoquer une douleur ou une blessure est transférée vers une partie du corps (voir la Figure 3).

Un transfert d'énergie électrique se produit lorsqu'il existe au moins deux contacts électriques avec le corps:

– le premier contact électrique se situe entre une partie du corps et une partie conductrice de l'équipement;
– le deuxième contact électrique se situe entre une autre partie du corps et
  - la terre, ou
  - une autre partie conductrice de l'équipement.



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Figure 3 – Schéma et modèle pour les douleurs ou les blessures dues à l'électricié

En fonction de l'amplitude, de la durée, de la forme d'onde et de la fréquence du courant, l'effet sur le corps humain peut être indétectable, détectable ou douloureux et peut aller jusqu'à provoquer une blessure.

0.6.2 Modèles pour se protéger contre les douleurs ou blessures dues à l'électricité

Une ou plusieurs **protections** sont interposées entre la source d'énergie électrique pouvant provoquer une douleur ou une blessure et une partie du corps pour se protéger contre les douleurs ou blessures dues à l'électricité (voir la Figure 4).

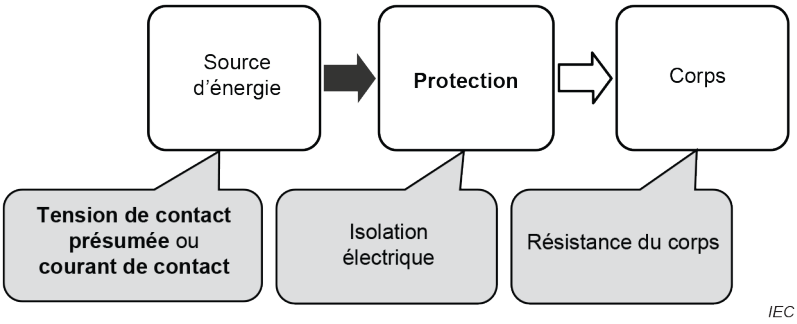


Figure 4 – Modèle pour se protéger contre les douleurs ou blessures dues à l'électricité

Une protection contre les douleurs dues à l'électricité est prévue dans les **conditions normales de fonctionnement** et les **conditions anormales de fonctionnement**. Pour une protection de ce type, dans les **conditions normales de fonctionnement** et dans les **conditions anormales de fonctionnement**, une **protection principale** est interposée entre une source d'énergie électrique pouvant provoquer une douleur et une **personne ordinaire**.

La **protection principale** la plus courante contre une source d'énergie électrique pouvant provoquer une douleur est l'isolation électrique (également appelée **isolation principale**) interposée entre la source d'énergie et une partie du corps.

Il est prévu de se protéger contre les blessures dues à l'électricité dans les **conditions normales de fonctionnement**, dans les **conditions anormales de fonctionnement**, et dans les **conditions de premier défaut**. Pour une protection de ce type, dans les **conditions normales de fonctionnement** et dans les **conditions anormales de fonctionnement**, à la fois une **protection principale** et une **protection supplémentaire** sont interposées entre la source d'énergie électrique pouvant provoquer une blessure et une **personne ordinaire** (voir 4.3.2.4) ou une **personne avertie** (voir 4.3.3.3). En cas de dysfonctionnement de l'une des **protections**, l'autre **protection** devient effective. La **protection supplémentaire** contre une source d'énergie électrique pouvant provoquer une blessure est placée entre la **protection principale** et une partie du corps. Une **protection supplémentaire** peut être une isolation électrique supplémentaire (**isolation supplémentaire**) ou une barrière conductrice mise à la terre de protection, voire une autre construction qui réalise la même fonction.

Une autre **protection** contre une source d'énergie électrique pouvant provoquer une blessure est l'isolation électrique (également appelée **double isolation** ou **isolation renforcée**) placée entre la source d'énergie et une partie du corps.

De même, une **protection renforcée** peut être placée entre une source d'énergie électrique pouvant provoquer une blessure et une partie du corps.

0.7 Incendie d'origine électrique

0.7.1 Modèles pour les incendies d'origine électrique

Un incendie d'origine électrique est causé par la conversion d'énergie électrique en énergie thermique (voir la Figure 5), lorsque l'énergie thermique chauffe un matériau combustible, entraînant son inflammation et sa combustion.

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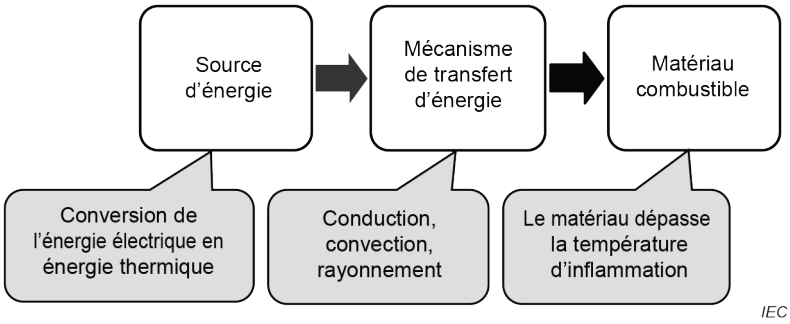


Figure 5 – Modèles pour les incendies d'origine électrique

L'énergie électrique est convertie en énergie thermique soit dans une résistance soit dans un arc, et est transférée vers un matériau combustible par conduction, convection ou rayonnement. À mesure que le matériau combustible chauffe, il se décompose chimiquement en gaz, en liquides et en solides. Une source d'inflammation peut enflammer le gaz, lorsque celui-ci a atteint sa température d'inflammation. Lorsque le gaz a atteint sa température d'inflammation spontanée, l'inflammation de ce dernier est automatique. Les deux cas entraînent un incendie.

0.7.2 Modèles pour se protéger contre les incendies d'origine électrique

La **protection principale** contre les incendies d'origine électrique (voir la Figure 6) consiste à maintenir le matériau à une température, dans les **conditions normales de fonctionnement** et dans les **conditions anormales de fonctionnement**, qui n'entraîne pas d'inflammation du matériau.

La **protection supplémentaire** contre les incendies d'origine électrique réduit la probabilité d'inflammation ou, en cas d'inflammation, réduit la probabilité de propagation de l'incendie.

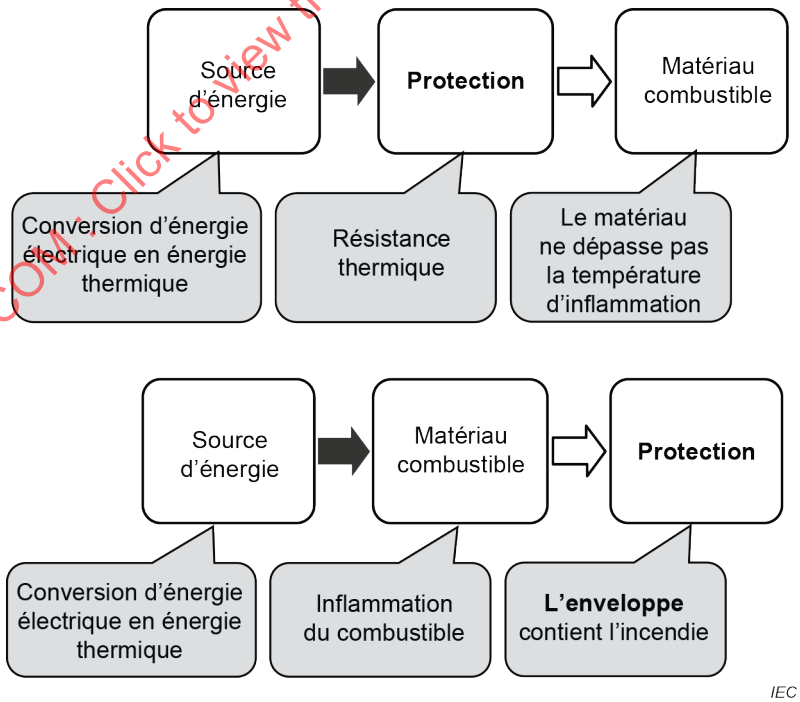


Figure 6 – Modèles pour se protéger contre les incendies

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0.8 Blessures dues à des substances dangereuses

Les blessures dues à des **substances dangereuses** sont provoquées par une réaction chimique avec une partie du corps. L'étendue des blessures causées par une substance donnée dépend à la fois de l'amplitude et de la durée de l'exposition et de la sensibilité de la partie du corps concernée à cette substance.

La **protection principale** contre les blessures dues à des **substances dangereuses** est le confinement du matériau.

Les **protections supplémentaires** contre les blessures dues à des **substances dangereuses** peuvent comprendre:

– un second récipient ou un récipient résistant au débordement;
– des enceintes de confinement;
– des vis inviolables pour empêcher l'accès non autorisé;
– des **protections par instructions**.

Les réglementations nationales et régionales régissent l'utilisation de et l'exposition à des **substances dangereuses** utilisées dans l'équipement. Ces réglementations ne permettent pas une classification pratique des **substances dangereuses** semblable à la classification des autres sources d'énergie dans le présent document. Par conséquent, la classification des sources d'énergie ne s'applique pas dans l'Article 7.

0.9 Blessures dues à un choc mécanique

Les blessures dues à un choc mécanique sont dues au transfert d'énergie cinétique vers une partie du corps lorsqu'une collision se produit entre ladite partie et une partie de l'équipement. L'énergie cinétique est fonction du mouvement relatif entre une partie du corps et les parties **accessibles** de l'équipement, y compris les parties éjectées de l'équipement qui entrent en collision avec une partie du corps.

Exemples de sources d'énergie cinétique:

– mouvement du corps par rapport aux angles et aux arêtes vives;
– mouvement d'une partie dû à la rotation ou à d'autres parties mobiles, y compris les bouts rétreints;
– mouvement d'une partie dû au desserrage, à l'explosion ou à l'implosion de parties;
– mouvement de l'équipement dû à l'instabilité;
– mouvement de l'équipement dû à un défaut du mur, du plafond ou du montage;
– mouvement de l'équipement dû à un défaut d'une poignée;
– mouvement d'une partie dû à une explosion de la **batterie**;
– mouvement de l'équipement dû à une instabilité ou à un défaut du chariot ou du support.

La **protection principale** contre les blessures dues à un choc mécanique est fonction de la source d'énergie spécifique. Les **protections principales** peuvent être:

– des arêtes et des angles arrondis;
– une **enveloppe** pour empêcher une partie mobile d'être **accessible**;
– une **enveloppe** pour empêcher la projection d'une partie mobile;
– un **verrouillage de sécurité** pour contrôler l'accès à une autre partie mobile;
– un moyen d'arrêter le mouvement d'une partie mobile;
– un moyen de stabiliser l'équipement;
– des poignées robustes;

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– des dispositifs de montage robustes;
– des moyens de retenir les parties projetées lors d'une **explosion** ou d'une implosion.

La **protection supplémentaire** contre les blessures dues à un choc mécanique dépend de la source d'énergie spécifique. Les **protections supplémentaires** peuvent être:

– des **protections par instructions**;
– des instructions et une formation;
– des **enveloppes** ou des barrières supplémentaires;
– des **verrouillages de sécurité**.

La **protection renforcée** contre les blessures dues à un choc mécanique dépend de la source d'énergie spécifique. Les **protections renforcées** peuvent être:

– du verre extra épais à l'avant d'un tube cathodique;
– des rails de glissière et des moyens de support;
– un **verrouillage de sécurité**.

0.10 Blessures dues à la chaleur (brûlure de la peau)

0.10.1 Modèles pour les blessures dues à la chaleur

Une blessure due à la chaleur peut survenir lorsque de l'énergie thermique susceptible de provoquer une blessure est transférée vers une partie du corps (voir la Figure 7).

Un transfert d'énergie thermique se produit lorsqu'un corps entre en contact avec une partie chaude de l'équipement. L'étendue de la blessure dépend de la différence de température, de la masse thermique de l'objet, du débit de transfert d'énergie thermique vers la peau et de la durée du contact.

Les exigences du présent document concernent uniquement les **protections** contre un transfert d'énergie thermique par conduction. Le présent document ne traite pas des **protections** contre le transfert d'énergie thermique par convection ou rayonnement.

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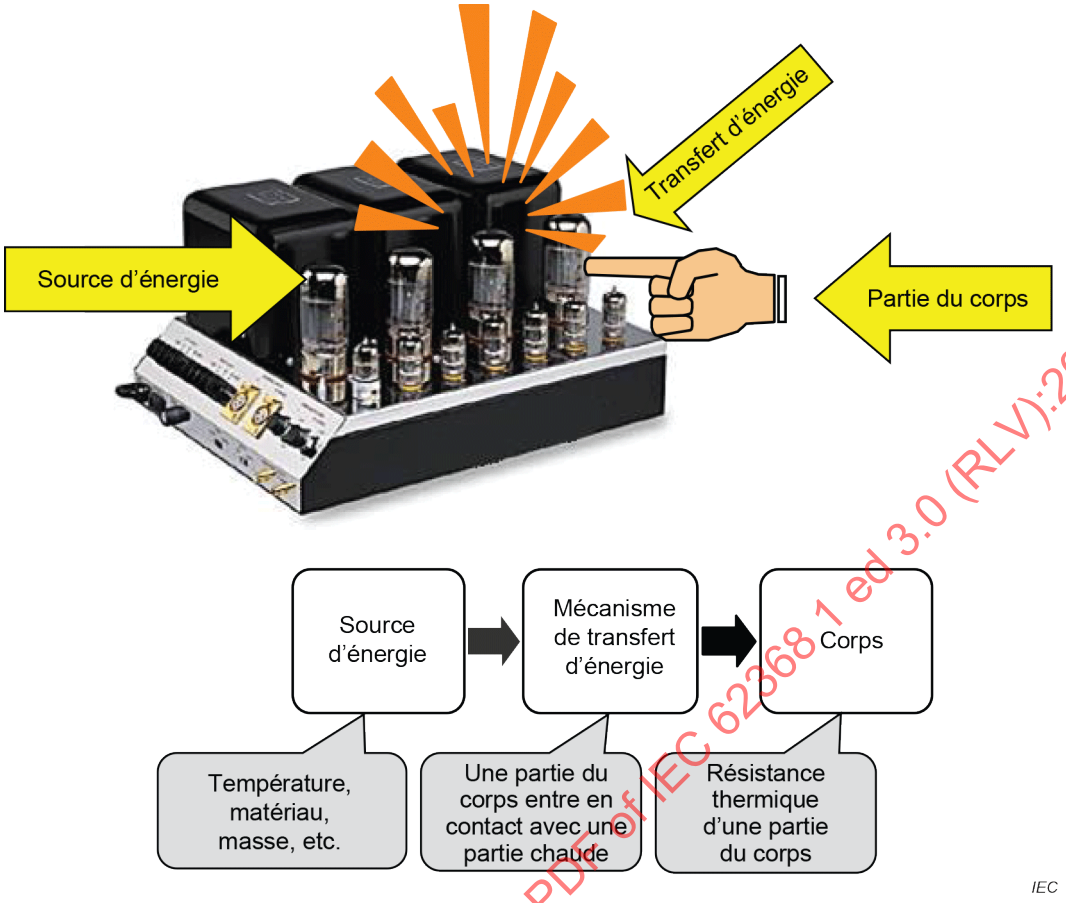


Figure 7 – Schéma et modèle pour les blessures dues à la chaleur

En fonction de la température, de la durée du contact, des propriétés du matériau et de la masse du matériau, la perception du corps humain peut aller d'une chaleur douce à une forte chaleur pouvant entraîner une douleur ou une blessure (brûlure).

0.10.2 Modèles pour se protéger contre les douleurs ou blessures dues à la chaleur

Une ou plusieurs **protections** sont interposées entre une source d'énergie thermique pouvant provoquer une douleur ou une blessure et une **personne ordinaire** (voir la Figure 8).

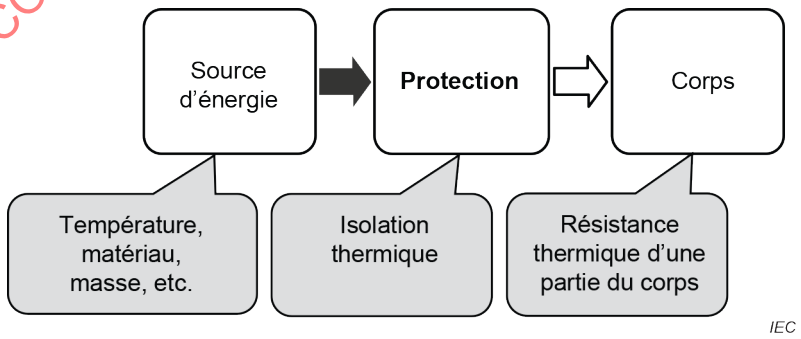


Figure 8 – Modèle pour se protéger contre les blessures dues à la chaleur

Dans les **conditions normales de fonctionnement** et dans les **conditions anormales de fonctionnement,** une protection est appliquée contre les douleurs dues à la chaleur. Pour une protection de ce type, une **protection principale** est interposée entre une source d'énergie thermique pouvant provoquer une douleur et une **personne ordinaire**.

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Dans les **conditions normales de fonctionnement**, dans les **conditions anormales de fonctionnement** et dans les **conditions de premier défaut,** une protection est appliquée contre les blessures dues à la chaleur. Pour une protection de ce type, une **protection principale** et une **protection supplémentaire** sont interposées entre une source d'énergie thermique pouvant provoquer une blessure et une **personne ordinaire**.

La **protection principale** contre une source d'énergie thermique pouvant provoquer une douleur ou une blessure est l'isolation thermique placée entre la source d'énergie et une partie du corps. Dans certains cas, une **protection principale** contre une source d'énergie thermique pouvant provoquer une douleur ou une blessure peut être une **protection par instructions** identifiant les parties chaudes et le moyen de réduire la probabilité d'une blessure. Dans certains cas, une **protection principale** réduit la probabilité qu'une source d'énergie thermique ne pouvant pas provoquer de blessure se transforme en source d'énergie thermique pouvant provoquer une douleur ou une blessure.

Des exemples de **protections principales** de ce type sont:

– le contrôle de la conversion d'énergie électrique en énergie thermique (par exemple, un **thermostat**);

– la dissipation de chaleur, etc.

La **protection supplémentaire** contre une source d'énergie thermique pouvant provoquer une blessure est l'isolation thermique placée entre la source d'énergie et une partie du corps. Dans certains cas, une **protection supplémentaire** contre une source d'énergie thermique pouvant provoquer une douleur ou une blessure peut être une **protection par instructions** identifiant les parties chaudes et le moyen de réduire la probabilité d'une blessure.

0.11 Blessures dues à des rayonnements

Les blessures dues au rayonnement relevant du domaine d'application du présent document sont généralement attribuées à l'un des mécanismes de transfert d'énergie suivants:

– montée en température d'un organe du corps provoquée par une exposition à un rayonnement non ionisant, comme l'énergie fortement localisée d'un laser dirigé sur la rétine, ou

– blessure auditive provoquée par une surstimulation de l'oreille par des pics excessifs ou des sons graves répétés, entraînant un endommagement physique ou nerveux; ou

– rayonnement X; ou

– rayonnement UV.

L'énergie rayonnée est transférée par l'impact d'une onde émise sur une partie du corps.

La **protection principale** contre les blessures dues à un rayonnement est le confinement de l'énergie dans une **enveloppe** opaque à l'énergie rayonnée.

Il existe plusieurs **protections supplémentaires** contre les blessures dues au rayonnement. Les **protections supplémentaires** peuvent comprendre des **verrouillages de sécurité** pour déconnecter l'alimentation du générateur, des vis inviolables pour empêcher l'accès non autorisé, etc.

La **protection principale** contre les blessures auditives consiste à limiter l'émission sonore des lecteurs de musique individuels et leurs casques et écouteurs associés.

Des exemples de **protections supplémentaires** contre les douleurs ou les blessures auditives consistent à prévoir des messages d'avertissement et d'information pour expliquer à l'utilisateur comment manipuler l'équipement correctement.

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ÉQUIPEMENTS DES TECHNOLOGIES DE L'AUDIO/VIDÉO, DE L'INFORMATION ET DE LA COMMUNICATION –

Partie 1: Exigences de sécurité

1 Domaine d'application

La présente partie de l'IEC 62368 s'applique à la sécurité de l'équipement électrique et électronique dans le domaine des technologies audio, vidéo, d'information et de communication, et des machines commerciales ou de bureau dont la **tension assignée** est inférieure ou égale à 600 V. Le présent document ne contient ni les exigences de performances ni les caractéristiques fonctionnelles de l'équipement.

NOTE 1 Des exemples d'équipement relevant du domaine d'application du présent document sont donnés à l'Annexe A.

NOTE 2 Une **tension assignée** de 600 V est considérée comme inclure les équipements ayant une tension assignée de 400 V/690 V.

Le présent document s'applique également:

– aux composants et aux sous-ensembles destinés à être intégrés dans cet équipement. Il n'est pas nécessaire que ces composants et sous-ensembles soient conformes à toutes les exigences présentées dans le présent document, à condition que l'équipement complet, qui intègre ces composants et sous-ensembles, le soit;

– aux alimentations externes destinées à alimenter d'autres équipements entrant dans le domaine d'application du présent document;

– aux accessoires destinés à être utilisés avec des équipements entrant dans le domaine d'application du présent document;

– aux équipements de grande taille dans les **zones à accès limité**. Pour les équipements à machines de grande taille, des exigences supplémentaires peuvent s'appliquer; et

– aux équipements à utiliser dans les régions tropicales.

Le présent document contient également des exigences relatives aux équipements des technologies de l'audio/vidéo, de l'information et de la communication destinés à être installés dans un **emplacement pour installation extérieure**. Les exigences relatives au **matériel pour installation extérieure** s'appliquent également, le cas échéant, aux **enveloppes extérieures** prévues pour l'installation directe sur site et fournies pour recevoir l'équipement de technologie de l'audio/vidéo, de l'information et de la communication à installer dans un **emplacement pour installation extérieure**. Voir l'Annexe Y pour les exigences de construction spécifiques non couvertes dans les autres parties du présent document.

Chaque installation peut faire l'objet d'exigences particulières. De plus, les exigences de protection du **matériel pour installation extérieure** contre les effets des coups de foudre directs ne sont pas couvertes par le présent document.

NOTE 3 Pour des informations sur le sujet, voir l'IEC 62305-1.

Le présent document part du principe d'une altitude maximale de 2 000 m, sauf spécification contraire par le fabricant.

Des exigences supplémentaires pour les équipements capables d'assurer l'alimentation en courant continu à l'aide des câbles de communication les plus souvent utilisés (USB ou Ethernet (PoE), par exemple) sont données dans l'IEC 62368-3. L'IEC 62368-3 ne s'applique pas:

– aux équipements fournissant de la puissance à l'aide de connecteurs propriétaires; ou

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– aux équipements utilisant un protocole propriétaire pour la sélection de puissance.

Le présent document spécifie des **protections** pour les **personnes ordinaires**, les **personnes averties** et les **personnes qualifiées**. Des exigences supplémentaires peuvent s'appliquer aux équipements clairement conçus ou destinés à être utilisés par des enfants ou particulièrement attrayants pour les enfants.

NOTE 4 En Australie, les opérations effectuées par une **personne avertie** ou par une **personne qualifiée** peuvent exiger une licence formelle de la part des autorités de réglementation.

NOTE 5 En Allemagne, dans la plupart des cas, une personne peut uniquement être considérée comme une **personne avertie** ou une **personne qualifiée** si certaines exigences légales sont satisfaites.

Le présent document ne s'applique pas:

– aux matériels qui comportent des parties mobiles dangereuses qui ne sont pas autonomes (les équipements robotiques, par exemple); et

NOTE 6 Pour les exigences relatives aux équipements robotiques dans un environnement industriel, voir l'IEC 60204-1, l'EC 60204-11, l'ISO 10218-1 et l'ISO 10218-2.

– aux robots de soins personnels, y compris les robots d'assistance à la personne mobiles, les robots d'assistance physique et les robots de transport de personne; et

NOTE 7 Pour les exigences relatives aux robots de soins personnels, voir l'ISO 13482.

– aux systèmes d'alimentation électrique ne faisant pas partie intégrante de l'équipement (les groupes convertisseurs, les systèmes de **batterie** de secours et les transformateurs de distribution, par exemple).

Le présent document ne traite pas:

– des processus de fabrication, à l'exception des **essais individuels de série**;
– des effets pouvant provoquer des blessures des gaz libérés par la décomposition ou la combustion thermique;
– des processus de destruction;
– des effets du transport (autres que ceux spécifiés dans le présent document);
– des effets du stockage des matériaux, des composants ou de l'équipement lui-même;
– de la probabilité de blessures provoquées par un rayonnement particulaire, par exemple de particules alpha et bêta;
– de la probabilité de blessures thermiques dues à une énergie thermique de rayonnement ou de convection;
– de la probabilité de blessures provoquées par des liquides inflammables;
– de l'utilisation de l'équipement dans des atmosphères enrichies en oxygène ou **explosives**;
– de l'exposition à des substances chimiques autres que celles spécifiées à l'Article 7;
– des décharges électrostatiques;
– de l'exposition aux champs électromagnétiques;
– des aspects environnementaux;
– des exigences en matière de sécurité fonctionnelle, à l'exception de celles liées aux **cellules de travail**.

NOTE 8 Pour les exigences spécifiques relatives à la sécurité fonctionnelle et à la sûreté logicielle des systèmes électroniques liés à la sécurité (les circuits électroniques de protection, par exemple), voir l'IEC 61508-1.

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2 Références normatives

Les documents suivants cités dans le texte constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60027-1, *Symboles littéraux à utiliser en électrotechnique – Partie 1: Généralités*

IEC 60065, *Appareils audio, vidéo et appareils électroniques analogues – Exigences de sécurité*

IEC 60068-2-6, *Essais d'environnement – Partie 2-6: Essais – Essai Fc: Vibrations (sinusoïdales)*

IEC 60068-2-11, *Essais fondamentaux climatiques et de robustesse mécanique d'environnement – Partie 2-11: Essais – Essai Ka: Brouillard salin*

IEC 60068-2-78, *Essais d'environnement – Partie 2-78: Essais – Essai Cab: Chaleur humide, essai continu*

IEC 60073, *Principes fondamentaux et de sécurité pour l'interface homme-machine, le marquage et l'identification – Principes de codage pour les indicateurs et les organes de commande*

IEC 60076-14, *Transformateurs de puissance – Partie 14: Transformateurs de puissance immergés dans du liquide utilisant des matériaux isolants haute température*

IEC TR 60083, *Prises de courant pour usages domestiques et analogues normalisées par les pays membres de la CEI*

IEC 60085, *Isolation électrique – Évaluation et désignation thermiques*

IEC 60086-4, *Piles électriques – Partie 4: Sécurité des piles au lithium*

IEC 60086-5, *Piles électriques – Partie 5: Sécurité des piles à électrolyte aqueux*

IEC 60107-1:1997, *Méthodes de mesures applicables aux récepteurs de télévision – Partie 1: Considérations générales – Mesures aux domaines radiofréquences et vidéofréquences*

IEC 60112, *Méthode de détermination des indices de résistance et de tenue au cheminement des matériaux isolants solides*

IEC 60127 (toutes les parties), *Coupe-circuit miniatures*

IEC 60227-1, *Conducteurs et câbles isolés au polychlorure de vinyle, de tension nominale au plus égale à 450/750 V – Partie 1: Exigences générales*

IEC 60227-2:1997, *Conducteurs et câbles isolés au polychlorure de vinyle, de tension nominale au plus égale à 450/750 V – Partie 2: Méthodes d'essais*
IEC 60227-2:1997/AMD1:2003

IEC 60245-1, *Conducteurs et câbles isolés au caoutchouc – Tension assignée au plus égale à 450/750 V – Partie 1: Exigences générales*

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IEC 60296, *Fluides pour applications électrotechniques – Huiles minérales isolantes neuves pour transformateurs et appareillages de connexion*

IEC 60309 (toutes les parties), *Prises de courant pour usages industriels*

IEC 60317 (toutes les parties), *Spécifications pour types particuliers de fils de bobinage*

IEC 60317-0-7:2017, *Spécifications pour types particuliers de fils de bobinage – Partie 0-7: Exigences générales – Fil de section circulaire, isolé en continu (FIW), en cuivre émaillé, sans défaut d'isolation électrique*

IEC 60317-43, *Spécifications pour types particuliers de fils de bobinage – Partie 43: Fil de section circulaire en cuivre recouvert d'un ruban de polyimide aromatique, classe 240*

IEC 60317-56, *Spécifications pour types particuliers de fils de bobinage – Partie 56: Fil brasable de section circulaire, isolé en continu, en cuivre émaillé avec polyuréthane sans défaut électrique, classe 180*

IEC 60320 (toutes les parties), *Connecteurs pour usages domestiques et usages généraux analogues*

IEC 60320-1, *Connecteurs pour usages domestiques et usages généraux analogues – Partie 1: exigences générales*

IEC 60332-1-2, *Essais des câbles électriques et à fibres optiques soumis au feu – Partie 1-2: Essai de propagation verticale de la flamme sur conducteur ou câble isolé – Procédure pour flamme à prémélange de 1 kW*

IEC 60332-1-3, *Essais des câbles électriques et à fibres optiques soumis au feu – Partie 1-3: Essai de propagation verticale de la flamme sur conducteur ou câble isolé – Procédure pour la détermination des particules/gouttelettes enflammées*

IEC 60332-2-2, *Essais des câbles électriques et à fibres optiques soumis au feu – Partie 2-2: Essai de propagation verticale de la flamme sur conducteur ou câble isolé de petite section – Procédure pour une flamme de type à diffusion*

IEC 60384-14, *Condensateurs fixes utilisés dans les équipements électroniques – Partie 14: spécification intermédiaire: condensateurs fixes d'antiparasitage et raccordement à l'alimentation*

IEC 60417, *Symboles graphiques utilisables sur le matériel*, disponible à l'adresse suivante: <http://www.graphical-symbols.info/equipment>

IEC 60529, *Degrés de protection procurés par les enveloppes (Code IP)*

IEC 60664-1:2007, *Coordination de l'isolement des matériels dans les systèmes (réseaux) à basse tension – Partie 1: Principes, exigences et essais*

IEC 60664-3, *Coordination de l'isolement des matériels dans les systèmes (réseaux) à basse tension – Partie 3: Utilisation de revêtement, d'empotage ou de moulage pour la protection contre la pollution*

IEC 60691:2015, *Protecteurs thermiques – Exigences et guide d'application*

IEC 60695-2-11, *Essais relatifs aux risques du feu – Partie 2-11: essais au fil incandescent/chauffant – Méthode d'essai d'inflammabilité pour produits finis*

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IEC 60695-10-2, *Essais relatifs aux risques du feu – Partie 10-2: Chaleurs anormales – Essai à la bille*

IEC 60695-10-3, *Essais relatifs aux risques du feu – Partie 10-3: Chaleur anormale – Essai de déformation par réduction des contraintes de moulage*

IEC 60695-11-5:2016, *Essais relatifs aux risques du feu – Partie 11-5: Flammes d'essai – Méthode d'essai au brûleur-aiguille – Appareillage, dispositif d'essai de vérification et lignes directrices*

IEC 60695-11-10, *Essais relatifs aux risques du feu – Partie 11-10: Flammes d'essai – Méthodes d'essai horizontale et verticale à la flamme de 50 W*

IEC 60695-11-20:2015, *Essais relatifs aux risques du feu – Partie 11-20: Flammes d'essai – Méthodes d'essai à la flamme de 500 W*

IEC TS 60695-11-21, *Essais relatifs aux risques du feu – Partie 11-21: Flammes d'essai – Méthodes d'essai à la flamme de 500 W pour matériaux tubulaires polymères*

IEC 60728-11:2016, *Réseaux de distribution par câbles pour signaux de télévision, signaux de radiodiffusion sonore et services interactifs – Partie 11: Sécurité*

IEC 60730 (toutes les parties), *Dispositifs de commande électrique automatiques à usage domestique et analogue*

IEC 60730-1:2013, *Dispositifs de commande électrique automatiques à usage domestique et analogue – Partie 1: Exigences générales*

IEC 60738-1:2006, *Thermistances à coefficient de température positif à chauffage direct – Partie 1: Spécification générique*

IEC 60747-5-5:2007, *Dispositifs à semiconducteurs – Dispositifs discrets – Partie 5-5: Dispositifs optoélectroniques – Photocoupleurs*
IEC 60747-5-5:2007/AMD1:2015

IEC 60825-1, *Sécurité des appareils à laser – Partie 1: Classification des matériels et exigences*

IEC 60825-2, *Sécurité des appareils à laser – Partie 2: Sécurité des systèmes de télécommunication par fibres optiques (STFO)*

IEC 60825-12, *Sécurité des appareils à laser – Partie 12: Sécurité des systèmes de communications optiques en espace libre utilisés pour la transmission d'informations*

IEC 60836, *Spécifications pour liquides isolants silicones neufs pour usages électrotechniques*

IEC 60851-3:2009, *Fils de bobinage – Méthodes d'essai – Partie 3: Propriétés mécaniques*
IEC 60851-3:2009/AMD1:2013

IEC 60851-5:2008, *Fils de bobinage – Méthodes d'essai – Partie 5: Propriétés électriques*
IEC 60851-5:2008/AMD1:2011

IEC 60884-1, *Prises de courant pour usages domestiques et analogues – Partie 1: Règles générales*

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IEC 60896-11, *Batteries stationnaires au plomb – Partie 11: Batteries au plomb du type ouvert – Prescriptions générales et méthodes d'essai*

IEC 60896-21:2004, *Batteries stationnaires au plomb – Partie 21: Types étanches à soupapes – Méthodes d'essai*

IEC 60896-22, *Batteries stationnaires au plomb – Partie 22: Types étanches à soupapes – Exigences*

IEC 60906-1, *Système CEI de prises de courant pour usages domestiques et analogues – Partie 1: prises de courant 16 A 250 V en courant alternatif*

IEC 60906-2, *Système CEI de prises de courant pour usages domestiques et analogues – Partie 2: prises de courant 15 A 125 V en courant alternatif*

IEC 60947-1, *Appareillage à basse tension – Partie 1: règles générales*

IEC 60947-5-5, *Appareillage à basse tension – Partie 5-5: appareils et éléments de commutation pour circuits de commande. Appareil d'arrêt d'urgence électrique à accrochage mécanique*

IEC 60950-1, *Matériels de traitement de l'information – Sécurité – Partie 1: exigences générales*

IEC 60990:2016, *Méthodes de mesure du courant de contact et du courant dans le conducteur de protection*

IEC 60998-1, *Dispositifs de connexion pour circuits basse tension pour usage domestique et analogue – Partie 1: exigences générales*

IEC 60999-1, *Dispositifs de connexion – Conducteurs électriques en cuivre – Prescriptions de sécurité pour organes de serrage à vis et sans vis – Partie 1: Prescriptions générales et particulières pour les organes de serrage pour les conducteurs de 0,2 mm^2 à 35 mm^2 (inclus)*

IEC 60999-2, *Dispositifs de connexion – Conducteurs électriques en cuivre – Prescriptions de sécurité pour organes de serrage à vis et sans vis – Partie 2: Prescriptions particulières pour les organes de serrage pour conducteurs au-dessus de 35 mm^2 et jusqu'à 300 mm^2 (inclus)*

IEC 61039, *Classification des liquides isolants*

IEC 61051-1, *Varistances utilisées dans les équipements électroniques – Partie 1: Spécification générique*

IEC 61051-2:1991, *Varistances utilisées dans les équipements électroniques – Partie 2: spécification intermédiaire pour varistances pour limitations de surtensions transitoires*
IEC 61051-2:1991/AMD1:2009

IEC 61056-1, *Batteries d'accumulateurs au plomb-acide pour usage général (types à soupapes) – Partie 1: prescriptions générales et caractéristiques fonctionnelles – Méthode d'essai*

IEC 61056-2, *Batteries d'accumulateurs au plomb-acide pour usage général (types à soupapes) – Partie 2: Dimensions, bornes et marquage*

IEC 61058-1:2016, *Interrupteurs pour appareils – Partie 1: Exigences générales*

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IEC 61099, *Liquides isolants – Spécifications relatives aux esters organiques de synthèse neufs destinés aux matériels électriques*

IEC 61204-7, *Alimentations à découpage basse tension – Partie 7: Exigences de sécurité*

IEC 61293, *Marquage des matériels électriques avec des caractéristiques assignées relatives à l'alimentation électrique – Prescriptions de sécurité*

IEC 61427 (toutes les parties), *Accumulateurs pour le stockage de l'énergie renouvelable – Exigences générales et méthodes d'essais*

IEC TS 61430, *Accumulateurs – Méthodes d'essai pour la vérification de la performance des dispositifs conçus pour réduire les risques d'explosion – Batteries de démarrage au plomb*

IEC 61434, *Accumulateurs alcalins et autres accumulateurs à électrolyte non acide – Guide pour l'expression des courants dans les normes d'accumulateurs alcalins*

IEC 61558-1:2017, *Sécurité des transformateurs, bobines d'inductance, blocs d'alimentation et des combinaisons de ces éléments – Partie 1: Exigences générales et essais*

IEC 61558-2-16, *Sécurité des transformateurs, alimentations, bobines d'inductance et produits analogues pour des tensions d'alimentation jusqu'à 1 100 V – Partie 2-16: Règles particulières et essais pour les blocs d'alimentation à découpage et les transformateurs pour blocs d'alimentation à découpage*

IEC 61643-11:2011, *Parafoudres basse tension – Partie 11: Parafoudres connectés aux systèmes basse tension – Exigences et méthodes d'essai*

IEC 61643-331:2017, *Components for low-voltage surge protective devices – Part 331: Performance requirements and test methods for metal oxide varistors (MOV)* (disponible en anglais seulement)

IEC 61810-1:2015, *Relais électromécaniques élémentaires – Partie 1: Exigences générales et de sécurité*

IEC 61959, *Accumulateurs alcalins et autres accumulateurs à électrolyte non acide – Essais mécaniques pour accumulateurs portables étanches*

IEC 61965, *Mechanical safety of cathode ray tubes* (disponible en anglais seulement)

IEC 61984, *Connecteurs – Exigences de sécurité et essais*

IEC 62133 (toutes les parties), *Accumulateurs alcalins et autres accumulateurs à électrolyte non acide – Exigences de sécurité pour les accumulateurs portables étanches, et pour les batteries qui en sont constituées, destinés à l'utilisation dans des applications portables*

IEC 62133-1, *Accumulateurs alcalins et autres accumulateurs à électrolyte non acide – Exigences de sécurité pour les accumulateurs portables étanches, et pour les batteries qui en sont constituées, destinés à l'utilisation dans des applications portables – Partie 1: Systèmes au nickel*

IEC 62133-2, *Accumulateurs alcalins et autres accumulateurs à électrolyte non acide – Exigences de sécurité pour les accumulateurs portables étanches, et pour les batteries qui en sont constituées, destinés à l'utilisation dans des applications portables – Partie 2: systèmes au lithium*

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IEC 62281, *Sécurité des piles et des accumulateurs au lithium pendant le transport*

IEC TS 62332-1, *Electrical insulation systems (EIS) – Thermal evaluation of combined liquid and solid components – Part 1: General requirements* (disponible en anglais seulement)

IEC 62440:2008, *Câbles électriques avec une tension assignée n'excédant pas 450/750 V – Guide d'emploi*

IEC 62471:2006, *Sécurité photobiologique des lampes et des appareils utilisant des lampes*

IEC 62471-5:2015, *Photobiological safety of lamps and lamp systems – Part 5: Image projectors* (disponible en anglais seulement)

IEC 62485-2, *Exigences de sécurité pour les batteries d'accumulateurs et les installations de batteries – Partie 2: batteries stationnaires*

IEC 62619, *Accumulateurs alcalins et autres accumulateurs à électrolyte non acide – Exigences de sécurité pour les éléments et batteries d'accumulateurs au lithium pour applications industrielles*

ISO 37, *Caoutchouc vulcanisé ou thermoplastique -Détermination des caractéristiques de contrainte-déformation en traction*

ISO 178, *Plastiques – Détermination des propriétés en flexion*

ISO 179-1, *Plastiques – Détermination de la résistance au choc Charpy – Partie 1: Essai de choc non instrumenté*

ISO 180, *Plastiques – Détermination de la résistance au choc Izod*

ISO 306, *Plastiques – Matières thermoplastiques – Détermination de la température de ramollissement Vicat (VST)*

ISO 527 (toutes les parties), *Plastiques – Détermination des propriétés en traction*

ISO 871, *Plastiques – Détermination de la température d'allumage au moyen d'un four à air chaud*

ISO 1798, *Matériaux polymères alvéolaires souples – Détermination de la résistance à la traction et de l'allongement à la rupture*

ISO 1817:2015, *Rubber, vulcanized or thermoplastic – Determination of the effect of liquids* (disponible en anglais seulement)

ISO 2719, *Détermination du point d'éclair – Méthode Pensky-Martens en vase clos*

ISO 3231, *Peintures et vernis – Détermination de la résistance aux atmosphères humides contenant du dioxyde de soufre*

ISO 3679, *Détermination de l'éclair de type passe/ne passe pas et du point d'éclair – Méthode rapide à l'équilibre en vase clos*

ISO 3864 (toutes les parties), *Symboles graphiques – Couleurs de sécurité et signaux de sécurité*

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ISO 3864-2, *Symboles graphiques – Couleurs de sécurité et signaux de sécurité – Partie 2: principes de conception pour l'étiquetage de sécurité des produits*

ISO 4892-1, *Plastiques – Méthodes d'exposition à des sources lumineuses de laboratoire – Partie 1: Lignes directrices générales*

ISO 4892-2, *Plastiques – Méthodes d'exposition à des sources lumineuses de laboratoire – Partie 2: Lampes à arc au xénon*

ISO 4892-4, *Plastiques – Méthodes d'exposition à des sources lumineuses de laboratoire – Partie 4: Lampes à arc au carbone*

ISO 7000, *Symboles graphiques utilisables sur le matériel – Symboles enregistrés*, disponible à l'adresse: <http://www.graphical-symbols.info/equipment>

ISO 7010, *Symboles graphiques – Couleurs de sécurité et signaux de sécurité – Signaux de sécurité utilisés sur les lieux de travail et dans les lieux publics*

ISO 8256, *Plastiques – Détermination de la résistance au choc-traction*

ISO 9772, *Plastiques alvéolaires – Détermination des caractéristiques de combustion de petites éprouvettes en position horizontale, soumises à une petite flamme*

ISO 9773, *Plastiques – Détermination du comportement au feu d'éprouvettes minces verticales souples au contact d'une petite flamme comme source d'allumage*

ISO 14993, *Corrosion des métaux et alliages – Essais accélérés comprenant des expositions cycliques à des conditions de brouillard salin, de séchage et d'humidité*

ISO 21207, *Essais de corrosion en atmosphères artificielles – Essais de corrosion accélérée par expositions alternées à des gaz oxydants ou au brouillard salin neutre et à un séchage*

ASTM D412, *Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers – Tension*

ASTM D471-98, *Standard Test Method for Rubber Property-Effect of Liquids*

ASTM D3574, *Standard Test Methods for Flexible Cellular Materials—Slab, Bonded, and Molded Urethane Foams*

EN 50332-1:2013, *Équipement de systèmes acoustiques: casques et écouteurs associés avec un baladeur – Méthode de mesure de niveau maximal de pression acoustique et prise en compte d'une limite – Partie 1: Méthode générale pour "un équipement complet"*

EN 50332-2, *Équipement de systèmes acoustiques: casques et écouteurs associés avec un baladeur – Méthode de mesure de niveau maximal de pression acoustique et prise en compte d'une limite – Partie 2: Adaptation des équipements avec des écouteurs provenant de différents fabricants*

EN 50332-3, *Équipements de diffusion sonore: casques et écouteurs associés avec un lecteur de musique individuel – Méthode de mesure de niveau maximal de pression acoustique – Partie 3: Méthode de mesure pour la gestion de la dose de bruit*

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3 Termes, définitions et abréviations

3.1 Abréviations des sources d'énergie

Abréviation	Description	
ES	Source d'énergie électrique	voir 5.2
ES1	Source d'énergie électrique de classe 1	
ES2	Source d'énergie électrique de classe 2	
ES3	Source d'énergie électrique de classe 3	
MS	Source d'énergie mécanique	voir 8.2
MS1	Source d'énergie mécanique de classe 1	
MS2	Source d'énergie mécanique de classe 2	
MS3	Source d'énergie mécanique de classe 3	
PS	Source d'énergie de puissance	voir 6.2
PS1	Source d'énergie de puissance classe 1	
PS2	Source d'énergie de puissance classe 2	
PS3	Source d'énergie de puissance classe 3	
RS	Source d'énergie par rayonnement	voir 10.2
RS1	Source d'énergie par rayonnement de classe 1	
RS2	Source d'énergie par rayonnement de classe 2	
RS3	Source d'énergie par rayonnement de classe 3	
TS	Source d'énergie thermique	voir 9.2
TS1	Source d'énergie thermique de classe 1	
TS2	Source d'énergie thermique de classe 2	
TS3	Source d'énergie thermique de classe 3	

3.2 Autres abréviations

Abréviation	Description
CD	compact disc (disque compact)
CD ROM	compact disc read-only memory (disque optique compact)
CRT	cathode ray tube (à tube cathodique)
CSD	calculated sound dose (dose acoustique calculée)
IRC	indice de résistance au cheminement
DVD	digital versatile disc (disque numérique polyvalent)
E	exposition au bruit
EIS	electrical insulation system (système d'isolation électrique)
EUT	equipment under test (appareil en essai)
FIW	fully insulated winding wire (fil de bobinage totalement isolé)
GDT	gas discharge tube (tube à décharge dans un gaz)
IC	integrated circuit (circuit intégré)
ICX	integrated circuit with X-capacitor function (circuit intégré avec fonction X du condensateur)

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Abréviation	Description
IR	infrarouge
LED	light emitting diode (diode électroluminescente)
LEL	lower explosion limit (limite inferieure d'explosivité)
LFC	liquid filled component (composant rempli de liquide)
LPS	limited power source (source d'alimentation limitée)
MEL	momentary exposure level (niveau d'exposition momentané)
MOV	metal oxide varistor (varistance à oxyde métallique)
NEMA	National Electrical Manufacturers Association
NiCd	nickel-cadmium
PIS	potential ignition source (source potentielle d'incendie)
PMP	personal music player (lecteur de musique individuel)
PoE	power over Ethernet (alimentation électrique par câble Ethernet)
EPI	équipement de protection individuelle
CTP	coefficient de température positif
ITC	indice de tenue au cheminement
RC	résistance capacité
RG	risk group (groupe de risque)
Sb	antimoine
SEL	sound exposure level (niveau d'exposition au bruit)
SPD	surge protective device (dispositif de protection contre les surtensions)
SRME	slide rail mounted equipment (équipement monté sur rail à glissières)
TSS	thyristor surge suppressor (parafoudre à thyristor)
ASI	alimentation sans interruption
USB	universal serial bus (bus universel série)
UV	ultraviolet
VDR	voltage dependent resistor (varistance – résistance sensible à la tension))
VRLA	valve regulated lead acid battery (batterie étanche à soupapes)

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3.3 Termes et définitions

Pour les besoins du présent document, les termes et définitions suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse http://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse http://www.iso.org/obp.

Pour le confort de l'utilisateur, les termes définis sont énumérés ci-dessous dans l'ordre alphabétique, avec indication du numéro afférent au terme défini.

Sauf spécification contraire, lorsque les mots "tension" et "courant" ou leurs abréviations sont utilisés, il s'agit de valeurs efficaces.

accessible 3.3.6.1
accumulateur au lithium 3.3.17.8
batterie 3.3.17.1

câble d'alimentation fixé à demeure	3.3.6.6
cellule	3.3.17.2
cellule de travail	3.3.6.16
circuit externe	3.3.1.1
classe d'inflammabilité du matériau	3.3.4.2
condition anormale de fonctionnement	3.3.7.1
condition de premier défaut	3.3.7.9
condition normale de fonctionnement	3.3.7.4
conducteur de liaison de protection	3.3.11.9
conducteur de mise à la terre de protection	3.3.11.12
conducteur de protection	3.3.11.10
construction de classe II	3.3.15.2
courant assigné	3.3.10.1
courant dans le conducteur de protection	3.3.14.4
courant dans le conducteur de protection	3.3.10.6
courant de charge maximale	3.3.17.6
courant de contact	3.3.6.14
degré de pollution	3.3.6.8
disjoncteur thermique	3.3.13.2
dispositif de déconnexion	3.3.6.4
distance d'isolement	3.3.12.1
dose acoustique calculée, CSD	3.3.19.1
double isolation	3.3.5.2
double protection	3.3.11.3
émetteur de puissance sans fil	3.3.3.12
emplacement pour installation extérieure	3.3.6.7
enveloppe	3.3.2.2
enveloppe électrique	3.3.2.1
enveloppe extérieure	3.3.2.5
enveloppe ignifuge	3.3.2.3
enveloppe mécanique	3.3.2.4
équipement de classe I	3.3.15.1
équipement de classe II	3.3.15.3
équipement de classe III	3.3.15.4
équipement enfichable de type A	3.3.3.7
équipement enfichable de type B	3.3.3.8
équipement fixe	3.3.3.2
équipement relié en permanence	3.3.3.6
équipement stationnaire	3.3.3.10
équipement transportable	3.3.3.11

IECNORM.COM : Click to view the full PDF of IEC 62368 1 ed 3.0 (R)(V)2018

équipements à enficher directement	3.3.3.1
équipements mobiles	3.3.3.4
équipements portatifs	3.3.3.3
essai de type	3.3.6.15
essai individuel de série	3.3.6.10
essai sur prélèvement	3.3.6.11
étamine	3.3.6.3
explosif	3.3.16.3
explosion	3.3.16.2
exposition au bruit, E	3.3.19.3
fil de bobinage totalement isolé, FIW	3.3.18.1
fonctionnement de courte durée	3.3.7.8
fonctionnement intermittent	3.3.7.2
fréquence assignée	3.3.10.2
fréquence de réponse crête	3.3.7.5
impédance assignée de charge	3.3.7.6
isolant liquide	3.3.5.4
isolation fonctionnelle	3.3.5.3
isolation principale	3.3.5.1
isolation renforcée	3.3.5.5
isolation solide	3.3.5.6
isolation supplémentaire	3.3.5.7
ligne de fuite	3.3.12.2
limiteur de température	3.3.13.1
matériau combustible	3.3.4.1
matériau consommable	3.3.16.1
matériau de classe 5VA	3.3.4.2.1
matériau de classe V-0	3.3.4.2.8
matériau de classe V-1	3.3.4.2.9
matériau de classe V-2	3.3.4.2.10
matériau de classe VTM-0	3.3.4.2.11
matériau de classe VTM-1	3.3.4.2.12
matériau de classe VTM-2	3.3.4.2.13
Matériau de classe 5VB	3.3.4.2.2
matériau de classe HB40	3.3.4.2.3
matériau de classe HB75	3.3.4.2.4
matériau plastique cellulaire de classe HBF	3.3.4.2.5
matériau plastique cellulaire de classe HF-1	3.3.4.2.6
matériau plastique cellulaire de classe HF-2	3.3.4.2.7
matériel pour installation extérieure	3.3.3.5

IECNORM.COM : Click to view the full PDF of IEC 62368 1 ed 3.0 (R.V.):2018

matériel professionnel	3.3.3.9
mauvais usage raisonnablement prévisible	3.3.7.7
mise à la terre de protection	3.3.11.11
mise à la terre pour des raisons fonctionnelles	3.3.6.5
mode de fonctionnement en autonomie	3.3.6.12
niveau de fil totalement isolé	3.3.18.2
niveau d'exposition au bruit, SEL	3.3.19.4
niveau d'exposition momentané, MEL	3.3.19.2
niveau de signal numérique par rapport à la pleine échelle, dBFS	3.3.19.5
outil	3.3.6.13
papier mousseline	3.3.6.17
personne avertie	3.3.8.1
personne ordinaire	3.3.8.2
personne qualifiée	3.3.8.3
pile ou accumulateur bouton	3.3.17.3
plage de tensions assignées	3.3.10.5
protection	3.3.11.14
protection contre les retours de tension en entrée	3.3.11.1
protection de l'installation	3.3.11.5
protection de l'équipement	3.3.11.4
protection de précaution	3.3.11.8
protection individuelle	3.3.11.7
protection mise en place grâce à l'expérience acquise	3.3.11.16
protection par instructions	3.3.11.6
protection principale	3.3.11.2
protection renforcée	3.3.11.13
protection supplémentaire	3.3.11.17
puissance assignée	3.3.10.3
puissance de sortie non écrêtée	3.3.7.3
réseau d'alimentation	3.3.1.2
retour de tension en entrée	3.3.6.2
source potentielle d'incendie causé par la formation d'un arc électrique	3.3.9.2
source potentielle d'incendie causé par un phénomène résistif	3.3.9.3
source potentielle d'incendie, PIS	3.3.9.1
substance dangereuse	3.3.16.4
surtension temporaire	3.3.14.7
température de charge la moins élevée	3.3.17.5
température de charge la plus élevée	3.3.17.4
tension assignée	3.3.10.4
tension continue	3.3.14.1

IECNORM.COM : Click to view the full PDF of IEC 62368 1 ed 3.0 (R.V.):2018

tension de charge maximale	3.3.17.7
tension de contact présumée	3.3.14.3
tension de service	3.3.14.8
tension de service efficace	3.3.14.6
tension de tenue exigée	3.3.14.5
tension transitoire du réseau d'alimentation	3.3.14.2
thermostat	3.3.13.3
verrouillage de sécurité	3.3.11.15
zone à accès limité	3.3.6.9

3.3.1 Termes relatifs aux circuits

3.3.1.1
circuit externe
circuit électrique qui est externe à l'équipement et n'est pas un **réseau d'alimentation**

Note 1 à l'article: Un **circuit externe** est classifié comme ES1, ES2 ou ES3, et PS1, PS2 ou PS3.

3.3.1.2
réseau d'alimentation
réseau de distribution de puissance en courant alternatif ou en courant continu (externe à l'équipement) qui fournit la puissance de fonctionnement à l'équipement et est de classe PS3

Note 1 à l'article: Un **réseau d'alimentation** comprend des services publics ou privés et, sauf spécification contraire dans le présent document, des sources équivalentes à des générateurs motorisés et des alimentations sans interruption.

3.3.2 Termes relatifs à l'enveloppe

3.3.2.1
enveloppe électrique
enveloppe assurant la **protection** contre les blessures dues à l'électricité

[SOURCE: IEC 60050-195:1998, 195-06-13, modifiée – le terme **protection** a été utilisé]

3.3.2.2
enveloppe
enceinte assurant le type et le degré de protection approprié pour l'application prévue

[SOURCE: IEC 60050-195:1998, 195-02-35]

3.3.2.3
enveloppe ignifuge
enveloppe assurant la **protection** contre la propagation du feu depuis l'intérieur de l'**enveloppe** vers l'extérieur de l'**enveloppe**

3.3.2.4
enveloppe mécanique
enveloppe assurant la **protection** contre les douleurs et blessures dues à un choc mécanique

3.3.2.5
enveloppe extérieure
enveloppe destinée à assurer la protection contre des conditions particulières dans un **emplacement pour installation extérieure**

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Note 1 à l'article: Une **enveloppe extérieure** peut également assurer les fonctions d'une autre **enveloppe**, par exemple: une **enveloppe ignifuge**, une **enveloppe électrique**, une **enveloppe mécanique**.

Note 2 à l'article: Une enceinte ou un boîtier séparé(e) dans laquelle ou lequel l'équipement est placé peut faire office d'**enveloppe extérieure**.

3.3.3 Termes relatifs à l'équipement

3.3.3.1
équipement à enficher directement
équipement dans lequel la fiche de raccordement au **réseau d'alimentation** fait partie intégrante de l'**enveloppe** de l'équipement

3.3.3.2
équipement fixe
équipement spécifié dans les instructions d'installation pour n'être fixé sur place que par des moyens définis par le fabricant

Note 1 à l'article: Un équipement comportant un trou de vis ou d'autres moyens permettant à une **personne ordinaire** de fixer l'équipement (pour la fixation à une table ou pour une protection sismique, par exemple) n'est pas considéré comme un **équipement fixe**.

Note 2 à l'article: Généralement, l'équipement fixe est monté au mur, au plafond ou posé au sol.

3.3.3.3
équipement portatif
équipement mobile ou partie d'un équipement de type indifférent, destiné à être tenu à la main en utilisation normale

3.3.3.4
équipement mobile
équipement soit:

– pesant au maximum 18 kg et qui n'est pas un **équipement fixe**; soit
– fourni avec des roues, des roulettes ou un autre moyen permettant de faciliter les mouvements par une **personne ordinaire** tel que requis pour son utilisation prévue

3.3.3.5
matériel pour installation extérieure
matériel installé ou exposé dans un **emplacement pour installation extérieure**, spécifié par le fabricant pour satisfaire en tout ou partie aux conditions particulières

Note 1 à l'article: Un **équipement transportable** (un ordinateur portable, un bloc-note électronique ou un téléphone, par exemple) n'est pas un **matériel pour installation extérieure**, sauf si cela est spécifié par le fabricant dans le cadre d'une utilisation continue dans un **emplacement pour installation extérieure**.

3.3.3.6
équipement relié en permanence
équipement pouvant uniquement être connecté électriquement au ou déconnecté électriquement du **réseau d'alimentation** à l'aide d'un **outil**

3.3.3.7
équipement enfichable de type A
équipement prévu pour être raccordé au **réseau d'alimentation** par une fiche et un socle de prise de courant non industriels ou par un connecteur non industriel ou les deux

Note 1 à l'article: Des exemples sont les fiches et socles de prise de courant couverts par les normes telles que l'IEC TR 60083 et l'IEC 60320-1.

3.3.3.8
équipement enfichable de type B
équipement prévu pour être raccordé au **réseau d'alimentation** par une fiche et un socle de prise de courant industriels ou par un connecteur industriel ou les deux

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Note 1 à l'article: Des exemples sont les fiches et socles de prise de courant couverts par les normes telles que l'IEC 60309-1.

3.3.3.9
matériel professionnel
matériel utilisé dans les métiers, les professions, ou dans l'industrie, et qui n'est pas destiné à être vendu au grand public

[SOURCE: IEC 60050-161:1990, 161-05-05]

3.3.3.10
équipement stationnaire

– **équipement fixe**, ou
– **équipement relié en permanence**, ou
– équipement qui, en raison de ses caractéristiques physiques, n'est normalement pas déplacé

Note 1 à l'article: Un **équipement stationnaire** n'est ni un **équipement mobile** ni un **équipement transportable**.

3.3.3.11
équipement transportable
équipement prévu pour être régulièrement transporté

Note 1 à l'article: Il peut s'agir par exemple d'ordinateurs portables, de lecteurs CD et d'accessoires portables, y compris leurs alimentations externes.

3.3.3.12
émetteur de puissance sans fil
équipement qui utilise les champs électromagnétiques pour transférer la puissance électrique pour charger des appareils portatifs alimentés par batterie

3.3.4 Termes relatifs à l'inflammabilité

3.3.4.1
matériau combustible
matériau susceptible de s'enflammer ou de brûler

Note 1 à l'article: Tous les matériaux thermoplastiques sont considérés comme susceptibles de s'enflammer ou de brûler, indépendamment de la **classe d'inflammabilité du matériau**.

3.3.4.2
classe d'inflammabilité du matériau
reconnaissance du comportement au feu des matériaux et de leur capacité de s'éteindre s'ils sont allumés

Note 1 à l'article: Les matériaux sont classifiés comme ci-dessous lorsqu'ils sont soumis à l'essai conformément à l'IEC 60695-11-10, à l'IEC 60695-11-20, à l'ISO 9772 ou à l'ISO 9773.

3.3.4.2.1
matériau de classe 5VA
matériau soumis à l'essai dans l'épaisseur significative la plus fine utilisée et classifié 5VA conformément à l'IEC 60695-11-20

3.3.4.2.2
matériau de classe 5VB
matériau soumis à l'essai dans l'épaisseur significative la plus fine utilisée et classifié 5VB conformément à l'IEC 60695-11-20

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3.3.4.2.3
matériau de classe HB40
matériau soumis à l'essai dans l'épaisseur significative la plus fine utilisée et classifié HB40 conformément à l'IEC 60695-11-10

3.3.4.2.4
matériau de classe HB75
matériau soumis à l'essai dans l'épaisseur significative la plus fine utilisée et classifié HB75 conformément à l'IEC 60695-11-10

3.3.4.2.5
matériau plastique cellulaire de classe HBF
matériau plastique cellulaire soumis à l'essai dans l'épaisseur significative la plus fine utilisée et classifié HBF conformément à l'ISO 9772

3.3.4.2.6
matériau plastique cellulaire de classe HF-1
matériau plastique cellulaire soumis à l'essai dans l'épaisseur significative la plus fine utilisée et classifié HF-1 conformément à l'ISO 9772

3.3.4.2.7
matériau plastique cellulaire de classe HF-2
matériau plastique cellulaire soumis à l'essai dans l'épaisseur significative la plus fine utilisée et classifié HF-2 conformément à l'ISO 9772

3.3.4.2.8
matériau de classe V-0
matériau soumis à l'essai dans l'épaisseur significative la plus fine utilisée et classifié V-0 conformément à l'IEC 60695-11-10

3.3.4.2.9
matériau de classe V-1
matériau soumis à l'essai dans l'épaisseur significative la plus fine utilisée et classifié V-1 conformément à l'IEC 60695-11-10

3.3.4.2.10
matériau de classe V-2
matériau soumis à l'essai dans l'épaisseur significative la plus fine utilisée et classifié V-2 conformément à l'IEC 60695-11-10

3.3.4.2.11
matériau de classe VTM-0
matériau soumis à l'essai dans l'épaisseur significative la plus fine utilisée et classifié VTM-0 conformément à l'ISO 9773

3.3.4.2.12
matériau de classe VTM-1
matériau soumis à l'essai dans l'épaisseur significative la plus fine utilisée et classifié VTM-1 conformément à l'ISO 9773

3.3.4.2.13
matériau de classe VTM-2
matériau soumis à l'essai dans l'épaisseur significative la plus fine utilisée et classifié VTM-2 conformément à l'ISO 9773

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3.3.5 Isolation électrique

3.3.5.1
isolation principale
isolation assurant une **protection principale** contre les chocs électriques

Note 1 à l'article: Ce concept ne s'applique pas à l'isolation utilisée exclusivement dans un but fonctionnel.

3.3.5.2
double isolation
isolation comprenant à la fois une **isolation principale** et une **isolation supplémentaire**

[SOURCE: IEC 60050-195:1998, 195-06-08]

3.3.5.3
isolation fonctionnelle
isolation entre parties conductrices qui est uniquement nécessaire au bon fonctionnement du matériel

3.3.5.4
isolant liquide
matériau isolant entièrement constitué d'un liquide

[SOURCE: IEC 60050-212:2010, 212-11-04]

3.3.5.5
isolation renforcée
système d'isolation unique qui assure un degré de protection contre les chocs électriques équivalant à une **double isolation**

3.3.5.6
isolation solide
isolation entièrement constituée d'un matériau solide

[SOURCE: IEC 60050-212:2010, 212-11-02]

3.3.5.7
isolation supplémentaire
isolation indépendante appliquée en plus de l'**isolation principale** pour fournir une **isolation supplémentaire** pour la protection contre le choc électrique

3.3.6 Divers

3.3.6.1
accessible
qui peut être touché par une partie du corps

Note 1 à l'article: Une partie du corps est représentée par une ou plusieurs des sondes spécifiées à l'Annexe V.

3.3.6.2
retour de tension en entrée
condition pendant laquelle une tension ou une énergie disponible dans l'alimentation de secours par **batterie** est renvoyée vers l'une quelconque des bornes d'entrée, soit directement soit en suivant une voie de courant de fuite pendant le **mode de fonctionnement en autonomie** et lorsque la puissance du **réseau d'alimentation** n'est pas disponible

3.3.6.3
étamine
pièce de coton blanchi d'environ 40 g/m^2

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Note 1 à l'article: L'**étamine** est une gaze en coton grossier, tissée de façon non serrée, utilisée à l'origine pour emballer le fromage.

3.3.6.4
dispositif de déconnexion
moyen de déconnecter électriquement l'équipement du **réseau d'alimentation** qui, en position ouverte, est conforme aux exigences spécifiées pour l'isolation

3.3.6.5
mise à la terre pour des raisons fonctionnelles
mise à la terre d'un ou de plusieurs points d'un réseau, d'une installation ou d'un matériel pour des raisons autres que la sécurité électrique

[SOURCE: IEC 60050-195:1998/AMD1:2001, 195-01-13]

3.3.6.6
câble d'alimentation fixé à demeure
câble souple d'alimentation fixé ou monté sur l'équipement et ne pouvant pas être retiré de l'équipement sans l'utilisation d'**outils**

3.3.6.7
emplacement pour installation extérieure
emplacement pour un matériel pour lequel la protection contre les intempéries et autres influences extérieures, assurée par un bâtiment ou une autre structure, est limitée ou inexistante

3.3.6.8
degré de pollution
chiffre caractérisant la pollution attendue du micro-environnement

[SOURCE: IEC 60050-581:2008, 581-21-07]

3.3.6.9
zone à accès limité
zone **accessible** uniquement aux **personnes qualifiées** et aux **personnes averties** munies de l'autorisation adéquate

3.3.6.10
essai individuel de série
essai auquel est soumis chaque dispositif en cours ou en fin de fabrication pour vérifier qu'il satisfait à des critères définis

[SOURCE: IEC 60664-1:2007, 3.19.2]

3.3.6.11
essai sur prélèvement
essai effectué sur un certain nombre de dispositifs prélevés au hasard dans un lot

[SOURCE: IEC 60664-1:2007, 3.19.3]

3.3.6.12
mode de fonctionnement en autonomie
mode stable de fonctionnement que l'alimentation de secours par **batterie** atteint dans les conditions spécifiées

Note 1 à l'article: Conformément à l'IEC 62040-1:2017, les conditions spécifiées sont les suivantes:

– l'alimentation alternative d'entrée est déconnectée ou en dehors des tolérances exigées;
– la puissance de fonctionnement et de sortie provient du système de stockage de l'énergie;

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– la charge est conforme aux caractéristiques assignées spécifiées de l'alimentation de secours par **batterie**.

3.3.6.13
outil
objet pouvant être utilisé sur une vis, un verrou ou un moyen de fixation similaire

Note 1 à l'article: Les **outils** peuvent être par exemple des pièces de monnaie, de la vaisselle, un tournevis, une pince, etc.

3.3.6.14
courant de contact
courant électrique traversant le corps humain lorsqu'une partie du corps entre en contact avec au moins deux parties **accessibles** ou une partie **accessible** et la terre

3.3.6.15
essai de type
essai réalisé sur un échantillon représentatif avec l'objectif de déterminer si, tel que conçu et fabriqué, il peut répondre aux exigences du présent document

3.3.6.16
cellule de travail
espace situé à l'intérieur du matériel d'une taille telle qu'une personne peut y pénétrer complètement ou en partie (par exemple en y entrant tout un membre ou toute la tête) pour procéder à l'entretien ou au fonctionnement de l'équipement et à l'intérieur duquel peuvent exister des dangers mécaniques

Note 1 à l'article: Une **cellule de travail** peut contenir plusieurs compartiments. Un compartiment peut être utilisé à des fins opérationnelles ou de maintenance.

Note 2 à l'article: L'équipement contenant la **cellule de travail** est en général installé dans une **zone à accès limité**.

3.3.6.17
papier mousseline
papier mousseline entre 12 g/m^2 et 30 g/m^2

Note 1 à l'article: Le **papier mousseline** est un papier doux, fin, généralement transparent utilisé pour emballer les articles délicats.

3.3.7 Conditions de fonctionnement et de défaut

3.3.7.1
conditions anormales de fonctionnement
conditions de fonctionnement temporaires qui ne sont ni les **conditions normales de fonctionnement** ni les **conditions de premier défaut** de l'équipement proprement dit

Note 1 à l'article: Les **conditions anormales de fonctionnement** sont spécifiées à l'Article B.3.

Note 2 à l'article: Des **conditions anormales de fonctionnement** peuvent être induites par l'équipement ou par une personne.

Note 3 à l'article: Des **conditions anormales de fonctionnement** peuvent entraîner le dysfonctionnement d'un composant, d'un dispositif ou d'une **protection**.

3.3.7.2
fonctionnement intermittent
fonctionnement en une série de cycles, chacun étant composé d'une période de fonctionnement suivie d'une période pendant laquelle l'équipement est éteint ou en veille

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3.3.7.3
puissance de sortie non écrêtée
puissance dissipée aux bornes de l'**impédance assignée de charge** en régime sinusoïdal, la mesure étant effectuée à 1 000 Hz à l'apparition de l'écrêtage de l'une ou l'autre des alternances

3.3.7.4
condition normale de fonctionnement
mode de fonctionnement qui reflète le mieux le domaine d'utilisation normale qu'il est raisonnable d'attendre

Note 1 à l'article: Sauf spécification contraire, les conditions d'utilisation normale les plus rigoureuses sont les valeurs par défaut les plus défavorables telles que spécifiées à l'Article B.2.

Note 2 à l'article: Le **mauvais usage raisonnablement prévisible** n'est pas couvert par les **conditions normales de fonctionnement**. Il est en revanche couvert par les **conditions anormales de fonctionnement**.

3.3.7.5
fréquence de réponse crête
fréquence d'essai qui produit la puissance de sortie maximale mesurée à l'**impédance assignée de charge**

Note 1 à l'article: Il convient que la fréquence appliquée se situe dans la plage de fonctionnement prévue de l'amplificateur/du transducteur.

3.3.7.6
impédance assignée de charge
impédance ou résistance, spécifiée par le fabricant par laquelle il convient de terminer un circuit de sortie

3.3.7.7
mauvais usage raisonnablement prévisible
utilisation d'un produit, procédé ou service dans des conditions ou à des fins non prévues par le fournisseur mais qui peut provenir d'un comportement humain envisageable

Note 1 à l'article: Le **mauvais usage raisonnablement prévisible** est considéré être une forme de **conditions anormales de fonctionnement**.

[SOURCE: Guide ISO/IEC 51:2014, 3.7, modifiée – Dans la définition, "d'un produit ou d'un système" a été remplacé par "d'un produit, procédé ou service". Les Notes à l'article ont été remplacées.]

3.3.7.8
fonctionnement de courte durée
fonctionnement dans les **conditions normales de fonctionnement** pendant une période spécifiée, qui commence alors que l'équipement est froid, les intervalles après chaque période de fonctionnement étant suffisants pour permettre à l'équipement de refroidir à la température ambiante

3.3.7.9
condition de premier défaut
défaut dans les **conditions normales de fonctionnement** d'une **protection** unique (mais non d'une **protection renforcée**) ou d'un composant unique ou d'un dispositif

Note 1 à l'article: Les **conditions de premier défaut** sont spécifiées à l'Article B.4.

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3.3.8 Personnes

3.3.8.1
personne avertie
personne avertie ou encadrée par une **personne qualifiée** en sources d'énergie et qui peut utiliser les **protections de l'équipement** et les **protections de précaution** de manière responsable par rapport à ces sources d'énergie

Note 1 à l'article: Encadré, tel qu'utilisé dans la définition, signifie qui dirige et surveille les performances des autres.

Note 2 à l'article: En Allemagne, dans la plupart des cas, une personne peut uniquement être considérée comme une **personne avertie** si certaines exigences légales sont satisfaites.

3.3.8.2
personne ordinaire
personne qui n'est ni une **personne qualifiée** ni une **personne avertie**

[SOURCE: IEC 60050-826:2004, 826-18-03]

3.3.8.3
personne qualifiée
personne ayant la formation ou l'expérience appropriée pour lui permettre d'identifier les dangers et de prendre les mesures appropriées pour réduire les risques de blessure pour elle-même et les autres

Note 1 à l'article: En Allemagne, dans la plupart des cas, une personne peut uniquement être considérée comme une **personne qualifiée** si certaines exigences légales sont satisfaites.

[SOURCE: IEC 60050-826:2004, 826-18-01, modifiée – La définition a été revisée pour s'appliquer à tous les types de dangers.]

3.3.9 Sources potentielles d'incendie

3.3.9.1
source potentielle d'incendie
PIS
emplacement dans lequel une énergie électrique peut provoquer une inflammation

Note 1 à l'article: L'abréviation «PIS» est dérivée du terme anglais développé correspondant «potential ignition source».

3.3.9.2
source potentielle d'incendie causé par la formation d'un arc électrique
PIS dans laquelle un arc peut se produire en raison de l'ouverture d'un conducteur ou d'un contact

Note 1 à l'article: Un circuit de protection électronique ou des mesures de construction supplémentaires peuvent être utilisés pour empêcher qu'un emplacement ne devienne une **source potentielle d'incendie causé par la formation d'un arc électrique**.

Note 2 à l'article: Un faux contact ou une rupture dans une connexion électrique qui peut se produire sur des pistes conductrices sur des cartes imprimées est considéré comme relevant du domaine d'application de cette définition.

3.3.9.3
source potentielle d'incendie causé par un phénomène de résistivité
PIS dans laquelle un composant peut s'enflammer en raison d'une puissance dissipée excessive

Note 1 à l'article: Un circuit de protection électronique ou des mesures de construction supplémentaires peuvent être utilisés pour empêcher qu'un emplacement ne devienne une **source potentielle d'incendie causé par un phénomène de résistivité**.

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3.3.10 Caractéristiques assignées

3.3.10.1
courant assigné
courant d'entrée de l'équipement tel que déclaré par le fabricant dans les **conditions normales de fonctionnement**

3.3.10.2
fréquence assignée
fréquence d'alimentation ou plage de fréquences telle que déclarée par le fabricant

3.3.10.3
puissance assignée
puissance d'entrée de l'équipement tel que déclarée par le fabricant dans les **conditions normales de fonctionnement**

3.3.10.4
tension assignée
valeur de la tension, fixée par le fabricant à un composant, à un dispositif ou à un matériel et à laquelle on se réfère pour le fonctionnement et pour les caractéristiques fonctionnelles

Note 1 à l'article: L'équipement peut présenter plus d'une valeur de **tension assignée** ou bien une **plage de tensions assignées**.

[SOURCE: IEC 60664-1:2007, 3.9]

3.3.10.5
plage de tensions assignées
plage de tensions d'alimentation telle que déclarée par le fabricant, exprimée par ses **tensions assignées** supérieure et inférieure

3.3.10.6
caractéristiques assignées du courant de protection
caractéristiques assignées du courant d'un dispositif de protection contre les surintensités qui est en place dans l'installation du bâtiment ou l'équipement pour protéger un circuit

3.3.11 Protections

3.3.11.1
protection contre le retour de tension en entrée
schéma de commande permettant de réduire le risque de choc électrique dû à un retour de tension en entrée

3.3.11.2
protection principale
protection assurée dans les **conditions normales de fonctionnement** et les **conditions anormales de fonctionnement** lorsqu'une source d'énergie susceptible de provoquer une douleur ou une blessure est présente dans l'équipement

3.3.11.3
double protection
protection comprenant une **protection principale** et une **protection supplémentaire**

3.3.11.4
protection de l'équipement
protection constituant une partie physique de l'équipement

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3.3.11.5
protection de l'installation
protection qui constitue une partie physique d'une installation réalisée par l'homme

3.3.11.6
protection par instructions
instruction impliquant un comportement spécifié

3.3.11.7
protection individuelle
équipement de protection individuelle qui est porté sur le corps et qui réduit l'exposition à une source d'énergie

Note 1 à l'article: Les exemples sont des écrans faciaux, des lunettes et des masques de protection, des gants, des tabliers, des appareils de protection respiratoires.

3.3.11.8
protection de précaution
comportement d'une **personne avertie** visant à éviter tout contact ou exposition à une source d'énergie de classe 2, sous la supervision ou d'après les instructions d'une **personne qualifiée**

3.3.11.9
conducteur de liaison de protection
conducteur de protection dans l'équipement, prévu pour réaliser une liaison équipotentielle de protection des parties devant être mises à la terre pour des raisons de sécurité

Note 1 à l'article: un **conducteur de liaison de protection** est interne à l'équipement.

3.3.11.10
conducteur de protection
conducteur prévu à des fins de sécurité (par exemple, protection contre les chocs électriques)

Note 1 à l'article: un **conducteur de protection** est soit un **conducteur de mise à la terre de protection**, soit un **conducteur de liaison de protection**.

[SOURCE: IEC 60050-195:1998, 195-02-09]

3.3.11.11
mise à la terre de protection
mise à la terre d'un ou de plusieurs points d'un réseau, d'une installation ou d'un matériel pour des raisons de sécurité électrique

[SOURCE: IEC 60050-195:1998/AMD1:2001, 195-01-11, modifiée – Le terme "mise à la terre pour des raisons de protection" est devenu "mise à la terre de protection".]

3.3.11.12
conducteur de mise à la terre de protection
conducteur de protection raccordant une borne principale de **mise à la terre de protection** dans l'équipement à un point de terre dans l'installation du bâtiment pour une **mise à la terre de protection**

3.3.11.13
protection renforcée
protection unique qui est effective dans:

– les **conditions normales de fonctionnement**,
– les **conditions anormales de fonctionnement**, et
– **les conditions de premier défaut**

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3.3.11.14
protection
partie physique, système ou instruction spécifiquement prévu pour réduire la probabilité de douleur ou de blessure ou, en cas d'incendie, pour réduire la probabilité d'inflammation ou de propagation du feu

Note 1 à l'article: Voir 0.5 pour une explication plus détaillée d'une **protection**.

3.3.11.15
verrouillage de sécurité
moyen de transformer automatiquement une source d'énergie en une source d'énergie de classe inférieure préalablement à la possibilité de transfert de l'énergie supérieure vers une partie du corps

Note 1 à l'article: Un **verrouillage de sécurité** englobe le système des composants et circuits qui sont directement impliqués dans la fonction de **protection**, y compris les dispositifs électromécaniques, les conducteurs sur les cartes imprimées, le câblage et leurs extrémités, etc., selon le cas.

3.3.11.16
protection mise en place grâce à l'expérience acquise
comportement d'une **personne qualifiée** visant à éviter le contact ou l'exposition à une source d'énergie de classe 2 ou de classe 3 basé sur une formation et l'expérience

3.3.11.17
protection supplémentaire
protection appliquée en plus de la **protection principale** qui est ou devient opérationnelle en cas de dysfonctionnement de la **protection principale**

3.3.12 Distances

3.3.12.1
distance d'isolement
distance la plus courte dans l'air entre deux parties conductrices

[SOURCE: IEC 60664-1:2007, 3.2]

3.3.12.2
ligne de fuite
distance la plus courte, le long de la surface d'un isolant, entre deux parties conductrices

[SOURCE: IEC 60664-1:2007, 3.3, modifiée – Dans la définition, "solide" a été supprimé.]

3.3.13 Températures et commandes

3.3.13.1
limiteur de température
dispositif permettant de limiter la température d'un système, soit au-dessous soit au-dessus d'une valeur particulière, en contrôlant, soit directement soit indirectement, le flux d'une énergie thermique à l'intérieur ou à l'extérieur du système

Note 1 à l'article: un **limiteur de température** peut être à réenclenchement automatique ou réenclenchement manuel.

3.3.13.2
disjoncteur thermique
dispositif permettant de limiter la température d'un système, dans les **conditions de premier défaut**, en contrôlant, soit directement soit indirectement, le flux d'une énergie thermique à l'intérieur ou à l'extérieur du système

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3.3.13.3
thermostat
dispositif permettant de maintenir la température d'un système à l'intérieur d'une plage en contrôlant, soit directement soit indirectement, le flux d'une énergie thermique à l'intérieur ou à l'extérieur du système

3.3.14 Tensions et courants

3.3.14.1
tension continue
tension présentant une ondulation crête à crête ne dépassant pas 10 % de la valeur moyenne

Note 1 à l'article: Lorsqu'une ondulation crête à crête dépasse 10 % de la valeur moyenne, les exigences liées à la tension crête sont applicables.

3.3.14.2
tension transitoire du réseau d'alimentation
tension crête la plus élevée attendue au niveau de l'entrée du **réseau d'alimentation** dans l'équipement, provenant de transitoires externes

3.3.14.3
tension de contact présumée
tension apparaissant entre des parties conductrices simultanément **accessibles** ou entre une partie conductrice **accessible** et la terre quand ces parties conductrices ne sont pas touchées

[SOURCE: IEC 60050-195:1998, 195-05-09, modifiée – Dans la définition, «ou entre une partie conductrice **accessible** et la terre» a été ajouté.]

3.3.14.4
courant dans le conducteur de protection
courant s'écoulant à travers le **conducteur de mise à la terre de protection** dans **les conditions normales de fonctionnement**

Note 1 à l'article: Le **courant du conducteur de protection** était auparavant compris dans le terme "courant de fuite".

3.3.14.5
tension de tenue exigée
tension crête que l'isolation considérée est tenue de supporter

3.3.14.6
tension de service efficace
valeur efficace vraie de la **tension de service**

Note 1 à l'article: La valeur efficace vraie de la **tension de service** comprend une composante continue de la forme d'onde.

Note 2 à l'article: La valeur efficace obtenue d'une forme d'onde présentant une tension efficace en courant alternatif "A" et une tension à composante continue "B" est donnée par la formule suivante:

$$\text{valeur efficace} = (A^2 + B^2)^{1/2}$$

3.3.14.7
surtension temporaire
surtension à fréquence industrielle de durée relativement longue

3.3.14.8
tension de service
tension appliquée à une isolation particulière lorsque l'équipement est alimenté en **tension assignée** ou toute tension comprise dans la **plage de tensions assignées** dans les **conditions normales de fonctionnement**

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Note 1 à l'article: Les transitoires externes ne sont pas pris en considération.

Note 2 à l'article: Les tensions de crête récurrentes ne sont pas prises en considération.

3.3.15 Classes d'équipement par rapport à la protection contre les chocs électriques

3.3.15.1
équipement de classe I
équipement dont l'**isolation principale** est utilisée comme une **protection principale**, et dont la liaison de protection et la **mise à la terre de protection** sont utilisées comme **protection supplémentaire**

Note 1 à l'article: Les **équipements de classe I** peuvent être fournis avec une **construction de classe II**.

[SOURCE: IEC 60050-851:2008, 851-15-10, modifiée – La définition a été revisée pour l'adapter au principe de **protection**.]

3.3.15.2
construction de classe II
partie d'un équipement dont la protection contre les chocs électriques repose sur une **double isolation** ou sur une **isolation renforcée**

3.3.15.3
équipement de classe II
équipement dont la protection contre les chocs électriques ne repose pas sur une **isolation principale** uniquement, mais dans lequel une **protection supplémentaire** est prévue, ces mesures ne comportant pas de moyen de **mise à la terre de protection** et ne dépendant pas des conditions d'installation

3.3.15.4
équipement de classe III
équipement dont la protection contre les chocs électriques dépend de l'alimentation de ES1 et dans lequel ES3 n'est pas généré

3.3.16 Termes relatifs aux éléments chimiques

3.3.16.1
matériau consommable
matériau utilisé par l'équipement pour remplir sa fonction prévue, et destiné à être remplacé ou reconstitué périodiquement ou occasionnellement, y compris un matériau ayant une durée de vie inférieure à celle de l'équipement

Note 1 à l'article: Les filtres à air ne sont pas considérés comme des matériaux consommables.

3.3.16.2
explosion
réaction chimique d'un composé chimique ou d'un mélange mécanique qui, quand elle commence, subit une combustion ou une décomposition très rapide, libérant de grands volumes de gaz fortement chauffés qui exercent une pression sur le milieu environnant

Note 1 à l'article: Une **explosion** peut également être une réaction mécanique dans laquelle un dysfonctionnement du conteneur provoque un échappement soudain de pression, et le contenu, depuis l'intérieur d'un appareil sous pression. En fonction du débit de l'échappement d'énergie, une **explosion** peut être catégorisée comme une déflagration, une détonation ou une rupture de pression.

3.3.16.3
explosif
substance ou mélange de substances qui peut subir une modification chimique rapide avec ou sans une source extérieure d'oxygène, générant de grandes quantités d'énergie généralement accompagnées par des gaz chauds

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3.3.16.4
substance chimique dangereuse
substance ayant la capacité d'affecter de façon préjudiciable la santé humaine

Note 1 à l'article: Les critères permettant de déterminer si une substance est classifiée comme dangereuse sont généralement définis par voie juridique ou réglementaire.

3.3.17 Batteries

3.3.17.1
batterie
assemblage d'un ou de plusieurs **éléments** prêt à être utilisé comme source d'énergie électrique caractérisé par sa tension, ses dimensions, l'assemblage de ses bornes, sa capacité et son débit

Note 1 à l'article: Le terme bloc de **batteries** est considéré comme étant équivalent à **batterie**.

3.3.17.2
élément
unité de base fabriquée pour fournir une source d'énergie électrique obtenue par transformation directe d'énergie chimique, qui se compose d'électrodes, de séparateurs, d'un électrolyte, d'un conteneur et de bornes

3.3.17.3
pile ou accumulateur bouton
élément de batterie individuel de petite dimension dont le diamètre est supérieur à la hauteur

3.3.17.4
température de charge la plus élevée
température la plus élevée spécifiée par le fabricant à un site sur chaque **élément** individuel comprenant la **batterie** pendant la charge d'un **accumulateur**

Note 1 à l'article: Il est généralement supposé que le fabricant du produit fini est en charge de spécifier la température de sécurité, la tension ou le courant de la **batterie**, sur la base des spécifications fournies par le fournisseur de la **batterie**.

3.3.17.5
température de charge la moins élevée
température la plus basse spécifiée par le fabricant à un site sur chaque **élément** individuel comprenant la **batterie** pendant la charge d'un **accumulateur**

Note 1 à l'article: Par hypothèse, le fabricant du produit fini est généralement en charge de spécifier la température sensible à la sécurité, la tension ou le courant de la **batterie**, sur la base des spécifications fournies par le fournisseur de la **batterie**.

3.3.17.6
courant de charge maximale
courant de charge le plus élevé spécifiée par le fabricant pendant la charge d'un **accumulateur**

3.3.17.7
tension de charge maximale
tension de charge la plus élevée spécifiée par le fabricant pendant la charge d'un **accumulateur**

3.3.17.8
accumulateur au lithium
batterie qui:

– comprend un ou plusieurs **éléments** au lithium; et
– comprend un boîtier et des bornes; et

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– peut avoir des dispositifs de commande électronique; et

– est prêt à l'emploi

Note 1 à l'article: des exemples d'**accumulateurs au lithium** comprennent un **accumulateur** au lithium-ion, un **accumulateur** polymère-lithium et un **accumulateur** lithium-manganèse.

3.3.18 Termes relatifs aux fils de bobinage totalement isolés

3.3.18.1
fil de bobinage totalement isolé
FIW
fil de cuivre rond émaillé de polyuréthane, classe 180

Note 1 à l'article: Les propriétés isolantes sont conformes à l'IEC 60317-0-7, à l'IEC 60317-56 et à l'IEC 60851-5:2008. Ces normes appellent également ce fil "fil sans défaut électrique", qu'elles définissent comme un "fil de bobinage qui ne présente pas de discontinuité électrique lorsqu'il est soumis aux essais dans des conditions spécifiques".

Note 2 à l'article: Le terme "fil sans défaut électrique" est souvent utilisé pour parler de **fil de bobinage totalement isolé**.

Note 3 à l'article: L'abréviation «**FIW**» est dérivée du terme anglais développé correspondant «fully insulated winding wire».

3.3.18.2
niveau de fil totalement isolé
plage de diamètres globaux d'un fil (FIW3 à FIW9)

3.3.19 exposition au bruit

3.3.19.1
dose acoustique calculée
CSD
estimation sur une semaine glissante de l'exposition au bruit, exprimée en pourcentage de la valeur maximale considérée comme sûre

Note 1 à l'article: voir B.4 de l'EN 50332-3:2017 pour des informations supplémentaires.

Note 2 à l'article: L'abréviation «CSD» est dérivée du terme anglais développé correspondant «calculated sound dose».

3.3.19.2
niveau d'exposition momentané
MEL
mesure de l'estimation du niveau d'exposition au bruit de 1 s à partir d'un signal d'essai spécifique appliqué aux deux canaux (voir l'EN 50332-1:2013, 4.2)

Note 1 à l'article: MEL est mesuré en dB(A).

Note 2 à l'article: voir B.3 de l'EN 50332-3:2017 pour des informations supplémentaires.

Note 3 à l'article: L'abréviation «MEL» est dérivée du terme anglais développé correspondant «momentary exposure level».

3.3.19.3
exposition au bruit
E
pression acoustique pondérée A (p) au carré et intégrée sur une période de temps établie, T

$$E = \int_0^T p(t)^2 \, \mathrm{d}t$$

Note 1 à l'article: L'unité SI est Pa^2 s.

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3.3.19.4
niveau d'exposition au bruit
SEL
mesure logarithmique de l'exposition au bruit par rapport à une valeur de référence , E_0, en général le seuil auditif de 1 kHz chez l'homme

$$\mathrm{SEL} = 10 \log_{10}\left(\frac{E}{E_0}\right)$$

Note 1 à l'article: SEL est mesuré en dB(A).

Note 2 à l'article: La valeur de référence , E_0, est en général le seuil auditif de 1 kHz chez l'homme.

Note 3 à l'article: Voir B.4 de l'EN 50332-3:2017 pour des informations supplémentaires.

Note 4 à l'article: L'abréviation «SEL» est dérivée du terme anglais développé correspondant «sound exposure level».

3.3.19.5
niveau de signal numérique par rapport à la pleine échelle
dBFS
niveau de l'onde sinusoïdale de 997 Hz hors courant continu dont la valeur crête positive limitée est une pleine échelle numérique positive, laissant le code correspondant à la pleine échelle numérique négative non utilisée

Note 1 à l'article: Les niveaux indiqués en dBFS sont toujours des valeurs efficaces.

Note 2 à l'article: Il n'est pas correct d'utiliser dBFS pour des niveaux non efficaces. La définition de la pleine échelle s'appuyant sur une onde sinusoïdale, le niveau des signaux dont le facteur de crête est inférieur à celui de l'onde sinusoïdale peut dépasser 0 dBFS. En particulier, les signaux carrés peuvent atteindre +3,01 dBFS.

4 Exigences générales

4.1 Généralités

4.1.1 Application des exigences d'acceptation des matériaux, composants et sous-ensembles

Les exigences sont spécifiées dans les articles correspondants et, lorsqu'une référence figure dans ces articles, dans les annexes correspondantes.

Lorsque la conformité des matériaux, des composants ou des sous-ensembles est démontrée par une inspection, cette conformité peut provenir de la révision de données publiées ou de résultats d'essais antérieurs.

Les composants internes et externes et les sous-ensembles conformes à l'IEC 60950-1 ou l'IEC 60065 sont acceptables en tant que partie de l'équipement traité dans le présent document sans autre évaluation que la considération de l'utilisation appropriée du composant ou du sous-ensemble dans le produit fini.

NOTE L'alinéa ci-dessus sera supprimé dans la prochaine révision du présent document, soumise au vote des Comités nationaux à ce moment-là. Il est ajouté ici pour favoriser la transition des dernières éditions de l'IEC 60950-1 et de l'IEC 60065 au présent document.

4.1.2 Utilisation de composants

Lorsque le composant ou une caractéristique d'un composant constitue une **protection** ou une partie d'une **protection**, les composants doivent satisfaire aux exigences du présent document ou, lorsque cela est spécifié dans un article d'exigences, aux aspects relatifs à la sécurité des normes IEC appropriées sur les composants.

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NOTE 1 Une norme IEC sur les composants est considérée comme appropriée uniquement si le composant en question relève clairement de son domaine d'application.

NOTE 2 L'essai applicable pour la conformité à une norme sur les composants est, en général, réalisé séparément.

Lorsqu'il est admis d'utiliser une norme IEC sur les composants, l'évaluation et les essais des composants doivent être réalisés comme suit:

– l'application et l'utilisation correctes d'un composant doivent être vérifiées conformément à ses caractéristiques assignées;
– un composant dont la conformité à une norme harmonisée avec la norme IEC sur les composants appropriée a été démontrée doit être soumis aux essais applicables du présent document en tant que partie de l'équipement, à l'exception des essais faisant partie de la norme IEC sur les composants appropriée;
– un composant dont la conformité à une norme appropriée comme ci-dessus n'a pas été démontrée doit être soumis aux essais applicables du présent document, en tant que partie de l'équipement, et aux essais applicables de la norme sur les composants, dans les conditions présentes dans l'équipement; et
– lorsque les composants sont utilisés dans des circuits non conformes à leurs caractéristiques assignées spécifiées, les composants doivent être soumis à l'essai dans les conditions présentes dans l'équipement. Le nombre d'échantillons exigé pour l'essai est, en général, identique à celui exigé par une norme équivalente.

La conformité est vérifiée par examen et par les données ou essais appropriés.

4.1.3 Conception et construction de l'équipement

L'équipement doit être conçu et monté de telle sorte que, dans les **conditions normales de fonctionnement** tel que spécifié dans l'Article B.2, les **conditions anormales de fonctionnement** tel que spécifié dans l'Article B.3 et les **conditions de premier défaut** tel que spécifié dans l'Article B.4, des **protections** soient prévues pour réduire la probabilité de blessure ou, en cas d'incendie, de dommage matériel.

Les parties de l'équipement pouvant provoquer des blessures ne doivent pas être **accessibles**, et les parties **accessibles** ne doivent pas provoquer de blessure.

La conformité est vérifiée par examen et par les essais appropriés.

4.1.4 Installation de l'équipement

À l'exception des spécifications de 4.1.6, l'évaluation de l'équipement conformément au présent document doit tenir compte des instructions des fabricants concernant l'installation, le déplacement, l'entretien et le fonctionnement, le cas échéant.

Les **enveloppes extérieures** assurant une fonction de **protection** doivent satisfaire aux dispositions de l'Annexe Y. Le **matériel pour installation extérieure** et les **enveloppes extérieures** doivent être adaptés à une utilisation à toutes les températures se trouvant dans la plage spécifiée par le fabricant. Si le fabricant n'a spécifié aucune plage, il doit alors s'agir:

– de la température ambiante minimale: –33 °C;
– de la température ambiante maximale: +40 °C.

La conformité est vérifiée par examen et par une évaluation des données fournies par le fabricant.

NOTE 1 Les valeurs de température reposent sur l'IEC 60721-3-4, Classe 4K2. Ces températures ne tiennent pas compte des environnements sévères (froid ou chaleur extrême, par exemple), ni n'incluent les dispositions en matière de chauffage par rayonnement solaire (charge solaire).

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NOTE 2 L'attention est portée sur l'IEC 61587-1 pour obtenir des informations supplémentaires relatives aux niveaux de performances C1, C2 et C3.

4.1.5 Aspects relatifs aux constructions et composants non traités spécifiquement

Lorsque l'équipement implique des technologies, des composants et des matériaux ou méthodes de construction non traités spécifiquement dans le présent document, l'équipement doit présenter des **protections** correspondant au moins à celles généralement prévues par le présent document et aux principes de sécurité énoncés ci-après.

Il convient que la nécessité d'exigences détaillées supplémentaires pour répondre à une situation nouvelle soit portée rapidement à l'attention du comité concerné.

4.1.6 Orientation lors du transport et de l'utilisation

Lorsqu'il est clair que l'orientation d'utilisation de l'équipement est susceptible d'avoir un effet significatif sur l'application des exigences ou sur les résultats des essais, toutes les orientations d'utilisation spécifiées dans les instructions d'installation ou utilisateur doivent être prises en compte. Toutefois, si l'équipement comporte des moyens de fixation par une **personne ordinaire** (des trous de vis pour la fixation directe à une surface de montage ou par l'utilisation de fixations ou d'éléments similaires, par exemple) qui sont soit fournis avec l'équipement soit aisément disponibles dans le commerce, toutes les positions probables de l'orientation de l'équipement doivent être prises en compte, y compris la possibilité de montage sur une surface non verticale, quelles que soient les instructions d'installation ou d'utilisation fournies par le fabricant.

En outre, pour les **équipements transportables**, toutes les orientations de transport doivent être prises en compte.

4.1.7 Choix de critères

Lorsque le présent document indique un choix entre différents critères de conformité ou entre différentes méthodes ou conditions d'essai, ce choix est spécifié par le fabricant.

4.1.8 Liquides et composants remplis de liquide (LFC)

À moins qu'il ne s'agisse d'un **isolant liquide**, les liquides doivent être traités comme des matériaux électriquement conducteurs.

Les exigences de construction et d'essai pour les LFC sous pression utilisés à l'intérieur de l'équipement afin d'éviter toute blessure provoquée par des fuites de liquide dans le LFC au sens du présent document doivent être conformes à l'Article G.15. Toutefois, l'Article G.15 ne s'applique pas:

– à un LFC étanche mais ouvert à l'atmosphère dans l'équipement; ou
– aux composants contenant de petites quantités de liquides non susceptibles d'engendrer une blessure (par exemple, écrans à cristaux liquides, condensateurs électrolytiques, caloducs refroidisseurs de liquide, etc.); ou
– aux **batteries à piles** liquides (pour les **batteries à piles** liquides, voir l'Annexe M); ou
– à un LFC et ses parties associées qui sont conformes à P.3.3; ou
– aux équipements contenant plus de 1 l de liquide.

4.1.9 Instruments de mesure électriques

Les instruments de mesure électriques doivent disposer d'une bande passante suffisante pour effectuer des lectures précises, prenant en compte l'ensemble des composants (courant continu, fréquence du **réseau d'alimentation**, haute fréquence et contenu harmonique) du paramètre mesuré.

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Si une valeur efficace est mesurée, il faut veiller à ce que l'appareil de mesure donne la valeur efficace vraie des formes d'onde non sinusoïdales comme celle des formes d'onde sinusoïdales.

Les mesures doivent être réalisées à l'aide d'un appareil de mesure dont l'impédance d'entrée influence peu les mesures.

4.1.10 Mesures de température

Sauf spécification contraire, lorsque le résultat d'un essai est susceptible de dépendre de la température ambiante, la plage de températures ambiantes de l'équipement spécifiée par le fabricant (T_{ma}) doit être prise en compte. Lors d'un essai réalisé à une température ambiante spécifique (T_{amb}), une extrapolation (supérieure et inférieure) des résultats de l'essai peut être utilisée pour considérer l'impact de T_{ma} sur le résultat. Les composants et les sous-ensembles peuvent être considérés en dehors de l'équipement si l'extrapolation et les résultats d'essai sont représentatifs de l'ensemble de l'équipement tel que soumis à l'essai. Les données d'essai et les spécifications du fabricant appropriées peuvent être examinées pour déterminer l'effet des variations de température sur un composant ou un sous-ensemble (voir B.1.5).

4.1.11 Conditions stables

Des conditions stables sont les conditions dans lesquelles l'équilibre thermique est considéré comme atteint (voir B.1.5).

4.1.12 Hiérarchie des protections

Les **protections** nécessaires pour les **personnes ordinaires** sont acceptables, mais pas systématiquement nécessaires, pour les **personnes averties** et les **personnes qualifiées**. De même, les **protections** nécessaires pour les **personnes averties** sont acceptables, mais pas systématiquement nécessaires, pour les **personnes qualifiées**.

Une **protection renforcée** peut être utilisée à la place d'une **protection principale**, d'une **protection supplémentaire** ou d'une **double protection**. Une **double protection** peut être utilisée à la place d'une **protection renforcée**.

Des **protections** autres que les **protections de l'équipement** sont spécifiées dans des articles correspondants.

4.1.13 Exemples mentionnés dans le présent document

Lorsque des exemples sont donnés dans le présent document, d'autres exemples, situations et solutions ne sont pas exclus.

4.1.14 Essais sur des parties ou des échantillons autres que sur le produit fini

Si un essai est réalisé sur une partie ou un échantillon en dehors du produit fini, l'essai doit être effectué comme si la partie ou l'échantillon se situait dans le produit fini.

4.1.15 Marquages et instructions

L'équipement qui, selon le présent document, doit:

– porter des marquages; ou
– présenter des instructions; ou
– disposer de **protections par instructions**

doit satisfaire aux exigences appropriées de l'Annexe F.

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La conformité est vérifiée par examen.

NOTE En Finlande, en Norvège et en Suède, l'**équipement enfichable de type A de classe I** prévu pour être raccordé à un autre équipement ou à un réseau doit, si la sécurité repose sur une connexion de mise à la terre fiable ou si les parasurtenseurs sont connectés entre les bornes du réseau et les parties **accessibles**, présenter un marquage spécifiant que l'équipement doit être connecté à un socle de prise de courant du **réseau d'alimentation** mis à la terre.

4.2 Classification des sources d'énergie

4.2.1 Source d'énergie de classe 1

Sauf spécification contraire, une source de classe 1 est une source d'énergie dont les niveaux ne dépassent pas les limites de classe 1 dans:

– les **conditions normales de fonctionnement**; et

– les **conditions anormales de fonctionnement** qui ne conduisent pas à une **condition de premier défaut**, et

– les **conditions de premier défaut** qui ne conduisent pas au dépassement des limites de classe 2.

Un **conducteur de protection** est considéré comme une source d'énergie électrique de classe 1.

4.2.2 Source d'énergie de classe 2

Sauf spécification contraire, une source de classe 2 est une source d'énergie dont les niveaux dépassent les limites de classe 1 et ne dépassent pas celles de classe 2 dans les **conditions normales de fonctionnement**, dans les **conditions anormales de fonctionnement** ou dans les **conditions de premier défaut**.

4.2.3 Source d'énergie de classe 3

Une source de classe 3 est une source d'énergie dont les niveaux dépassent les limites de classe 2 dans les **conditions normales de fonctionnement**, dans les **conditions anormales de fonctionnement** ou dans les **conditions de premier défaut**, ou toute source d'énergie déclarée comme étant une source de classe 3, comme indiqué en 4.2.4.

Un conducteur de neutre est considéré comme une source d'énergie électrique de classe 3.

4.2.4 Classification des sources d'énergie selon un mode déclaratif

Le fabricant peut déclarer:

– une source d'énergie de classe 1 comme étant une source d'énergie de classe 2 ou une source d'énergie de classe 3;

– une source d'énergie de classe 2 comme étant une source d'énergie de classe 3.

4.3 Protection contre les sources d'énergie

4.3.1 Généralités

Les termes "personnes", "corps" et "parties du corps" sont représentés par les sondes d'accessibilité de l'Annexe V.

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4.3.2 Protections destinées à protéger une personne ordinaire

4.3.2.1 Protections entre une source d'énergie de classe 1 et une personne ordinaire

Aucune **protection** n'est exigée entre une source d'énergie de classe 1 et une **personne ordinaire** (voir la Figure 9). Ainsi, une source d'énergie de classe 1 peut être **accessible** à une **personne ordinaire**.

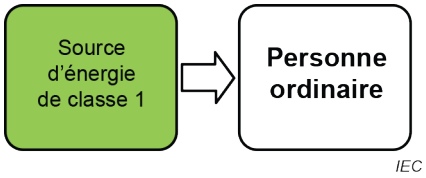


Figure 9 – Modèle pour protéger une personne ordinaire contre une source d'énergie de classe 1

4.3.2.2 Protections entre une source d'énergie de classe 2 et une personne ordinaire

Au moins une **protection principale** est exigée entre une source d'énergie de classe 2 et une **personne ordinaire** (voir la Figure 10).



Figure 10 – Modèle pour protéger une personne ordinaire contre une source d'énergie de classe 2

4.3.2.3 Protections entre une source d'énergie de classe 2 et une personne ordinaire dans les conditions d'entretien par une personne ordinaire

Si les conditions d'entretien par une **personne ordinaire** exigent qu'une **protection principale** soit ôtée ou supprimée, une **protection par instructions** telle que décrite dans l'Article F.5 doit être prévue et placée de telle sorte qu'une **personne ordinaire** prenne connaissance des instructions avant d'ôter ou de détruire la **protection principale** de l'équipement (voir la Figure 11).

La **protection par instructions** (voir l'Article F.5) doit inclure toutes les actions suivantes:

– identifier les parties et les emplacements de la source d'énergie de classe 2;
– spécifier des actions pour protéger les personnes de cette source d'énergie, et
– spécifier des actions pour rétablir ou restaurer la **protection principale**.

Si les conditions d'entretien par une **personne ordinaire** exigent qu'une **protection principale** soit ôtée ou supprimée, et lorsque l'équipement est destiné à un usage domestique, une **protection par instructions** (voir l'Article F.5), à l'attention des adultes, doit constituer un avertissement contre le retrait ou la destruction de la **protection principale** par les enfants.

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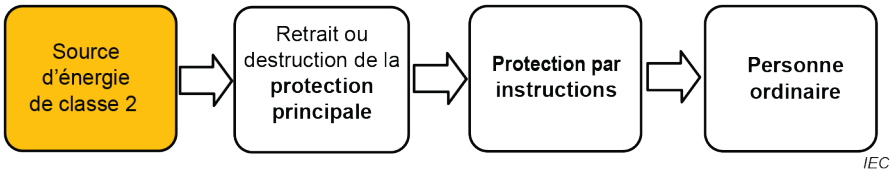


Figure 11 – Modèle pour protéger une personne ordinaire contre une source d'énergie de classe 2 dans les conditions d'entretien par une personne ordinaire

4.3.2.4 Protections entre une source d'énergie de classe 3 et une personne ordinaire

Sauf spécification contraire,

– une **protection principale d'équipement** et une **protection supplémentaire d'équipement** (formant une **double protection**); ou

– une **protection renforcée**

sont exigées entre une source d'énergie de classe 3 et une **personne ordinaire** (voir la Figure 12).

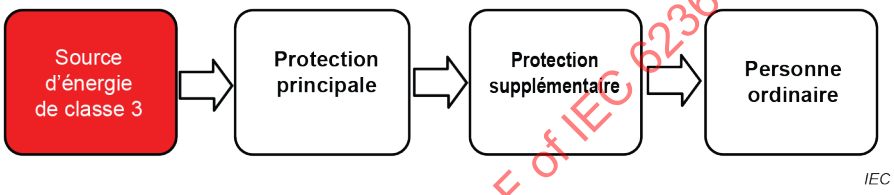


Figure 12 – Modèle pour protéger une personne ordinaire contre une source d'énergie de classe 3

4.3.3 Protections d'une personne avertie

4.3.3.1 Protections entre une source d'énergie de classe 1 et une personne avertie

Aucune **protection** n'est exigée entre une source d'énergie de classe 1 et une **personne avertie** (voir la Figure 13).

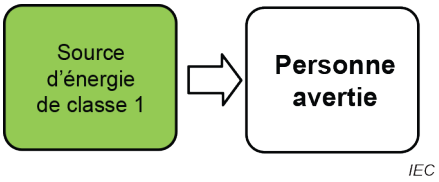


Figure 13 – Modèle pour protéger une personne avertie contre une source d'énergie de classe 1

4.3.3.2 Protections entre une source d'énergie de classe 2 et une personne avertie

Une **personne avertie** utilise une **protection de précaution** (voir la Figure 14). Aucune **protection** supplémentaire n'est exigée entre une source d'énergie de classe 2 et une **personne avertie**. Ainsi, une source d'énergie de classe 2 peut être **accessible** à une **personne avertie**.

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Figure 14 – Modèle pour protéger une personne avertie contre une source d'énergie de classe 2

4.3.3.3 Protections entre une source d'énergie de classe 3 et une personne avertie

Sauf spécification contraire,

– une **protection principale d'équipement** et une **protection supplémentaire d'équipement** (formant une **double protection**); ou

– une **protection renforcée**

est exigée entre une source d'énergie de classe 3 et une **personne avertie** (voir la Figure 15).

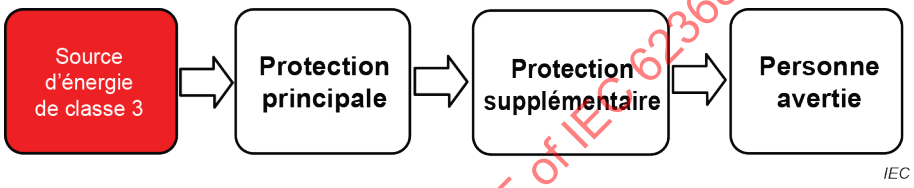


Figure 15 – Modèle pour protéger une personne avertie contre une source d'énergie de classe 3

4.3.4 Protection d'une personne qualifiée

4.3.4.1 Protections entre une source d'énergie de classe 1 et une personne qualifiée

Il n'est exigé aucune **protection** entre une source d'énergie de classe 1 et une **personne qualifiée**. Ainsi, une source d'énergie de classe 1 peut être **accessible** à une **personne qualifiée** (voir la Figure 16).

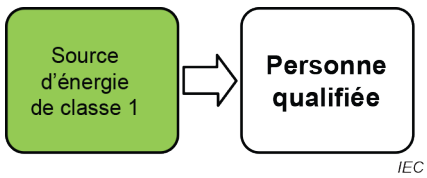


Figure 16 – Modèle pour protéger une personne qualifiée contre une source d'énergie de classe 1

4.3.4.2 Protections entre une source d'énergie de classe 2 et une personne qualifiée

Une **personne qualifiée** utilise une **protection mise en place grâce à l'expérience acquise** (voir la Figure 17). Aucune **protection** supplémentaire n'est exigée entre une source d'énergie de classe 2 et une **personne qualifiée**. Ainsi, une source d'énergie de classe 2 peut être **accessible** à une **personne qualifiée**.

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Figure 17 – Modèle pour protéger une personne qualifiée contre une source d'énergie de classe 2

4.3.4.3 Protections entre une source d'énergie de classe 3 et une personne qualifiée

Une **personne qualifiée** utilise une **protection mise en place grâce à l'expérience acquise** (voir la Figure 18). Sauf spécification contraire (voir l'exemple de 8.5.4), il n'est exigé aucune **protection** supplémentaire entre une source d'énergie de classe 3 et une **personne qualifiée**. Ainsi, une source d'énergie de classe 3 peut être **accessible** à une **personne qualifiée**.

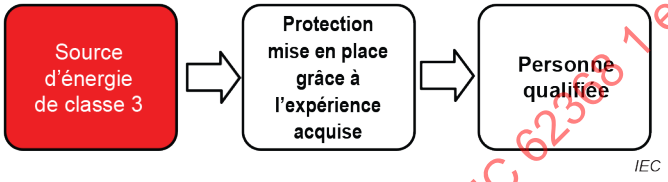


Figure 18 – Modèle pour protéger une personne qualifiée contre une source d'énergie de classe 3

Dans les conditions d'entretien de l'équipement sur une source d'énergie de classe 3, une **protection** prévue pour réduire la probabilité de blessure due à une réaction involontaire est exigée entre:

– une autre source d'énergie de classe 3, n'étant pas en cours d'entretien et à proximité de la source d'énergie de classe 3 en cours d'entretien; et

– une **personne qualifiée** (voir 0.5.7 et la Figure 19).

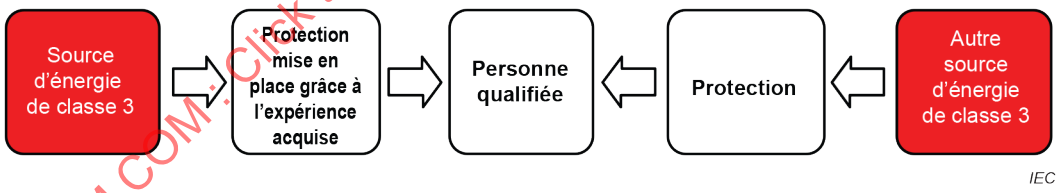


Figure 19 – Modèle pour protéger une personne qualifiée contre des sources d'énergie de classe 3 dans les conditions d'entretien de l'équipement

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4.3.5 Protections dans une zone à accès limité

Certains équipements sont destinés à être installés exclusivement dans des **zones à accès limité**. Ce type d'équipement doit présenter des **protections** telles qu'exigées en 4.3.3 pour les **personnes averties** et en 4.3.4 pour les **personnes qualifiées**.

4.4 Protections

4.4.1 Matériaux ou composants équivalents

Lorsque le présent document spécifie un paramètre particulier de **protection**, comme une classe thermique d'isolation ou une **classe d'inflammabilité du matériau**, une **protection** présentant un paramètre supérieur peut être utilisée.

NOTE Pour une hiérarchisation des **classes d'inflammabilité du matériau**, voir le Tableau S.1, le Tableau S.2 et le Tableau S.3.

4.4.2 Composition d'une protection

Une **protection** peut être composée d'un ou de plusieurs éléments.

4.4.3 Robustesse de la protection

4.4.3.1 Généralités

Lorsqu'une **protection** solide (par exemple, une **enveloppe**, une barrière, une i**solation solide**, du métal mis à la terre, du verre, etc.) est **accessible** à une **personne ordinaire** ou à une **personne avertie**, la **protection** doit être conforme aux essais de robustesse applicables tels que spécifiés de 4.4.3.2 à 4.4.3.10.

Pour une **protection accessible** après ouverture d'une **enveloppe** externe, voir 4.4.3.5.

Les exigences concernant:

– l'adhérence des revêtements métallisés; et
– les pièces de fixation adhésives servant de **protections**; et
– les parties qui peuvent supprimer une **protection** en cas de défaillance d'un adhésif

sont spécifiées dans l'Article P.4.

4.4.3.2 Essais de force constante

Une **enveloppe** ou barrière qui est **accessible** et qui est utilisée comme une **protection** des:

– **équipements transportables**; et
– **équipements portatifs**; et
– **équipement à enficher directement**

doit être soumise à l'essai de force constante de l'Article T.4.

Une **protection** qui est **accessible** et qui sert uniquement d'**enveloppe ignifuge** (contre le feu) ou de barrière contre le feu doit être soumise à l'essai de force constante de l'Article T.3.

Toutes les autres **enveloppes** ou barrières **accessibles** et utilisées comme une **protection** doivent être soumises à l'essai de force constante de l'Article T.5. Cette exigence ne s'applique pas au fond de l'équipement ayant une masse de plus de 18 kg à moins que les instructions utilisateur autorisent une orientation dans laquelle le fond de l'**enveloppe** devient le haut ou un côté de l'équipement.

Ce paragraphe ne s'applique pas au verre. Les exigences applicables au verre sont données en 4.4.3.6.

4.4.3.3 Essais de chute

Les équipements suivants doivent être soumis à l'essai de chute de l'Article T.7:

– **équipement portatif**;
– **équipements à enficher directement**;
– **équipement transportable**;
– **équipement mobile** qui exige d'être soulevé ou manipulé par une **personne ordinaire** dans le cadre de son utilisation prévue, y compris le déplacement de routine;

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NOTE Un exemple d'un tel équipement est une déchiqueteuse à papier posée sur un bac à ordure et nécessitant le déplacement de la déchiqueteuse pour vider le bac.

– les équipements de bureau ayant une masse de 7 kg ou moins et qui sont conçus pour être utilisés avec un des éléments suivants:
  - un combiné de téléphone relié par un câble; ou
  - un autre accessoire avec une fonction acoustique, tenu dans la main lors de son utilisation et relié par un câble; ou
  - un casque.

4.4.3.4 Essais de choc

Tous les équipements, autres que ceux spécifiés en 4.4.3.3, doivent être soumis à l'essai de choc de l'Article T.6.

L'essai de choc de l'Article T.6 n'est pas appliqué à ce qui suit:

– le fond d'une **enveloppe**, sauf si les instructions utilisateur autorisent une orientation dans laquelle le fond de l'**enveloppe** devient le haut ou un côté de l'équipement;
– le verre;

NOTE Les essais de choc sur le verre sont donnés en 4.4.3.6.

– la surface de l'**enveloppe** de l'**équipement stationnaire**, y compris l'équipement à encastrer, qui
  - n'est pas **accessible**; ou
  - protégé après l'installation.

4.4.3.5 Essais de protection accessible interne

Une **protection** interne solide **accessible** à une **personne ordinaire** après ouverture d'une **enveloppe** externe et dont la défaillance pourrait rendre les sources d'énergie de classe 2 ou de classe 3 **accessibles**, doit être soumise à l'essai de force constante de l'Article T.3.

4.4.3.6 Essais de choc sur le verre

Les exigences ci-dessous sont applicables à toutes les parties en verre, à l'exception:

– d'une glace d'exposition utilisée sur les photocopieurs, scanneurs et dispositifs analogues, lorsque le verre a fait l'objet de l'essai de force constante de l'Article T.3 et est pourvu d'un capot ou d'un dispositif de protection de la glace d'exposition; et
– des tubes cathodiques: les exigences relatives aux tubes cathodiques sont données à l'Annexe U; et
– le verre qui est feuilleté ou dont la construction est telle que les particules de verre ne se séparent pas l'une de l'autre en cas de bris de glace.

NOTE Le verre feuilleté inclut les constructions telles que le film plastique apposé sur un côté du verre.

Le verre qui est **accessible** à une **personne ordinaire** ou à une **personne avertie**:

– dont la surface dépasse 0,1 m^2; ou
– dont la dimension maximale dépasse 450 mm; ou
– empêchant l'accès aux sources d'énergie de classe 3 autres que PS3

doit être soumis à l'essai de choc sur le verre de l'Article T.9.

4.4.3.7 Essai de fixation du verre

Le verre feuilleté utilisé comme **protection** et empêchant l'accès aux sources d'énergie de classe 3 autres que PS3 doit être soumis aux essais de fixation suivants:

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– un essai de choc sur le verre (voir l'Article T.9) avec trois chocs successifs de 1 J chacun; et
– un essai de pousser/tirer de 10 N appliqué au centre du verre dans le sens le moins favorable.

NOTE Pour procéder à l'essai, n'importe quelle méthode adaptée peut être utilisée, comme l'utilisation de poignées d'aspiration ou en collant un support au verre.

4.4.3.8 Essais de matériau thermoplastique

Si une **protection** est composée d'un matériau thermoplastique moulé ou formé, cette **protection** doit être construite de sorte que toute contraction ou déformation du matériau due au relâchement des contraintes internes ne doit pas altérer sa fonction de **protection**. Le matériau thermoplastique doit être soumis à l'essai de relâchement des contraintes de l'Article T.8.

4.4.3.9 Protection contenant de l'air

Lorsqu'une **protection** est composée d'air (par exemple, une **distance dans l'air**), une barrière ou une **enveloppe** doit empêcher tout déplacement de l'air par une partie du corps ou une partie conductrice. La barrière ou l'**enveloppe** doit être conforme à l'essai de résistance mécanique spécifié à l'Annexe T, selon le cas.

4.4.3.10 Critères de conformité

Pendant et après les essais:

– *À l'exception de PS3, les sources d'énergie de classe 3 ne doivent pas devenir **accessibles** à une **personne ordinaire** ou à une **personne avertie**; et*
– *le verre:*
  - *ne doit pas se casser ou se fissurer; ou*
  - *ne doit pas expulser des morceaux de verre d'une masse supérieure à 30 g ou de dimension supérieure à 50 mm; ou*
  - *doit être soumis à l'essai de fragmentation de l'Article T.10 sur une éprouvette séparée; et*
– *toutes les autres **protections** doivent rester opérationnelles.*

4.4.4 Déplacement d'une protection par un isolant liquide

Si un **isolant liquide** déplace l'air composant une **protection**:

– les exigences de 5.4.12 et 6.4.9 s'appliquent à l'**isolant liquide**; et
– les exigences de 5.4.2 et 5.4.3 s'appliquent à l'équipement pourvu et dépourvu d'**isolant liquide**.

Une perte partielle ou totale d'**isolant liquide** doit être considérée comme une **condition anormale de fonctionnement** de l'équipement.

Si l'alimentation fournie aux parties plongées dans l'**isolant liquide** est déconnectée en cas de perte partielle ou totale d'**isolant liquide**, les exigences de 6.4.2 à 6.4.8 ne s'appliquent pas aux parties immergées. Un système d'interrupteur à flotteur conforme à l'Annexe K est un exemple de ce type de système de déconnexion.

NOTE Les exigences du présent document ne concernent pas l'utilisation d'**isolants liquides** pour remplacer une **isolation principale**, une **isolation supplémentaire** ou une **isolation renforcée**.

4.4.5 Verrouillages de sécurité

Sauf spécification contraire, si un **verrouillage de sécurité** est utilisé comme **protection** contre:

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– une source d'énergie de classe 2 ou de classe 3 pour une **personne ordinaire**; ou
– une source d'énergie de classe 3 pour une **personne avertie**

le **verrouillage de sécurité** doit satisfaire à l'Annexe K.

4.5 Explosion

4.5.1 Généralités

Une **explosion** peut être provoquée par

– une réaction chimique;
– une déformation mécanique d'un conteneur étanche;
– une combustion ou décomposition rapide, produisant un grand volume de gaz chaud;
– une pression élevée; ou
– une température élevée.

NOTE 1 En fonction du débit d'énergie, une **explosion** peut être catégorisée comme une déflagration, une détonation ou une rupture de pression.

NOTE 2 Un supercondensateur (un condensateur double couche, par exemple) est une source d'énergie élevée et peut exploser après une surcharge et d'une température élevée.

Pour les exigences concernant l'**explosion** des **batteries**, voir l'Annexe M.

4.5.2 Exigences

Dans les **conditions normales de fonctionnement** et dans les **conditions anormales de fonctionnement**, il ne doit pas se produire d'**explosion**.

Si une **explosion** se produit dans les **conditions de premier défaut**, elle ne doit pas provoquer de blessure et l'équipement doit être conforme aux parties appropriées du présent document.

La conformité est vérifiée par examen et par les essais spécifiés à l'Article B.2, à l'Article B.3 et à l'Article B.4.

4.6 Fixation des conducteurs

4.6.1 Exigences

Les conducteurs doivent être tels que le déplacement ne puisse supprimer une **protection**, tel que de réduire les **distances dans l'air** ou les **lignes de fuite** en dessous des valeurs spécifiées en 5.4.2 et 5.4.3.

La fixation des conducteurs doit être telle que, si un conducteur se desserre ou se détache, il ne peut supprimer une **protection**, au risque de réduire les **distances dans l'air** ou les **lignes de fuite** au-dessous des valeurs spécifiées en 5.4.2 et 5.4.3.

Pour les besoins de ces exigences, il est supposé que:

– deux fixations indépendantes ne se desserreront pas ni ne se détacheront en même temps; et
– les parties fixées par des vis ou des écrous avec des rondelles autobloquantes ou autre moyen de blocage ne risquent pas de se desserrer ou de se détacher.

NOTE Les rondelles élastiques et dispositifs analogues peuvent assurer un verrouillage satisfaisant.

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4.6.2 Critères de conformité

La conformité est vérifiée par examen, par mesure ou, en cas de doute, en réalisant l'essai de l'Article T.2 dans la direction la plus défavorable.

EXEMPLE Les constructions considérées comme satisfaisant aux exigences comprennent:

– les tubes ajustés (une gaine thermorétractable ou en caoutchouc, par exemple), appliqués sur le fil et ses extrémités;

– les conducteurs raccordés par soudage et maintenus en place à proximité de l'extrémité, indépendamment de la connexion soudée;

– les conducteurs raccordés par soudage et fermement accrochés avant soudage, à condition que l'orifice par lequel passe le conducteur ne soit pas indûment grand;

– les conducteurs raccordés aux bornes à vis, avec une fixation supplémentaire à proximité de la borne qui permet d'accrocher, pour des conducteurs toronnés, l'isolation et pas seulement les conducteurs;

– les conducteurs raccordés aux bornes à vis et munis d'extrémités peu susceptibles de se libérer (des attaches annulaires serties sur les conducteurs, par exemple). Toutefois, le pivotement de ce type d'extrémité est pris en compte; ou

– les conducteurs rigides courts qui restent en place lorsque la vis de la borne est desserrée.

4.7 Équipement pour insertion directe dans des socles d'alimentation

4.7.1 Généralités

Les équipements qui comportent des broches intégrées destinées à être insérées dans les socles d'**alimentation** ne doivent pas imposer de couple excessif aux socles. Les moyens utilisés pour retenir les broches doivent résister aux forces auxquelles celles-ci sont susceptibles d'être soumises en utilisation normale.

4.7.2 Exigences

La partie fiche d'**alimentation** doit être conforme à la norme applicable à la fiche d'**alimentation** correspondante.

L'équipement est inséré, comme en utilisation normale, dans un socle fixe ayant une configuration telle que prévue par le fabricant, qui peut pivoter autour d'un axe horizontal coupant les axes des alvéoles à une distance de 8 mm en arrière de la surface d'engagement du socle.

4.7.3 Critères de conformité

La conformité est vérifiée par examen et le couple supplémentaire qui doit être appliqué au socle pour maintenir la face d'insertion dans le plan vertical ne doit pas dépasser 0,25 Nm. Le couple nécessaire pour maintenir le socle lui-même dans le plan vertical n'est pas inclus dans cette valeur.

NOTE 1 En Australie et en Nouvelle-Zélande, la conformité est vérifiée conformément à la norme AS/NZS 3112.

NOTE 2 Au Royaume-Uni, l'essai de couple est réalisé en utilisant un socle conforme à la norme BS 1363, et la partie fiche doit être évaluée selon les articles applicables de la norme BS 1363.

4.8 Équipement contenant des piles ou accumulateurs boutons

4.8.1 Généralités

Ces exigences s'appliquent aux équipements, incorporant des télécommandes, qui:

– sont susceptibles d'être **accessibles** aux enfants; et

– contiennent des **piles ou accumulateurs boutons** dont le diamètre est inférieur ou égal à 32 mm.

Ces exigences ne s'appliquent pas:

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– aux **matériels professionnels**;
– aux équipements utilisés dans des emplacements où la présence d'enfants est peu probable; ou
– aux équipements contenant des **piles ou accumulateurs boutons** qui sont soudés en place.

4.8.2 Protection par instructions

Les équipements qui contiennent un ou plusieurs **piles ou accumulateurs boutons** doivent posséder une **protection par instructions** conforme à l'Article F.5.

La **protection par instructions** n'est pas exigée lorsque ces **batteries** ne sont pas destinées à être remplacées ou lorsqu'elles sont **accessibles** uniquement après un endommagement de l'équipement.

Les éléments de la **protection par instructions** doivent être comme suit:

– élément 1a: non disponible
– élément 2: "Ne pas ingérer la batterie. Risque de brûlure chimique" ou un libellé équivalent
– élément 3: le texte suivant ou équivalent

  [La télécommande fournie avec] Ce produit contient une pile ou accumulateur bouton. En cas d'ingestion, la pile ou l'accumulateur bouton, peut causer des brûlures internes sévères en à peine 2 heures qui peuvent être mortelles.
– élément 4: le texte suivant ou équivalent

  Conserver les batteries neuves et usagées hors de portée des enfants.

  Si le compartiment à batteries ne se ferme pas de manière sûre, ne plus utiliser le produit et le tenir hors de portée des enfants.

  En cas de soupçon d'ingestion d'une batterie ou d'introduction dans une partie quelconque du corps, demander immédiatement un avis médical.

4.8.3 Construction

Les équipements dont l'accès au compartiment à **batteries** est protégé par une porte/un couvercle doivent être conçus de manière à réduire la probabilité que des enfants retirent la **batterie** par l'une des méthodes suivantes:

– un **outil** (un tournevis ou une pièce, par exemple) est exigé pour ouvrir le compartiment à **batteries**, auquel cas un couple d'au moins 0,5 Nm et un angle de rotation d'au moins 90 degrés doivent être exigés pour ouvrir le compartiment; ou
– la réalisation d'au moins deux mouvements indépendants et simultanés sur le mécanisme de sécurité est nécessaire pour ouvrir manuellement la porte ou le couvercle du compartiment à **batteries**.

4.8.4 Essais

4.8.4.1 Séquence d'essais

Un échantillon doit être soumis aux essais applicables de 4.8.4.2 à 4.8.4.6. S'il est applicable, l'essai de 4.8.4.2 doit être réalisé le premier.

4.8.4.2 Essai de relâchement des contraintes

*Si le compartiment à **batteries** utilise des matériaux thermoplastiques moulés ou formés, l'échantillon comprenant l'équipement complet, ou l'**enveloppe** complète avec tout cadre de support, est soumis à l'essai de résistance de relâchement des contraintes de l'Article T.8.*

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*Pendant l'essai, la **batterie** peut être retirée.*

4.8.4.3 Essai de remplacement de la batterie

*Pour les équipements dont le compartiment à **batteries** est protégé par une porte/un couvercle, ce compartiment à **batteries** doit être ouvert et fermé et les **batteries** doivent être retirées et remplacées dix fois pour simuler un remplacement normal conformément aux instructions du fabricant.*

*Si la porte/le couvercle du compartiment à **batteries** est sécurisé(e) par une ou plusieurs vis, celles-ci sont desserrées puis resserrées en appliquant un couple linéaire continu conformément au Tableau 37, en utilisant un tournevis adapté ou une clé. Les vis sont à retirer et réinsérer complètement à chaque fois.*

4.8.4.4 Essai de chute

*Les équipements portables dont la masse est inférieure ou égale à 7 kg sont soumis à trois chutes sur une surface horizontale en les lâchant d'une hauteur de 1 m dans des positions susceptibles de produire la force maximale sur le compartiment à **batteries** conformément à l'Article T.7.*

Si l'équipement est une télécommande, il doit subir dix chutes.

4.8.4.5 Essai de choc

*La porte/le couvercle du compartiment à **batteries** doit être soumis à trois chocs appliqués perpendiculairement à la porte/au couvercle du compartiment à **batteries** conformément à la méthode d'essai de l'Article T.6 avec une force de:*

- *0,5 J (102 mm ± 10 mm de haut) pour les verres utilisés pour regarder, par exemple, une télévision 3D; ou*
- *2 J (408 mm ± 10 mm de haut) pour tous autres portes/couvercles.*

4.8.4.6 Essai d'écrasement

Les dispositifs de télécommande tenus à la main doivent être placés sur une surface support rigide fixe dans une position susceptible de produire les résultats les plus défavorables tant que la position peut être maintenue. Une force d'écrasement de (330 ± 5) N est appliquée aux surfaces exposées supérieure et arrière des dispositifs de télécommande placés de façon stable au moyen d'une surface plane mesurant approximativement 100 mm sur 250 mm pendant une durée de 10 s.

4.8.5 Critères de conformité

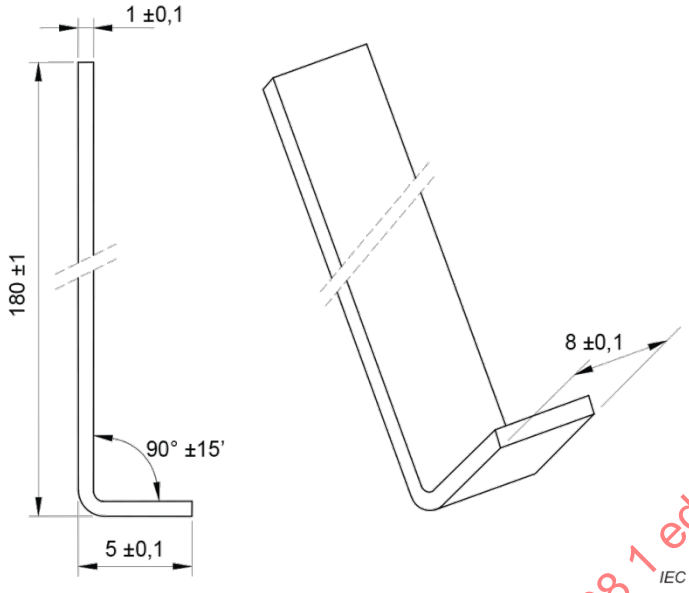
*La conformité est vérifiée en appliquant une force de (30 ± 1) N pendant 10 s sur la porte / le couvercle du compartiment à **batteries** au moyen de la version droite inarticulée de la sonde d'essai de la Figure V.1 à l'endroit le plus défavorable et dans la dir*ection la plus défavorable. La force doit être appliquée dans une seule direction à la fois.

*La porte/le couvercle du compartiment à **batteries** doit rester fonctionnel, et:*

- *la **batterie** ne doit pas devenir **accessible**; ou*
- *il ne doit pas être possible de retirer la **batterie** du produit avec le crochet d'essai de la Figure 20 en utilisant une force d'environ 20 N.*

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Dimensions en millimètres



Matériau: acier

Figure 20 – Crochet d'essai

4.9 Probabilité d'incendie ou de choc dû à l'entrée d'objets conducteurs

Lorsque l'entrée d'un objet conducteur depuis l'extérieur de l'équipement ou depuis une autre partie de l'équipement peut provoquer:

– sa mise en parallèle au sein des circuits PS3 et ES3; ou

– la mise en parallèle d'un circuit ES3 aux parties conductrices **accessibles** non mises à la terre;

les ouvertures supérieures et latérales au-dessus des circuits PS3 et ES3 doivent:

– être situées à plus de 1,8 m au-dessus du sol; ou

– être conformes à l'Annexe P.

La conformité est vérifiée par examen ou conformément à l'Annexe P.

4.10 Exigences sur les composants

4.10.1 Dispositif de déconnexion

L'équipement connecté au **réseau d'alimentation** doit comporter un dispositif de déconnexion conforme à l'Annexe L.

4.10.2 Interrupteurs et relais

Les interrupteurs et relais situés dans un circuit PS3 ou utilisés comme une protection doivent respectivement satisfaire à l'Article G.1 ou à l'Article G.2.

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5 Blessure due à un choc électrique

5.1 Généralités

Afin de réduire la probabilité d'effets douloureux et de blessures dus au courant électrique passant à travers le corps humain, l'équipement doit être muni des **protections** spécifiées dans l'Article 5.

5.2 Classification et limites des sources d'énergie électrique

5.2.1 Classifications des sources d'énergie électrique

5.2.1.1 ES1

ES1 est une source d'énergie électrique de classe 1 dont les niveaux de courant ou de tension

– ne dépassent pas les limites de ES1 dans
  - les **conditions normales de fonctionnement**, et
  - les **conditions anormales de fonctionnement**, et
  - les **conditions de premier défaut** d'un composant, dispositif ou isolation n'assurant pas une fonction de **protection**; et
– ne dépassent pas les limites de ES2 dans les **conditions de premier défaut** d'une **protection principale** ou d'une **protection supplémentaire**.

NOTE Pour les exigences d'accessibilité, voir 5.3.1.

5.2.1.2 ES2

ES2 est une source d'énergie électrique de classe 2 dont

– la **tension** et le **courant** dépassent les limites de ES1; et
– dans
  - les **conditions normales de fonctionnement**, et
  - les **conditions anormales de fonctionnement**, et
  - les **conditions de premier défaut**,

la **tension** ou le **courant** ne dépassent pas les limites de ES2.

NOTE Pour les exigences d'accessibilité, voir 5.3.1.

5.2.1.3 ES3

ES3 est une source d'énergie électrique de classe 3 dont la **tension** et le **courant** dépassent les limites de ES2.

5.2.2 Limites des sources d'énergie électrique ES1 et ES2

5.2.2.1 Généralités

Les limites spécifiées en 5.2.2 sont relatives à la terre ou bien à une partie **accessible**.

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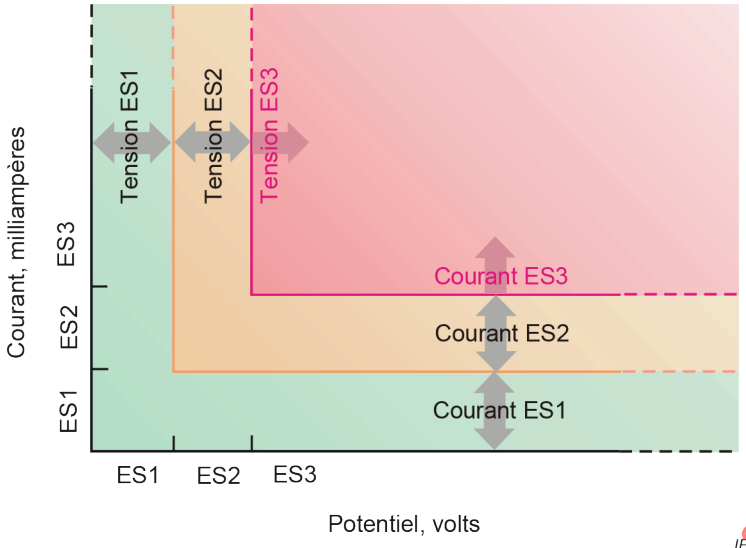


Figure 21 – Représentation des limites ES pour la tension et le courant

Pour toute tension jusqu'à la limite de tension, il n'existe pas de limite pour le courant. De même, pour les courants jusqu'à la limite de courant, il n'existe pas de limite pour la tension. Voir la Figure 21.

5.2.2.2 Limites de tension et de courant stables

Une classe de source d'énergie électrique est déterminée d'après la tension et le courant dans les **conditions normales de fonctionnement**, dans les **conditions anormales de fonctionnement** et dans les **conditions de premier défaut** (voir le Tableau 4).

Il s'agit des valeurs maximales pouvant être fournies par la source. Le régime stable est considéré comme établi lorsque les valeurs de tension ou de courant sont stables pendant 2 s ou plus. Sinon les limites de 5.2.2.3, 5.2.2.4 ou 5.2.2.5 s'appliquent, selon le cas.

NOTE Au Danemark, un avertissement (**protection** de marquage) pour le **courant de contact** élevé est exigé si le **courant de contact** dépasse les limites de 3,5 mA en courant alternatif ou 10 mA en courant continu

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Tableau 4 – Limites de sources d'énergie électrique pour les sources d'énergie ES1 et ES2 stables

<table>
<tr><th rowspan="2">Source d'énergie</th><th colspan="2">Limites de ES1</th><th colspan="2">Limites de ES2</th><th rowspan="2">ES3</th></tr>
<tr><th>Tension</th><th>Courant [a, c, d]</th><th>Tension</th><th>Courant [b, c, e]</th></tr>
<tr><td>en courant continu [c]</td><td>60 V</td><td>2 mA</td><td>120 V</td><td>25 mA</td><td rowspan="4">> ES2</td></tr>
<tr><td>en courant alternatif jusqu'à 1 kHz</td><td>30 V efficace
42,4 V crête</td><td rowspan="3">0,5 mA efficace
0,707 mA crête</td><td>50 V efficace
70,7 V crête</td><td rowspan="3">5 mA efficace
7,07 mA crête</td></tr>
<tr><td>en courant alternatif 1 kHz jusqu'à 100 kHz</td><td>30 V efficace + 0,4 f
42,4 V crête. + 0,4 $\sqrt{2}\,f$</td><td>50 V efficace + 0,9 f
70,7 V crête + 0,9 $\sqrt{2}\,f$</td></tr>
<tr><td>en courant alternatif au-dessus de 100 kHz</td><td>70 V efficace
99 V crête</td><td>140 V efficace
198 V crête</td></tr>
<tr><td>Combiné courant alternatif et courant continu</td><td>$\frac{U_{DC}(V)}{60}+\frac{U_{AC\ efficace}(V)}{U_{RMS\ efficace\ limite}}\le 1$
$\frac{U_{DC}(V)}{60}+\frac{U_{AC\ crête}(V)}{U_{limite\ crête}}\le 1$</td><td>$\frac{I_{DC}(mA)}{2}+\frac{I_{AC\ efficace}(mA)}{0,5}\le 1$
$\frac{I_{DC}(mA)}{2}+\frac{I_{AC\ crête}(mA)}{0,707}\le 1$</td><td>Voir la Figure 23</td><td>Voir la Figure 22</td><td>> ES2</td></tr>
<tr><td colspan="6">En alternative aux exigences ci-dessus, les valeurs ci-dessous peuvent être utilisées pour les formes d'onde purement sinusoïdales</td></tr>
<tr><th rowspan="2">Source d'énergie</th><th colspan="2">Limites de ES1</th><th colspan="2">Limites de ES2</th><th rowspan="2">ES3</th></tr>
<tr><th colspan="2">Courant [c]
Efficace</th><th colspan="2">Courant [c]
Efficace</th></tr>
<tr><td>en courant alternatif jusqu'à 1 kHz</td><td colspan="2">0,5 mA</td><td colspan="2">5 mA</td><td rowspan="3">> ES2</td></tr>
<tr><td>en courant alternatif 1 kHz jusqu'à 100 kHz</td><td colspan="2">0,5 mA × f [d]</td><td colspan="2">5 mA + 0,95 f [e]</td></tr>
<tr><td>en courant alternatif au-dessus de 100 kHz</td><td colspan="2">50 mA [d]</td><td colspan="2">100 mA [e]</td></tr>
<tr><td colspan="6">f est en kHz.
Les valeurs crête doivent être utilisées pour la tension et le courant non sinusoïdal. Les valeurs efficaces ne peuvent être utilisées que pour la tension et le courant sinusoïdal.
Voir 5.7 pour la mesure de la **tension de contact présumée** et du **courant de contact**.</td></tr>
</table>

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[a] Le courant est mesuré en utilisant le réseau de mesure spécifié à la Figure 4 de l'IEC 60990:2016.

[b] Le courant est mesuré en utilisant le réseau de mesure spécifié à la Figure 5 de l'IEC 60990:2016.

[c] Pour des formes d'onde sinusoïdales et le courant continu, le courant peut être mesuré en utilisant une résistance de 2 000 Ω.

[d] Au-delà de 22 kHz, la zone **accessible** est limitée à 1 cm^2.

[e] Au-delà de 36 kHz, la zone **accessible** est limitée à 1 cm^2.

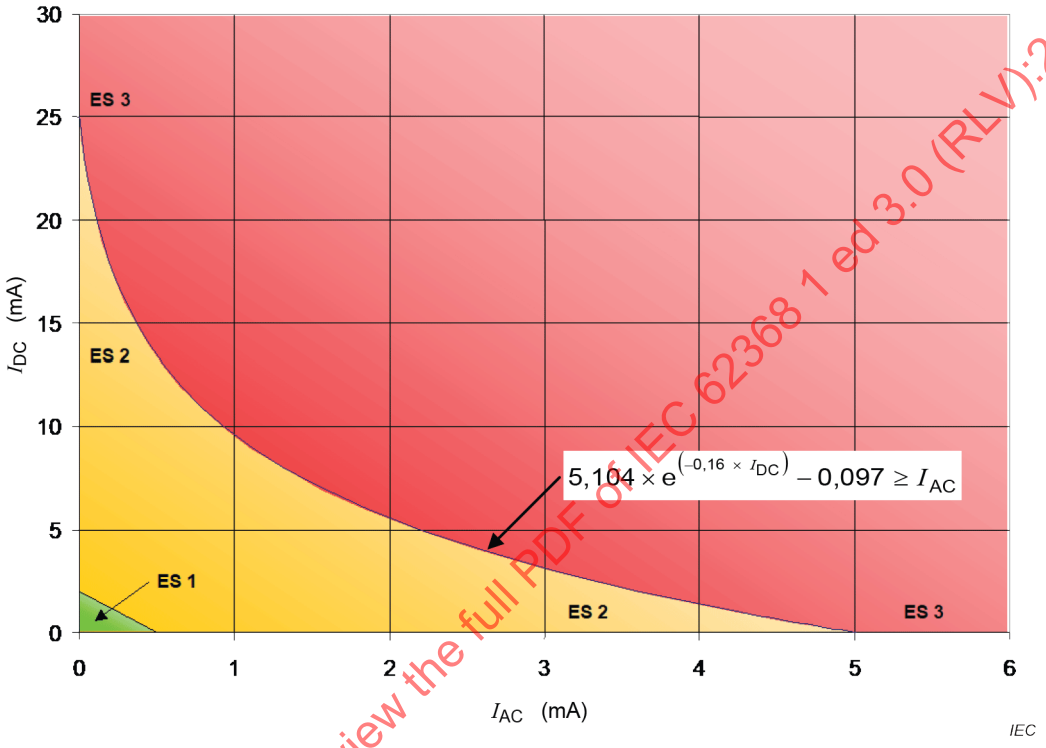


Figure 22 – Valeurs maximales pour les courants alternatif et continu combinés

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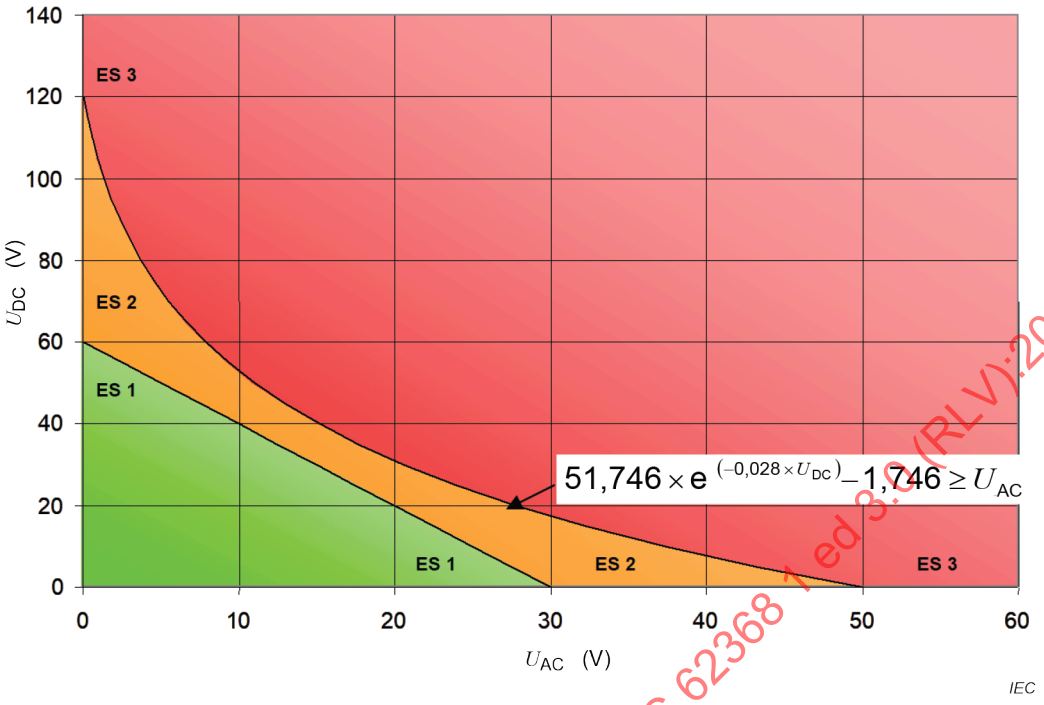


Figure 23 – Valeurs maximales pour les tensions alternative et continue combinées

5.2.2.3 Limites de capacité

Lorsque la source d'énergie électrique est un condensateur, la source d'énergie est classifiée à partir de la tension de charge et de la capacité.

La capacité est la valeur assignée du condensateur plus la tolérance spécifiée.

Les limites de ES1 et de ES2 pour les différentes valeurs de capacité sont indiquées au Tableau 5.

NOTE 1 Les valeurs de capacité pour ES2 proviennent du Tableau A.2 de l'IEC TS 61201:2007.

NOTE 2 Les valeurs pour ES1 sont calculées en divisant les valeurs du Tableau A.2 de l'IEC TS 61201:2007 par deux (2).

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Tableau 5 – Limites de sources d'énergie électrique pour un condensateur chargé

C nF	ES1 $U_{crête}$ V	ES2 $U_{crête}$ V	ES3 $U_{crête}$ V
300 au moins	60	120	> ES2
170	75	150	
91	100	200	
61	125	250	
41	150	300	
28	200	400	
18	250	500	
12	350	700	
8,0	500	1 000	
4,0	1 000	2 000	
1,6	2 500	5 000	
0,8	5 000	10 000	
0,4	10 000	20 000	
0,2	20 000	40 000	
0,133 au maximum	30 000	60 000	
Une interpolation linéaire peut être utilisée entre les deux points les plus proches.			

5.2.2.4 Limites d'impulsion unique

Lorsque la source d'énergie électrique est une impulsion unique, la source d'énergie est classifiée à partir de la tension et de la durée ou bien à partir du courant et de la durée. Les valeurs sont données au Tableau 6 et au Tableau 7. Si la tension dépasse la limite, alors le courant ne doit pas dépasser la limite. Si le courant dépasse la limite, la tension ne doit pas dépasser la limite. Les courants sont mesurés conformément à 5.7. Pour les impulsions répétitives, voir 5.2.2.5.

Pour les durées d'impulsion jusqu'à 10 ms, la limite de tension ou de courant valable pour 10 ms s'applique.

Si plusieurs impulsions sont détectées en l'espace de 3 s, la source d'énergie électrique est considérée comme une impulsion répétitive et les limites de 5.2.2.5 s'appliquent.

NOTE 1 Les limites d'impulsion sont calculées sur la base de la Figure 22 et du Tableau 10 de l'IEC TS 60479-1:2005.

NOTE 2 Ces impulsions uniques ne comprennent pas de transitoires.

NOTE 3 La durée d'impulsion est considérée comme le temps s'écoulant jusqu'au moment où la tension ou le courant dépasse les limites de ES1.

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Tableau 6 – Limites de tension pour les impulsions uniques

Durée d'impulsion au plus égale à ms	ES1 $U_{crête}$ V	ES2 $U_{crête}$ V	ES3 $U_{crête}$ V
10	60	196	> ES2
20		178	
50		150	
80		135	
100		129	
200 au moins		120	

Si la durée se situe entre les valeurs de deux des lignes, soit la valeur ES2 la plus faible de $U_{crête}$ doit être utilisée ou bien une interpolation linéaire entre deux lignes adjacentes peut être utilisée, en arrondissant la valeur de tension crête calculée au volt inférieur.

Si la tension de crête pour ES2 se situe entre les valeurs de deux des lignes, soit la valeur de la durée la plus courte peut être utilisée ou bien une interpolation linéaire peut être utilisée entre deux lignes adjacentes avec la durée calculée, arrondie à la milliseconde inférieure.

Tableau 7 – Limites de courant pour les impulsions uniques

Durée d'impulsion au plus égale à ms	ES1 $I_{crête}$ mA	ES2 $I_{crête}$ mA	ES3 $I_{crête}$ mA
10	2	200	> ES2
20		153	
50		107	
100		81	
200		62	
500		43	
1 000		33	
2 000 au moins		25	

Si la durée se situe entre les valeurs de deux des lignes, soit la valeur ES2 la plus faible de $I_{crête}$ doit être utilisée ou bien une interpolation linéaire entre deux lignes adjacentes peut être utilisée, en arrondissant la valeur calculée au milliampère inférieur.

Si le courant de crête pour ES2 se situe entre les valeurs de deux des lignes, soit la valeur de la durée la plus courte peut être utilisée ou bien une interpolation linéaire peut être utilisée entre deux lignes adjacentes avec la durée calculée, arrondie à la milliseconde inférieure.

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5.2.2.5 Limites pour les impulsions répétitives

À l'exception des impulsions traitées à l'Annexe H, une classe de source d'énergie électrique à impulsion répétitive est déterminée à partir, soit de la tension disponible, soit du courant disponible. Si la tension dépasse la limite, alors le courant ne doit pas dépasser la limite. Si le courant dépasse la limite, la tension ne doit pas dépasser la limite. Les courants sont mesurés conformément à 5.7.

Pour les temps de repos de moins de 3 s, les valeurs de crête de 5.2.2.2 s'appliquent. Pour des durées plus longues, les valeurs de 5.2.2.4 s'appliquent.

5.2.2.6 Signaux de sonnerie

Lorsque la source d'énergie électrique est un signal de sonnerie de réseau téléphonique analogique tel que défini à l'Annexe H, la classe de source d'énergie est considérée comme étant ES2.

5.2.2.7 Signaux audio

Pour les sources d'énergie électrique qui sont des signaux audio, les limites sont spécifiées à l'Article E.1.

5.3 Protection contre les sources d'énergie électrique

5.3.1 Généralités

À l'exception de ce qui est indiqué ci-dessous, des exigences de protection pour les parties **accessibles** aux **personnes ordinaires**, aux **personnes averties** et aux **personnes qualifiées** sont données en 4.3.

Les circuits ES2 ou ES3, dont sont déduits les circuits ES1 ou ES2 **accessibles**, doivent être séparés du **réseau d'alimentation** ES3 par une **double protection** ou une **protection renforcée**. De plus, ce qui suit s'applique:

– dans les **conditions de premier défaut** dans le circuit entre ES2/ES3 et l'ES1 **accessible**, les niveaux de courant ou de tension ne doivent pas dépasser les limites de ES1; et

– dans les **conditions de premier défaut** dans le circuit entre ES2/ES3 et l'ES2 **accessible**, les niveaux de courant ou de tension ne doivent pas dépasser les limites de ES2.

NOTE Un exemple de cette construction est un redresseur placé dans le circuit (secondaire) isolé d'une alimentation à découpage dans lequel plusieurs composants sont présents.

Les conducteurs nus en ES3 doivent être placés ou protégés de telle sorte qu'un contact involontaire avec ces conducteurs lors des opérations d'entretien par une **personne qualifiée** soit improbable (voir la Figure 19).

Pour une alimentation de secours par **batterie** capable d'assurer le retour de tension en entrée vers les bornes en courant alternatif d'entrée, voir 5.8.

5.3.2 Accessibilité des sources d'énergie électrique et des protections

5.3.2.1 Exigences

Les éléments suivants ne doivent pas être **accessibles** aux **personnes ordinaires**:

– les parties nues de ES2, à l'exception des broches des connecteurs. Cependant, ce type de broches ne doit pas être **accessible** dans les **conditions normales de fonctionnement** au calibre d'essai de la Figure V.3; et

– les parties nues de ES3, et

– une **protection principale** ES3.

Pour les parties nues du **matériel pour installation extérieure** qui sont **accessibles** à une **personne ordinaire** dans leur **emplacement pour installation extérieure** prévu, les éléments suivants ne doivent pas être **accessibles**:

– les parties nues dépassant 0,5 fois les limites de tension de ES1 dans les **conditions normales de fonctionnement**, les **conditions anormales de fonctionnement** et les **conditions de premier défaut** d'un composant, d'un dispositif ou d'une isolation qui ne fait pas office de **protection**; et

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– les parties nues dépassant les limites de tension de ES1 dans les **conditions de premier défaut** d'une **protection principale** ou d'une **protection supplémentaire** (voir 5.2.1.1).

Les éléments suivants ne doivent pas être **accessibles** aux **personnes averties**:

– les parties nues de ES3, et
– une **protection principale** ES3.

5.3.2.2 Exigences en matière de contact

Pour les tensions ES3 jusqu'à 420 V valeur de crête, la sonde d'essai adaptée indiquée à l'Annexe V ne doit pas entrer en contact avec une partie conductrice interne nue.

Pour les tensions ES3 supérieures à 420 V crête, la sonde d'essai adaptée indiquée à l'Annexe V ne doit pas entrer en contact avec une partie conductrice interne nue et doit garder un entrefer avec cette partie (voir la Figure 24).

Cet entrefer doit:

a) satisfaire à un essai de rigidité diélectrique conformément à 5.4.9.1 à une tension d'essai (continue ou alternative de crête) égale à la tension d'essai pour l'**isolation principale** du Tableau 26 correspondant à la valeur de crête de la **tension de service**; ou
b) présenter une distance minimale conformément au Tableau 8.

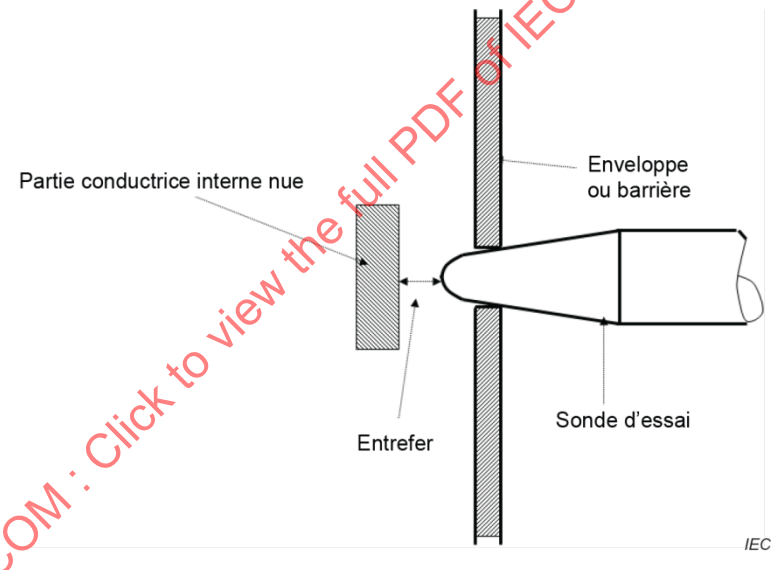


Figure 24 – Exigences en matière de contact avec des parties conductrices internes nues

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Tableau 8 – Distance d'entrefer minimale

Tension	Distance d'entrefer mm	
V en valeur crête ou en courant continu jusque et y compris	Degré de pollution	
	2	3
> 420 et ≤ 1 000	0,2	0,8
1 200	0,25	
1 500	0,5	
2 000	1,0	
2 500	1,5	
3 000	2,0	
4 000	3,0	
5 000	4,0	
6 000	5,5	
8 000	8,0	
10 000	11	
12 000	14	
15 000	18	
20 000	25	
25 000	33	
30 000	40	
40 000	60	
50 000	75	
60 000	90	
80 000	130	
100 000	170	
Une interpolation linéaire peut être utilisée entre les deux points les plus proches, la distance d'entrefer minimale calculée arrondie au 0,1 mm supérieur ou la valeur de la ligne suivante, la valeur la plus faible étant retenue. Pour les équipements destinés à être utilisés à une altitude de plus de 2 000 m, les valeurs de ce tableau sont multipliées par le facteur de multiplication applicable pour l'altitude souhaitée selon le Tableau 16.		

5.3.2.3 Critères de conformité

La conformité est vérifiée en réalisant l'essai de l'Article T.3.

En outre, pour les parties ES3 nues à une tension supérieure à 420 V crête, la conformité est vérifiée par une mesure de la distance ou par un essai de rigidité diélectrique.

Les composants et les sous-ensembles conformes aux normes IEC leur correspondant ne doivent pas être soumis à l'essai lorsqu'ils sont utilisés dans le produit fini.

5.3.2.4 Bornes utilisées pour connecter un fil dénudé

L'utilisation d'un fil dénudé pour réaliser une connexion avec une borne, destinée à être utilisée:

– par une **personne ordinaire** ne doit pas entraîner de contact avec ES2 ou ES3; et

– par une **personne avertie** ne doit pas entraîner de contact avec ES3.

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Pour les tensions de signal audio, voir le Tableau E.1 pour les valeurs de ES2 et de ES3. Les parties des bornes de signaux audio munies des **protections** du Tableau E.1 ne sont pas soumises aux essais.

La conformité est vérifiée par l'essai de V.1.6 pour chaque ouverture de borne de contact ainsi que toute ouverture à 25 mm de la borne. Pendant l'essai, aucune partie de la sonde insérée dans la borne ou l'ouverture ne doit toucher ES2 ou ES3.

5.4 Matériaux isolants et exigences

5.4.1 Généralités

5.4.1.1 Isolation

Les matériaux isolants, les **distances dans l'air**, les **lignes de fuite** et l'**isolation solide** qui assurent une fonction de **protection** sont désignés comme une **isolation principale**, une **isolation supplémentaire**, une **double isolation** ou une **isolation renforcée**.

5.4.1.2 Propriétés des matériaux isolants

Le choix et l'application de matériaux isolants doivent prendre en compte les besoins en termes de rigidité diélectrique, de résistance mécanique, de dimensions, de fréquences de **tension de service** et d'autres propriétés pour l'environnement de fonctionnement (température, pression, humidité et pollution) tels que spécifiés à l'Article 5 et à l'Annexe T.

Le matériau isolant ne doit pas être hygroscopique comme déterminé en 5.4.1.3.

5.4.1.3 Critères de conformité

La conformité est vérifiée par examen et, si nécessaire, par évaluation des données du matériau.

Si nécessaire, si les données ne confirment pas que le matériau est non hygroscopique, la nature hygroscopique du matériau est déterminée en soumettant le composant ou le sous-ensemble utilisant l'isolation en question au traitement d'humidité décrit en 5.4.8. L'isolation est ensuite soumise à l'essai de rigidité diélectrique approprié décrit en 5.4.9.1 alors qu'elle se trouve toujours dans l'enceinte humide ou dans le local dans lequel les échantillons ont été amenés à la température spécifiée.

5.4.1.4 Températures de fonctionnement maximales pour les matériaux, composants et systèmes

5.4.1.4.1 Exigences

Dans les **conditions normales de fonctionnement**, les températures du matériau isolant ne doivent pas dépasser la limite de température de l'EIS, y compris les matériaux isolants des composants, ni la limite de température maximale du système d'isolation telle que donnée au Tableau 9.

Pour les températures maximales inférieures ou égales à 100 ºC, aucun système d'isolation classifié n'est nécessaire. Un EIS non classifié est considéré comme étant de la Classe 105 (A).

5.4.1.4.2 Méthode d'essai

Les températures du matériau isolant sont mesurées conformément à B.1.5.

*L'équipement ou des parties de l'équipement fonctionnent dans les **conditions normales de fonctionnement** (voir l'Article B.2) comme suit:*

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– *pour le fonctionnement continu, jusqu'à ce que des conditions stables soient établies; et*

– *pour le* ***fonctionnement intermittent****, jusqu'à ce que des conditions stables soient établies, à l'aide des périodes assignées "ON" et "OFF"; et*

– *pour le* ***fonctionnement de courte durée****, pour le temps de fonctionnement spécifié par le fabricant.*

Des composants et d'autres parties peuvent être soumis à l'essai indépendamment du produit fini à condition que les conditions d'essai applicables au produit fini soient appliquées au composant ou à une partie du composant.

L'équipement destiné à la construction ou au montage, ou à être intégré dans un équipement de plus grande taille, est soumis à l'essai dans les conditions réelles ou simulées les plus défavorables spécifiées dans les instructions d'installation.

5.4.1.4.3 Critères de conformité

La température du matériau d'isolation électrique ou du système d'isolation électrique (EIS) ne doit pas dépasser les limites du Tableau 9.

Pour un matériau isolant unique, l'indice de température relatif déclaré du fabricant du matériau peut être utilisé s'il est adapté à la classe d'isolation applicable.

Pour un EIS, les données de classe thermique disponibles de l'EIS indiquées par le fabricant peuvent être utilisées si cela convient à la classe d'isolation applicable.

Pour les classifications thermiques au-dessus de la classe 105 (A), l'EIS doit satisfaire à l'IEC 60085.

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Tableau 9 – Limites de températures des matériaux, composants et systèmes

Partie	Température maximale T_{max} °C
Isolation, y compris l'isolation d'enroulement:	
du matériau ou de l'EIS de classe 105 (A)	100 [a]
du matériau ou de l'EIS de classe 120 (E)	115 [a]
du matériau ou de l'EIS de classe 130 (B)	120 [a]
du matériau ou de l'EIS de classe 155 (F)	140 [a]
du matériau ou de l'EIS de classe 180 (H)	165 [a]
du matériau ou de l'EIS de classe 200 (N)	180 [a]
du matériau ou de l'EIS de classe 220 (R)	200 [a]
du matériau ou de l'EIS de classe 250	225 [a]
Isolation du câblage interne et externe, y compris les cordons d'alimentation: – sans marquage de la température – avec marquage de la température	 70 Température marquée sur le câble ou la bobine, ou valeur assignée fixée par le fabricant
Autre isolation thermoplastique	Voir 5.4.1.10
Composants	Voir également l'Annexe G et 4.1.2
Les classes sont liées aux classes de températures des matériaux isolants électriques et des systèmes d'isolation électriques conformément à l'IEC 60085. Les désignations alphabétiques assignées sont données entre parenthèses. Pour chaque matériau, les données de ce matériau doivent être prises en compte pour déterminer la température maximale appropriée.	
[a] Si la température d'un enroulement est déterminée par des thermocouples, ces valeurs sont réduites de 10 K, excepté dans le cas d'un – moteur, ou – un enroulement avec thermocouples intégrés.	

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5.4.1.5 Degrés de pollution

5.4.1.5.1 Généralités

Les différents degrés de pollution de l'environnement de fonctionnement ou du microenvironnement pour les produits traités par le présent document sont donnés ci-dessous.

Degré de pollution 1

Absence de pollution ou uniquement pollution sèche, non conductrice. La pollution n'exerce aucune influence.

NOTE 1 À l'intérieur de l'équipement, des composants ou des sous-ensembles étanches de manière à exclure la poussière et l'humidité constituent des exemples du **degré de pollution** 1.

Degré de pollution 2

Uniquement pollution non conductrice, si ce n'est qu'une conductivité temporaire provoquée par la condensation est attendue ponctuellement.

NOTE 2 Le **degré de pollution** 2 est généralement adapté aux équipements couverts par le domaine d'application du présent document.

Degré de pollution 3

Pollution conductrice ou pollution sèche non conductrice devenant conductrice en raison de la condensation, ce qui est attendu.

5.4.1.5.2 Essai pour l'environnement de degré de pollution 1 et pour un isolant

Un échantillon est soumis à la séquence de cycles thermiques de 5.4.1.5.3.

Après refroidissement jusqu'à la température ambiante, l'échantillon est soumis à l'épreuve hygroscopique de 5.4.8.

*Si l'essai est réalisé pour la vérification de **l'isolation solide** faite dans un isolant, comme exigé en 5.4.4.3, le conditionnement est suivi immédiatement par l'essai de rigidité diélectrique de 5.4.9.1.*

*Pour les cartes imprimées, la conformité est vérifiée par examen visuel. Il ne doit pas y avoir de délaminage affectant les **lignes de fuite** nécessaires à la satisfaction des exigences du **degré de pollution** 1.*

Pour des éléments autres que les cartes imprimées, la conformité est vérifiée par examen de la section et il ne doit pas y avoir de vides apparents ou fissures dans le matériau isolant.

5.4.1.5.3 Procédure d'essai de cycles thermiques

Un échantillon d'un composant ou d'un sous-ensemble est soumis à la séquence suivante d'essais. L'échantillon est soumis 10 fois à la séquence suivante de cycles thermiques:

68 h	*à*	*($T_1 \pm 2$) °C;*
1 h	*à*	*(25 ± 2) °C;*
2 h	*à*	*(0 ± 2) °C;*
≥ 1 h	*à*	*(25 ± 2) °C.*

$T_1 = T_2 + T_{ma} - T_{amb} + 10$ K ou 85 °C, selon celui qui est le plus élevé. Cependant, la marge de 10 K n'est pas ajoutée si la température est mesurée par un thermocouple enfoui ou par la méthode par résistance.

T_2 est la température des parties mesurée au cours de l'essai décrit en 5.4.1.4.

La signification de T_{ma} et T_{amb} est donnée en B.2.6.1.

Le temps nécessaire pour le passage d'une température à une autre n'est pas spécifié, mais il est permis que le passage soit progressif.

5.4.1.6 Isolation dans les transformateurs à dimensions variables

Si l'isolation d'un transformateur présente différentes **tensions de service** sur la longueur de l'enroulement, les **distances dans l'air**, les **lignes de fuite** et les distances dans l'isolation peuvent varier de façon correspondante.

NOTE Un exemple d'une telle construction est un enroulement 30 kV, constitué de multiples bobines connectées en série, et mises à la terre ou connectées en un point commun à une extrémité.

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5.4.1.7 Isolation dans les circuits générant des impulsions de démarrage

Pour les circuits générant des impulsions de démarrage supérieures à ES1 (par exemple, pour allumer une lampe à décharge), les exigences relatives à l'**isolation principale**, à l'**isolation supplémentaire** et à l'**isolation renforcée** s'appliquent aux **lignes de fuite** et aux distances dans l'isolation.

NOTE 1 Pour les **tensions de service** dans les cas ci-dessus, voir 5.4.1.8.1 i).

NOTE 2 Si l'impulsion de démarrage est une forme d'onde en courant alternatif, la largeur de l'impulsion est déterminée en prenant en compte les valeurs de crête de la forme d'onde en courant alternatif.

Les **distances dans l'air** sont déterminées à l'aide de l'une des méthodes suivantes:

– déterminer la **distance dans l'air** minimale selon 5.4.2; ou

– effectuer l'un des essais de rigidité diélectrique suivants, les bornes de connexion du circuit des impulsions de démarrage (par exemple une lampe) étant court-circuitées ensemble:

  - l'essai donné en 5.4.9.1; ou
  - effectuer 30 impulsions dont l'amplitude est égale à la plus élevée des tensions d'essai exigées indiquées en 5.4.9.1 à l'aide d'un générateur d'impulsions externe. La largeur de l'impulsion doit être supérieure ou égale à l'impulsion de démarrage générée en interne.

La conformité est vérifiée par examen ou essai. Pendant l'essai, l'isolation ne doit présenter aucun signe de rupture ou de contournement.

5.4.1.8 Détermination de la tension de service

5.4.1.8.1 Généralités

Pour la détermination des **tensions de service**, toutes les exigences suivantes s'appliquent:

a) les parties conductrices **accessibles** non mises à la terre sont par hypothèse mises à la terre;

b) si un enroulement du transformateur ou une autre partie n'est pas connecté(e) à un circuit qui établit son potentiel par rapport à la terre, l'enroulement ou l'autre partie sont par hypothèse reliés à la terre au point où la **tension de service** la plus élevée est obtenue;

c) à l'exception des spécifications de 5.4.1.6, pour une isolation entre deux enroulements du transformateur, la tension la plus élevée entre deux points dans les deux enroulements est la **tension de service**, en tenant compte des tensions auxquelles les enroulements d'entrée seront connectés;

d) à l'exception des spécifications de 5.4.1.6, pour l'isolation entre un enroulement du transformateur et une autre partie, la tension la plus élevée entre un point sur l'enroulement et l'autre partie est la **tension de service**;

e) dans le cas d'une **double isolation**, la **tension de service** appliquée à l'**isolation principale** est déterminée en imaginant l'**isolation supplémentaire** en court-circuit, et inversement. Pour une **double isolation** entre les enroulements d'un transformateur, le court-circuit est par hypothèse situé au point où la **tension de service** la plus élevée est produite à travers l'autre isolation;

f) lorsque la **tension de service** est déterminée par mesure, la tension d'entrée fournie à l'équipement doit être la **tension assignée** ou la tension comprise dans la **plage de tensions assignées** qui produit la valeur mesurée la plus élevée;

g) la **tension de service** entre un point quelconque du circuit alimenté par le **réseau d'alimentation** et

  – une quelconque partie reliée à la terre; et

  – un point quelconque d'un circuit isolé du **réseau d'alimentation**,

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doit être prise comme la plus grande des deux valeurs suivantes:

– la **tension assignée** ou la tension supérieure de la **plage de tensions assignées**; et

– la tension mesurée;

h) lors de la détermination de la **tension de service** pour un **circuit externe** ES1 ou ES2, les tensions normales de fonctionnement doivent être prises en compte. Si les tensions de fonctionnement ne sont pas connues, la **tension de service** doit être établie comme les limites supérieures de ES1 ou ES2 selon le cas. Des signaux de courte durée (comme une sonnerie de téléphone) ne doivent pas être pris en compte pour la détermination de la **tension de service**;

i) pour les circuits générant des impulsions de démarrage (par exemple, les lampes à décharge, voir 5.4.1.7), la **tension de service** est la valeur de crête des impulsions alors que la lampe est connectée, mais avant qu'elle ne s'allume. La fréquence de la **tension de service** permettant de déterminer la **distance dans l'air** minimale doit être inférieure à 30 kHz. La **tension de service** pour déterminer les **lignes de fuite** minimales est la tension mesurée après l'allumage de la lampe.

5.4.1.8.2 Tension de service efficace

Les conditions à court terme (par exemple, des signaux de sonnerie de téléphone cadencés dans les **circuits externes**) et les transitoires non répétitifs (par exemple, en raison des perturbations atmosphériques) ne sont pas pris en compte pour déterminer la **tension de service efficace**.

NOTE Les **lignes de fuite** sont déterminées à partir des **tensions de service efficaces**.

5.4.1.9 Surfaces isolantes

Une surface isolante **accessible** est considérée comme couverte d'une feuille métallique fine pour la détermination des **distances dans l'air**, des **lignes de fuite** et des distances dans l'isolation (voir la Figure O.13).

5.4.1.10 Parties thermoplastiques sur lesquelles les parties métalliques conductrices sont montées directement

5.4.1.10.1 Exigences

Les parties thermoplastiques sur lesquelles des parties métalliques conductrices sont montées directement doivent être suffisamment résistantes à l'échauffement si le ramollissement du plastique est susceptible de provoquer le dysfonctionnement d'une **protection**.

La conformité est vérifiée par examen des données de l'essai Vicat ou de l'essai à la bille du fabricant du matériau. Si les données ne sont pas disponibles, la conformité est vérifiée soit par l'essai Vicat décrit en 5.4.1.10.2, soit par l'essai à la bille décrit en 5.4.1.10.3.

5.4.1.10.2 Essai Vicat

*La température mesurée dans les **conditions normales de fonctionnement**, telles que spécifiées à l'Article B.2, doit être au moins inférieure de 15 K à la température de ramollissement Vicat telle que spécifiée dans l'essai Vicat B50 de l'ISO 306.*

*La température mesurée dans les **conditions anormales de fonctionnement** de l'Article B.3 doit être inférieure à la température de ramollissement Vicat.*

*La température de ramollissement Vicat d'une partie non métallique soutenant des parties dans un circuit alimenté par le **réseau d'alimentation** ne doit pas être inférieure à 125 °C.*

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5.4.1.10.3 Essai à la bille

La conformité est vérifiée en soumettant la partie à l'essai à la bille conformément à l'IEC 60695-10-2. L'essai est effectué dans une étuve à une température de $(T - T_{amb} + T_{ma} + 15\ °C) \pm 2\ °C$ *(voir B.2.6.1 pour une explication de* T*,* T_{ma} *et de* T_{amb}*). Cependant, une partie thermoplastique soutenant des parties dans un circuit alimenté par le* ***réseau d'alimentation*** *est soumise à l'essai à une température minimale de 125 °C.*

Après l'essai, la dimension d *(diamètre de l'indentation) ne doit pas dépasser 2 mm.*

L'essai n'est pas effectué s'il apparaît clairement à l'examen des caractéristiques physiques du matériau que ce dernier répond aux exigences de cet essai.

5.4.2 Distances dans l'air

5.4.2.1 Exigences générales

Les **distances dans l'air** doivent être dimensionnées de manière à ce que la probabilité de rupture due aux

– **surtensions temporaires**, et
– aux tensions transitoires qui peuvent entrer dans l'équipement, et
– **tensions de crête récurrentes** et leurs fréquences associées générées à l'intérieur de l'équipement

soit réduite.

Toutes les **distances dans l'air** et tensions d'essai exigées s'appliquent jusqu'à 2 000 m d'altitude. Pour des altitudes plus élevées, les facteurs de multiplication de 5.4.2.5 s'appliquent après une interpolation linéaire, mais avant l'arrondi vers le haut, et avant d'appliquer tout autre facteur de multiplication tel qu'indiqué dans le Tableau 10, le Tableau 11, le Tableau 14 et le Tableau 15.

NOTE Pour les distances entre les contacts des **verrouillages de sécurité**, voir l'Annexe K. Pour les distances entre les contacts de **dispositifs de déconnexion**, voir l'Annexe L. Pour les distances entre les contacts des composants, voir l'Annexe G. Pour les connecteurs, voir G.4.1.

Sauf spécification contraire du fabricant et prévision de moyens permettant de garantir des **distances dans l'air** minimales pendant tous les modes de fonctionnement normal, la bobine mobile et les parties conductrices adjacentes d'un haut-parleur sont considérées comme étant en connexion conductrice.

Pour déterminer la **distance dans l'air**, la valeur la plus élevée des deux procédures suivantes doit être utilisée:

– Procédure 1: déterminer les **distances dans l'air** selon 5.4.2.2.
– Procédure 2: déterminer les **distances dans l'air** selon 5.2.2.3. En variante, le caractère approprié des **distances dans l'air** peut être déterminé en réalisant un essai de rigidité électrique conformément à 5.2.2.4, auquel cas, les valeurs selon la procédure 1 doivent être maintenues.

Pour la Catégorie de Surtension II, les **distances dans l'air** dans les circuits connectés à un **réseau d'alimentation** en courant alternatif ne dépassant 420 V crête (300 V efficace) peuvent en variante être déterminées conformément à l'Annexe X.

5.4.2.2 Procédure 1 de détermination des distances dans l'air

Pour déterminer la tension à utiliser au Tableau 10 et au Tableau 11, la tension la plus élevée est utilisée selon le cas:

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– la valeur crête de la **tension de service** sur la **distance dans l'air**;

– les tensions crêtes récurrentes, le cas échéant, sur la **distance dans l'air**;

– pour les circuits reliés au **réseau d'alimentation** en courant alternatif: la **surtension temporaire**, qui est prise égale à 2 000 V crête si la tension nominale du système du **réseau d'alimentation** en courant alternatif ne dépasse par 250 V, et égale à 2 500 V crête si la tension nominale du système du **réseau d'alimentation** en courant alternatif dépasse 250 V, sans dépasser 600 V.

  En variante, la **surtension temporaire** peut être déterminée selon 5.3.3.2.3 de l'IEC 60664-1:2007 à la discrétion du fabricant, auquel cas la référence à une "isolation solide" en 5.3.3.2.3 de l'IEC 60664-1:2007 est remplacée par "distances dans l'air". De plus, la valeur à court terme égale à U_n + 1 200 V est prise égale à la tension à utiliser au Tableau 10.

  NOTE U_n est la tension phase-neutre nominale du système d'alimentation dont le neutre est mis à la terre.

Cette tension doit être utilisée pour déterminer la **distance dans l'air** comme suit:

– les valeurs de **distance dans l'air** du Tableau 10 pour les circuits avec des fréquences fondamentales jusqu'à 30 kHz; ou

– les **valeurs de distance** dans l'air du Tableau 11 pour les circuits avec des fréquences fondamentales supérieures à 30 kHz; ou

– les valeurs les plus élevées de la **distance dans l'air** du Tableau 10 et du Tableau 11 pour les circuits présentant des fréquences inférieures à 30 kHz et supérieures à 30 kHz.

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Tableau 10 – Distances dans l'air minimales pour des tensions avec des fréquences jusqu'à 30 kHz

Tension jusque et y compris valeur de crête	**Isolation principale ou isolation supplémentaire** mm			**Isolation renforcée** mm		
	Degré de pollution			**Degré de pollution**		
	1 [a]	**2**	**3**	**1** [a]	**2**	**3**
330	0,01	0,2	0,8	0,02	0,4	1,5
400	0,02			0,04		
500	0,04			0,08		
600	0,06			0,12		
800	0,13			0,26		
1 000	0,26	0,26		0,52	0,52	
1 200	0,42			0,84		
1 500	0,76			1,52		1,6
2 000	1,27			2,54		
2 500	1,8			3,6		
3 000	2,4			4,8		
4 000	3,8			7,6		
5 000	5,7			11,0		
6 000	7,9			15,8		
8 000	11,0			20		
10 000	15,2			27		
12 000	19			33		
15 000	25			42		
20 000	34			59		
25 000	44			77		
30 000	55			95		
40 000	77			131		
50 000	100			175		
60 000	120			219		
80 000	175			307		
100 000	230			395		

Une interpolation linéaire peut être utilisée entre les deux points les plus proches, les **distances dans l'air** minimales calculées étant arrondies à l'incrément spécifié supérieur suivant. Pour les valeurs:

– ne dépassant pas 0,5 mm, l'incrément spécifié est de 0,01 mm; et

– dépassant 0,5 mm, l'incrément spécifié est de 0,1 mm.

[a] Les valeurs pour le **degré de pollution** 1 peuvent être utilisées si un échantillon satisfait aux essais de 5.4.1.5.2.

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Tableau 11 – Distances dans l'air minimales pour des tensions avec des fréquences supérieures à 30 kHz

Tension jusque et y compris valeur de crête	**Isolation principale ou isolation supplémentaire** mm	**Isolation renforcée** mm
600	0,07	0,14
800	0,22	0,44
1 000	0,6	1,2
1 200	1,68	3,36
1 400	2,82	5,64
1 600	4,8	9,6
1 800	8,04	16,08
2 000	13,2	26,4
Une interpolation linéaire peut être utilisée entre les deux points les plus proches, les **distances dans l'air** minimales calculées étant arrondies à l'incrément spécifié supérieur suivant. Pour les valeurs: – ne dépassant pas 0,5 mm, l'incrément spécifié est de 0,01 mm; et – dépassant 0,5 mm, l'incrément spécifié est de 0,1 mm. Pour le **degré de pollution** 1, utiliser un facteur de multiplication de 0,8. Pour le **degré de pollution** 3, utiliser un facteur de multiplication de 1,4.		

5.4.2.3 Procédure 2 de détermination des distances dans l'air

5.4.2.3.1 Généralités

La dimension pour une **distance dans l'air** soumise à des tensions transitoires du **réseau d'alimentation** ou d'un **circuit externe** est déterminée à partir de la **tension de tenue exigée** pour la **distance dans l'air** considérée.

Chaque **distance dans l'air** doit être déterminée selon les étapes suivantes:

– déterminer la tension transitoire selon 5.4.2.3.2; et
– déterminer la **tension de tenue exigée** selon 5.4.2.3.3; et
– déterminer la **distance dans l'air** minimale selon 5.4.2.3.4.

5.4.2.3.2 Détermination des tensions transitoires

5.4.2.3.2.1 Généralités

Les tensions transitoires peuvent être déterminées en fonction de leur origine ou peuvent être mesurées selon 5.4.2.3.2.5.

Si différentes tensions transitoires affectent la même **distance dans l'air**, la valeur la plus élevée de ces tensions est utilisée. Les valeurs ne sont pas ajoutées les unes aux autres.

Le **matériel pour installation extérieure** relié au **réseau d'alimentation** doit être adapté pour la **tension transitoire du réseau d'alimentation** prévue dans l'emplacement d'installation.

Les éléments suivants doivent être pris en compte:

– le courant de défaut présumé de l'alimentation du **matériel pour installation extérieure** peut être supérieur à celui du matériel pour installation intérieure (voir l'IEC 60364-4-43); et

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– la **tension transitoire du réseau d'alimentation** du **matériel pour installation extérieure** peut être supérieure à celle du matériel pour installation intérieure.

Les composants à l'intérieur du **matériel pour installation extérieure** qui réduisent la **tension transitoire du réseau d'alimentation** ou le courant de défaut présumé doivent satisfaire aux exigences de la série IEC 61643.

NOTE 1 La catégorie de surtension du **matériel pour installation extérieure** est en principe considérée comme étant l'une des suivantes:

– si l'alimentation est assurée par l'intermédiaire du câblage normal de l'installation des bâtiments, catégorie de surtension II;

– si l'alimentation est assurée depuis le système de distribution du **réseau d'alimentation**, catégorie de surtension III;

– si à l'origine ou à la proximité de l'origine de l'installation électrique, catégorie de surtension IV.

NOTE 2 Pour plus d'informations relatives à la protection contre les surtensions, voir l'IEC 60364-5-53.

La conformité est vérifiée par examen de l'équipement, des instructions de l'installation et, le cas échéant, par les essais de composants applicables spécifiés dans la série IEC 61643.

5.4.2.3.2.2 Détermination des tensions transitoires du réseau d'alimentation en courant alternatif

Pour les équipements à alimenter par le **réseau d'alimentation** en courant alternatif, la valeur de la **tension transitoire du réseau** d'alimentation dépend de la catégorie de surtension et de la tension du **réseau d'alimentation** en courant alternatif, et est donnée au Tableau 12. En général, les **distances dans l'air** dans l'équipement prévu pour être raccordé au **réseau d'alimentation** en courant alternatif doivent être conçues pour la Catégorie de Surtension II.

NOTE Voir l'Annexe I pour plus de recommandations sur la détermination des catégories de surtension.

L'équipement susceptible, une fois installé, d'être soumis à des tensions transitoires dépassant celles prévues pour la catégorie de surtension pour laquelle il est conçu exige une protection supplémentaire à l'extérieur de l'équipement. Dans ce cas, les instructions d'installation doivent indiquer la nécessité d'une protection externe.

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Tableau 12 – Tensions transitoires du réseau d'alimentation

Tension du réseau d'alimentation en courant alternatif [a] jusque et y compris V en valeur efficace	**Tension transitoire du réseau d'alimentation[b]** V en valeur crête			
	Catégorie de Surtension			
	I	**II**	**III**	**IV**
50	330	500	800	1 500
100 [c]	500	800	1 500	2 500
150 [d]	800	1 500	2 500	4 000
300 [e]	1 500	2 500	4 000	6 000
600 [f]	2 500	4 000	6 000	8 000

[a] Pour l'équipement prévu pour être raccordé à une alimentation à 3 conducteurs triphasée, ne présentant pas de conducteur neutre, la tension d'alimentation du **réseau d'alimentation** en courant alternatif est la tension entre phases. Dans tous les autres cas, dans lesquels un conducteur neutre est présent, il s'agit d'une tension phase-neutre.

[b] La **tension transitoire du réseau d'alimentation** constitue toujours l'une des valeurs du tableau. L'interpolation n'est pas admise.

[c] Au Japon, la valeur des **tensions transitoires du réseau d'alimentation** pour la tension d'alimentation nominale du **réseau d'alimentation** en courant alternatif de 100 V est déterminée à partir des colonnes applicables à la tension d'alimentation nominale du **réseau d'alimentation** en courant alternatif de 150 V.

[d] Y compris 120 V/208 V et 120 V/240 V.

[e] Y compris 230 V/400 V et 277 V/480 V.

[f] Y compris 400 V/690 V.

5.4.2.3.2.3 Détermination des tensions transitoires du réseau d'alimentation en courant continu

Si un système de distribution d'alimentation en courant continu mis à la terre est entièrement contenu dans un seul bâtiment, la tension transitoire est sélectionnée comme suit:

– si le système de distribution d'alimentation en courant continu est mis à la terre en un seul point, la valeur de crête de la tension transitoire est supposée être de 500 V; ou

– si le système de distribution d'alimentation en courant continu est mis à la terre à la source et au niveau de l'équipement, la valeur de crête de la tension transitoire est supposée être de 350 V; ou

NOTE La connexion à la terre de protection peut être à la source du système de distribution d'alimentation en courant continu ou au niveau de l'emplacement de l'équipement, ou les deux (voir la Recommandation K.27 de l'UIT-T).

– si le câblage associé au système de distribution d'alimentation en courant continu mesure moins de 4 m ou est entièrement installé dans un conduit métallique continu, la valeur de crête de la tension transitoire est supposée être de 150 V.

Si un système de distribution d'alimentation en courant continu n'est pas mis à la terre ou n'est pas contenu dans le même bâtiment, la tension transitoire par rapport à la terre doit être supposée égale à la **tension transitoire du réseau d'alimentation** dans le **réseau d'alimentation** à partir duquel l'alimentation en courant continu est dérivée.

Si le système de distribution d'alimentation en courant continu ne se trouve pas dans le même bâtiment, et est construit à l'aide de techniques d'installation et de protection identiques à celles des **circuits externes**, la tension transitoire doit être déterminée à l'aide de la classification appropriée décrite en 5.4.2.3.2.4.

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Si l'équipement est alimenté par une **batterie** particulière sans moyen de recharge à partir d'une alimentation du **réseau d'alimentation** sans retrait de l'équipement, la tension transitoire ne doit pas être prise en compte.

Lors de la détermination de la **tension transitoire du réseau d'alimentation** en courant continu, l'installation et la source du **réseau d'alimentation** en courant continu doivent être prises en compte. Si elles ne sont pas connues, la **tension transitoire du réseau d'alimentation** sur le **réseau d'alimentation** en courant continu d'un **matériel pour installation extérieure** doit être prise comme étant égale à 1,5 kV.

Si le système de distribution d'alimentation en courant continu ne se trouve pas dans le même bâtiment, le fabricant doit déclarer la **tension transitoire du réseau d'alimentation** sur l'alimentation du **réseau d'alimentation** en courant continu dans les instructions d'installation.

5.4.2.3.2.4 Détermination des tensions transitoires du circuit externe

La valeur applicable de la tension transitoire qui peut apparaître sur un **circuit externe** doit être déterminée à l'aide du Tableau 13. Lorsque plus d'un emplacement ou d'une condition est applicable, la tension transitoire la plus élevée s'applique. Une sonnerie ou un autre signal interrompu ne doit pas être pris en compte si la tension de ce signal est inférieure à celle de la tension transitoire.

Si la tension transitoire est inférieure à la tension crête du signal de courte durée (comme une sonnerie de téléphone), la tension crête du signal de courte durée doit être utilisée comme tension transitoire.

Si les tensions transitoires du **circuit externe** sont réputées supérieures aux valeurs indiquées au Tableau 13 , la valeur connue doit être utilisée.

NOTE 1 L'Australie a publié ses limites de surtension dans l'AS/ACIF G624:2005.

NOTE 2 Des mesures adaptées sont censées avoir été prises pour réduire la probabilité que les tensions transitoires présentées à l'équipement dépassent les valeurs spécifiées au Tableau 13. Dans les installations où des tensions transitoires présentées à l'équipement sont censées dépasser les valeurs spécifiées au Tableau 13, des mesures supplémentaires telles qu'une limitation des surtensions peuvent se révéler nécessaires.

NOTE 3 En Europe, l'exigence relative à l'interconnexion avec un **circuit externe** est également donnée dans l'EN 50491-3:2009, *Exigences générales relatives aux systèmes électroniques pour les foyers domestiques et les bâtiments (HBES) et aux Systèmes de Gestion Technique du Bâtiment (SGTB) – Partie 3: Exigences de sécurité électrique*.

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Tableau 13 – Tensions transitoires du circuit externe

ID	Type de câble	Conditions supplémentaires	Tensions transitoires
1	Conducteur à paires [a] – blindé ou non blindé	Le bâtiment ou la structure peut ou peut ne pas disposer d'une liaison équipotentielle	1 500 V 10/700 µs Différentiel uniquement si un conducteur est mis à la terre dans l'équipement
2	Tous les autres conducteurs	Le **circuit externe** n'est pas mis à la terre à chaque extrémité, mais il présente une référence à la terre (par exemple, entre la connexion et le **réseau d'alimentation**)	**Tension transitoire du réseau d'alimentation** ou tension transitoire du **circuit externe** du circuit à partir duquel le circuit en question est dérivé, en prenant la valeur la plus élevée
3	Câble coaxial dans le système de distribution du câble	Équipement autre que des répéteurs coaxiaux alimentés. Le blindage du câble est mis à la terre au niveau de l'équipement	4 000 V 10/700 µs Conducteur central au blindage
4	Câble coaxial dans le système de distribution du câble	Répéteurs coaxiaux alimentés (câble coaxial jusqu'à 4,4 mm). Le blindage du câble est mis à la terre au niveau de l'équipement	5 000 V 10/700 µs Conducteur central au blindage
5	Câble coaxial dans le système de distribution du câble	Équipement autre que des répéteurs coaxiaux alimentés. Le blindage du câble n'est pas mis à la terre au niveau de l'équipement. Le blindage du câble est mis à la terre à l'entrée du bâtiment	4 000 V 10/700 µs Conducteur central au blindage 1 500 V 1,2/50 µs blindage à la terre
6	Câble coaxial	Le câble se connecte à une antenne extérieure	pas de transitoire [b]
7	Conducteur à paires [a]	Le câble se connecte à une antenne extérieure	pas de transitoire [b]
8	Câble coaxial dans le bâtiment [b]	La connexion du câble venant de l'extérieur du bâtiment est réalisée via un point de transfert. Le blindage du câble coaxial depuis l'extérieur du bâtiment et le blindage du câble coaxial du câble situé dans le bâtiment sont connectés ensemble et connectés à la terre.	Non applicable

En général, pour les **circuits externes** installés complètement dans la même structure du bâtiment, les transitoires ne sont pas pris en compte. Cependant, un conducteur est considéré comme quittant le bâtiment s'il s'achève sur un équipement mis à la terre vers un réseau de mise à la terre différent.

Les effets des tensions stables non souhaitées générées à l'extérieur de l'équipement (par exemple, différences de potentiel de terre et tensions induites sur les réseaux de télécommunication par les systèmes de train électrique) sont contrôlés par les pratiques d'installation. Ces pratiques dépendent de l'application et ne sont pas traitées par le présent document.

Pour qu'un câble blindé entraîne une réduction dans les transitoires, le blindage doit être continu, mis à la terre aux deux extrémités et présenter une impédance de transfert maximale de 20 Ω/km (pour f inférieur à 1 MHz).

NOTE 1 Les appareils domestiques tels que les produits audio, vidéo et multimédia sont désignés par ID 6, 7 et 8.

NOTE 2 En Norvège et en Suède, le blindage du câble sur les câbles coaxiaux n'est généralement pas mis à la terre à l'entrée du bâtiment (voir la note en 5.7.7). Pour les conditions d'installation, voir l'EN 60728-11.

[a] Un conducteur à paires comprend une paire torsadée.

[b] Ces câbles ne sont pas soumis à des transitoires mais ils peuvent être affectés par une tension de décharge électrostatique de 10 kV (d'une capacité de 1 nF). L'effet de ces tensions de décharge électrostatique n'est pas pris en compte lors de la détermination des **distances dans l'air**. La conformité est vérifiée par l'essai de G.10.4.

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5.4.2.3.2.5 Détermination des niveaux de tension transitoire par mesure

La tension transitoire à travers la **distance dans l'air** est mesurée à l'aide de la procédure suivante.

Pendant la mesure, l'équipement n'est pas connecté au **réseau d'alimentation** ni à un quelconque **circuit externe**. Seuls les parasurtenseurs internes à l'équipement situés dans les circuits connectés au **réseau d'alimentation** sont déconnectés. Si l'équipement est destiné à être utilisé avec une alimentation séparée, cette dernière est connectée à l'équipement pendant la mesure.

Pour mesurer la tension transitoire à travers une **distance dans l'air**, le générateur d'impulsions d'essai approprié de l'Annexe D est utilisé pour générer les impulsions. Au moins trois impulsions de polarités alternées, avec des intervalles d'au moins 1 s entre les impulsions, sont appliquées entre tous les points applicables.

a) Tensions transitoires venant d'un **réseau d'alimentation** en courant alternatif

Le générateur d'impulsions d'essai du circuit 2 du Tableau D.1 est utilisé pour générer des impulsions 1,2/50 µs égales aux **tensions transitoires** du réseau d'alimentation en courant alternatif, entre les points suivants:

– entre phases;
– tous les conducteurs de ligne reliés galvaniquement ensemble et le neutre;
– tous les conducteurs de ligne reliés galvaniquement ensemble et la terre de protection; et
– le neutre et la terre de protection.

b) Tensions transitoires venant d'un **réseau d'alimentation** en courant continu

Le générateur d'impulsions d'essai du circuit 2 du Tableau D.1 est utilisé pour générer des impulsions 1,2/50 µs égales aux **tensions transitoires** du réseau d'alimentation en courant continu, aux points suivants:

– les points de connexion d'alimentation positif et négatif; et
– tous les points de connexion d'alimentation reliés ensemble et la terre de protection.

c) Tensions transitoires d'un **circuit externe**

Le générateur d'essai adapté de l'Annexe D est utilisé pour générer des impulsions applicables et décrites au Tableau 13 qui sont appliquées entre tous les points de connexion suivants du **circuit externe** d'un type d'interface unique:

– chaque paire de bornes dans une interface (par exemple, A et B ou tête et nuque); et
– toutes les bornes d'un type d'interface unique reliées ensemble et la terre.

Un dispositif de mesure de tension est connecté à travers la **distance dans l'air** concernée.

S'il existe plusieurs circuits identiques, un seul est soumis à l'essai.

5.4.2.3.3 Détermination de la tension de tenue exigée

La **tension de tenue exigée** est égale à la tension transitoire déterminée en 5.4.2.3.2, à l'exception des cas suivants:

– Si un circuit isolé du **réseau d'alimentation** est connecté à la borne principale de mise à la **terre de protection** par l'intermédiaire d'un **conducteur de liaison de protection**, la **tension de tenue exigée** peut être d'une catégorie de surtension inférieure ou une tension du **réseau d'alimentation** en courant alternatif inférieure (voir le Tableau 12). Pour un **réseau d'alimentation** en courant alternatif jusqu'à 50 V efficace inclus, aucun réglage n'est effectué.
– Dans un circuit isolé du **réseau d'alimentation** alimenté par une source en courant continu disposant d'un filtrage capacitif, et connecté à la terre de protection, la **tension de tenue exigée** doit par hypothèse être égale à la valeur de crête de la tension continue de la source, ou à la valeur de crête de la **tension de service** du circuit isolé du **réseau d'alimentation**, la valeur la plus élevée étant retenue.

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– Si l'équipement est alimenté par une **batterie** particulière sans moyen de recharge à partir d'un **réseau d'alimentation** sans retrait de l'équipement, la tension transitoire est nulle et la **tension de tenue exigée** est égale à la valeur de crête de la **tension de service**.

5.4.2.3.4 Détermination des distances dans l'air avec la tension de tenue exigée

Chaque **distance dans l'air** doit être conforme à la valeur applicable du Tableau 14.

Tableau 14 – Distances dans l'air minimales avec la tension de tenue exigée

Tension de tenue exigée	Isolation principale ou isolation supplémentaire mm			Isolation renforcée mm		
V en valeur crête ou en courant continu jusque et y compris	Degré de pollution			Degré de pollution		
	1 [a]	2	3	1 [a]	2	3
330	0,01	0,2	0,8	0,02	0,4	1,5
400	0,02			0,04		
500	0,04			0,08		
600	0,06			0,12		
800	0,10			0,2		
1 000	0,15			0,3		
1 200	0,25			0,5		
1 500	0,5			1,0		
2 000	1,0			2,0		
2 500	1,5			3,0		
3 000	2,0			3,8		
4 000	3,0			5,5		
5 000	4,0			8,0		
6 000	5,5			8,0		
8 000	8,0			14		
10 000	11			19		
12 000	14			24		
15 000	18			31		
20 000	25			44		
25 000	33			60		
30 000	40			72		
40 000	60			98		
50 000	75			130		
60 000	90			162		
80 000	130			226		
100 000	170			290		

Une interpolation linéaire peut être utilisée entre les deux points les plus proches, les **distances dans l'air** minimales calculées doivent être arrondies à l'incrément spécifié supérieur suivant. Pour les valeurs:

– ne dépassant pas 0,5 mm, l'incrément spécifié est de 0,01 mm; et

– dépassant 0,5 mm, l'incrément spécifié est de 0,1 mm.

[a] Les valeurs pour le **degré de pollution** 1 peuvent être utilisées si un échantillon satisfait aux essais de 5.4.1.5.2.

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5.4.2.4 Détermination du caractère approprié d'une distance dans l'air établi d'après l'essai de rigidité diélectrique

*Les **distances dans l'air** doivent supporter un essai de rigidité diélectrique. L'essai peut être réalisé à l'aide d'une tension d'impulsion, d'une tension en courant alternatif ou d'une **tension en courant continu**. La **tension de tenue exigée** est déterminée selon 5.4.2.3.*

L'essai de tension de tenue aux chocs est effectué avec une tension présentant une forme d'onde adaptée (voir l'Annexe D avec les valeurs spécifiées au Tableau 15. Cinq impulsions de chaque polarité sont appliquées avec un intervalle d'au moins 1 s entre les impulsions.

L'essai de tension en courant alternatif est réalisé à l'aide d'une tension sinusoïdale avec les valeurs crête spécifiées au Tableau 15, appliquée pendant 5 s.

*L'essai de **tension en courant continu** est réalisé à l'aide d'une **tension en courant continu** spécifiée au Tableau 15 appliquée pendant 5 s dans une polarité et ensuite pendant 5 s dans la polarité inverse.*

Tableau 15 – Tensions d'essai de rigidité diélectrique

Tension de tenue exigée jusque et y compris kV de crête	**Tension d'essai de rigidité diélectrique pour les distances dans l'air pour isolation principale ou isolation supplémentaire** kV de crête (impulsion, en courant alternatif ou en courant continu)
0,33	0,36
0,5	0,54
0,8	0,93
1,5	1,75
2,5	2,92
4,0	4,92
6,0	7,39
8,0	9,85
12,0	14,77
U [a]	1,23 × U [a]
Une interpolation linéaire peut être utilisée entre les deux points les plus proches, la tension d'essai minimale calculée étant arrondie au 0,1 kV supérieur. Pour l'**isolation renforcée**, la tension d'essai de rigidité diélectrique représente 160 % de la valeur de celle utilisée pour l'**isolation principale** après laquelle cette tension d'essai calculée est arrondie au 0,01 kV supérieur. Si l'EUT ne satisfait pas à l'essai en courant alternatif ou en courant continu, l'essai de choc doit être utilisé. Si l'essai est réalisé à une altitude de 200 m ou plus au-dessus du niveau de la mer, le Tableau F.5 de l'IEC 60664-1:2007 peut être utilisé, auquel cas une interpolation linéaire à des altitudes comprises entre 200 m et 500 m et entre les tensions d'essai de choc correspondantes du Tableau F.5 de l'IEC 60664-1:2007 peut être utilisée.	
[a] U est une **tension de tenue exigée** supérieure à 12,0 kV.	

5.4.2.5 Facteurs de multiplication pour des altitudes supérieures à 2 000 m au-dessus du niveau de la mer

Pour les équipements prévus et conçus pour être utilisés à une altitude de plus de 2 000 m au-dessus du niveau de la mer, les **distances dans l'air** minimales spécifiées au Tableau 10, au Tableau 11 et au Tableau 14, et les tensions d'essai de rigidité diélectrique indiquées au Tableau 15 sont multipliées par le facteur de multiplication pour l'altitude souhaitée selon le Tableau 16.

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NOTE 1 Des altitudes plus élevées peuvent être simulées dans une chambre à vide.

NOTE 2 En Chine, il existe des exigences particulières permettant de choisir des facteurs de multiplication à des altitudes supérieures à 2 000 m.

Tableau 16 – Facteurs de multiplication pour les distances dans l'air et les tensions d'essai

Altitude m	Pression barométrique normale kPa	Facteur de multiplication pour les distances dans l'air	Facteur de multiplication pour les tensions d'essai de rigidité diélectrique		
			< 1 mm	≥ 1 mm à < 10 mm	≥ 10 mm à < 100 mm
2 000	80,0	1,00	1,00	1,00	1,00
3 000	70,0	1,14	1,05	1,07	1,10
4 000	62,0	1,29	1,10	1,15	1,20
5 000	54,0	1,48	1,16	1,24	1,33
Une interpolation linéaire peut être utilisée entre les deux points les plus proches, le facteur de multiplication minimal calculé étant arrondi au 0,01 supérieur.					

5.4.2.6 Critères de conformité

La conformité est vérifiée par mesure et essai en prenant en compte les articles appropriés de l'Annexe O et de l'Annexe T.

Les conditions suivantes s'appliquent:

– *les parties mobiles sont placées dans leur position la plus défavorable;*

– *les **distances dans l'air** d'une **Enveloppe en matériau isolant** à travers un intervalle ou une ouverture sont mesurées conformément à la Figure O.13, point X;*

– *au cours des essais de force, les **enveloppes** en métal ne doivent pas entrer en contact avec les parties conductrices nues*

- *des circuits ES2, à moins que le produit ne soit dans une **zone à accès limité**, ou*
- *des circuits ES3;*

– *à l'issue des essais de l'Annexe T:*

- *les dimensions des **distances dans l'air** sont mesurées, et*
- *l'essai de rigidité diélectrique approprié doit être appliqué, et*
- *pour l'essai de choc sur le verre de l'Article T.9, les endommagements de la finition, les petits éclats ne réduisant pas les **distances dans l'air** en dessous des valeurs spécifiées, les fissures superficielles et les éléments similaires sont ignorés. Si une fissure apparaît, les **distances dans l'air** ne doivent pas être réduites. Pour les fissures non visibles à l'œil nu, un essai de rigidité diélectrique doit être réalisé; et*

– *les composants et parties, autres que ceux servant d'**enveloppe**, sont soumis à l'essai de l'Article T.2. Après l'application de la force, les **distances dans l'air** ne doivent pas être réduites à des valeurs inférieures à celles exigées.*

Pour les circuits connectés à la distribution du câble coaxial et aux antennes extérieures, la conformité est vérifiée par les essais de 5.5.8.

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5.4.3 Lignes de fuite

5.4.3.1 Généralités

Les **lignes de fuite** doivent être dimensionnées de telle façon que, pour une **tension de service efficace** donnée, un **degré de pollution** et un groupe de matériau, il n'y ait ni contournement ni rupture de l'isolation (par exemple, due au cheminement).

Les **lignes de fuite** pour l'**isolation principale** et l'**isolation supplémentaire** pour des fréquences jusqu'à 30 kHz doivent être conformes au Tableau 17. Les **lignes de fuite** pour l'**isolation principale** et l'**isolation supplémentaire** pour des fréquences supérieures à 30 kHz et jusqu'à 400 kHz doivent être conformes au Tableau 18.

Les exigences relatives aux **lignes de fuite** pour des fréquences jusqu'à 400 kHz peuvent s'appliquer pour des fréquences de plus de 400 kHz, jusqu'à ce que des données supplémentaires soient disponibles.

NOTE Les **lignes de fuite** pour des fréquences supérieures à 400 kHz sont à l'étude.

La **ligne de fuite** entre la surface isolante extérieure (voir 5.4.3.2) d'un connecteur (y compris une ouverture dans l'**enveloppe**) et les parties conductrices connectées à ES2 à l'intérieur du connecteur (ou dans l'**enveloppe**) doit être conforme aux exigences relatives à l'**isolation principale**.

La **ligne de fuite** entre la surface isolante extérieure (voir 5.4.3.2) d'un connecteur (y compris une ouverture dans l'**enveloppe**) et les parties conductrices connectées à ES3 à l'intérieur du connecteur (ou dans l'**enveloppe**) doit être conforme aux exigences relatives à l'**isolation renforcée**.

À titre d'exception, la **ligne de fuite** peut satisfaire aux exigences pour l'**isolation principale** si le connecteur est:

– fixé à l'équipement; et
– situé à l'intérieur de l'**enveloppe électrique** extérieure de l'équipement; et
– **accessible** uniquement après le retrait d'un sous-ensemble qui
  - exige d'être à sa place dans les **conditions normales de fonctionnement**, et
  - est fourni avec une **protection par instructions** pour remplacer le sous-ensemble retiré.

Pour toutes les autres **lignes de fuite** dans les connecteurs, y compris les connecteurs qui ne sont pas fixés à l'équipement, les valeurs minimales déterminées conformément à 5.4.3 s'appliquent.

Les **lignes de fuite** minimales ci-dessus pour les connecteurs ne s'appliquent pas aux connecteurs énumérés en l'Article G.4.

Si la **ligne de fuite** minimale déduite du Tableau 17 ou du Tableau 18 est inférieure à la **distance dans l'air** minimale, cette dernière doit être appliquée comme **ligne de fuite minimale**.

Pour le verre, le mica, la céramique vitrifiée ou les matériaux inorganiques similaires, si la **ligne de fuite** minimale est supérieure à la **distance dans l'air** minimale applicable, la valeur de la **distance dans l'air** minimale peut être appliquée comme **ligne de fuite** minimale.

Pour une **isolation renforcée**, les valeurs pour les **lignes de fuite** représentent le double des valeurs pour une **isolation principale** du Tableau 17 ou du Tableau 18.

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5.4.3.2 Méthode d'essai

Les conditions suivantes s'appliquent:

– *les parties mobiles sont placées dans leur position la plus défavorable;*

– *pour l'équipement intégrant des **câbles d'alimentation fixés à demeure** ordinaires, les mesures de **lignes de fuite** sont effectuées avec des conducteurs d'alimentation de la plus forte section spécifiée à l'Article G.7 et aussi sans conducteurs;*

– *lors de la mesure des **lignes de fuite** depuis la surface extérieure **accessible** d'une **enveloppe en matériau isolant** à travers un intervalle ou une ouverture dans l'**enveloppe** ou à travers une ouverture dans un connecteur **accessible**, la surface extérieure **accessible** de l'**enveloppe** doit être considérée comme conductrice comme si elle était recouverte d'une feuille de métal au cours de l'essai décrit en V.1.2, appliquée sans force appréciable (voir la Figure O.13, point X);*

– *les dimensions des **lignes de fuite** jouant le rôle d'**isolation principale**, d'**isolation supplémentaire** et d'**isolation renforcée** sont mesurées après les essais décrits à l'Annexe T selon 4.4.3;*

– *pour l'essai de choc sur le verre de l'Article T.9, les endommagements de la finition, les petits éclats ne réduisant pas les **lignes de fuite** en dessous des valeurs spécifiées, les fissures superficielles et les éléments similaires sont ignorés. Si une fissure profonde apparaît, les **lignes de fuite** ne doivent pas être réduites;*

– *les composants et parties, autres que ceux servant d'**enveloppe**, sont soumis à l'essai de l'Article T.2. Après l'application de la force, les **lignes de fuite** ne doivent pas être réduites à des valeurs inférieures à celles exigées.*

5.4.3.3 Groupe de matériaux et IRC

Les groupes de matériaux sont fondés sur l'IRC et sont classifiés comme suit:

Groupe de matériaux I	600 ≤ IRC
Groupe de matériaux II	400 ≤ IRC < 600
Groupe de matériaux IIIa	175 ≤ IRC < 400
Groupe de matériaux IIIb	100 ≤ IRC < 175

Le groupe de matériaux est vérifié par évaluation des données d'essai pour le matériau conformément à l'IEC 60112 en utilisant 50 gouttes de la solution A.

Si le groupe de matériaux n'est pas connu, par hypothèse le groupe de matériaux doit être IIIb.

Si un IRC égal ou supérieur à 175 est nécessaire et si les données ne sont pas disponibles, le groupe de matériaux peut être établi avec un essai pour l'indice de tenue au cheminement (ITC) détaillé dans l'IEC 60112. Un matériau peut être inclus dans un groupe si son ITC établi par ces essais est égal ou supérieur à la valeur la plus faible de l'indice de résistance au cheminement (IRC) spécifié pour le groupe.

5.4.3.4 Critères de conformité

La conformité est vérifiée par mesure, en prenant en compte l'Annexe O, l'Annexe T et l'Annexe V.

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Tableau 17 – Lignes de fuite minimales pour une isolation principale et une isolation supplémentaire, en mm

Tension de service efficace jusque et y compris V	Degré de pollution						
	1 [a]	2			3		
	Groupe de matériaux						
	I, II, IIIa, IIIb	I	II	IIIa, IIIb	I	II	IIIa, IIIb [b]
10	0,08	0,4	0,4	0,4	1,0	1,0	1,0
12,5	0,09	0,42	0,42	0,42	1,05	1,05	1,05
16	0,1	0,45	0,45	0,45	1,1	1,1	1,1
20	0,11	0,48	0,48	0,48	1,2	1,2	1,2
25	0,125	0,5	0,5	0,5	1,25	1,25	1,25
32	0,14	0,53	0,53	0,53	1,3	1,3	1,3
40	0,16	0,56	0,8	1,1	1,4	1,6	1,8
50	0,18	0,6	0,85	1,2	1,5	1,7	1,9
63	0,2	0,63	0,9	1,25	1,6	1,8	2,0
80	0,22	0,67	0,95	1,3	1,7	1,9	2,1
100	0,25	0,71	1,0	1,4	1,8	2,0	2,2
125	0,28	0,75	1,05	1,5	1,9	2,1	2,4
160	0,32	0,8	1,1	1,6	2,0	2,2	2,5
200	0,42	1,0	1,4	2,0	2,5	2,8	3,2
250	0,56	1,25	1,8	2,5	3,2	3,6	4,0
320	0,75	1,6	2,2	3,2	4,0	4,5	5,0
400	1,0	2,0	2,8	4,0	5,0	5,6	6,3
500	1,3	2,5	3,6	5,0	6,3	7,1	8,0
630	1,8	3,2	4,5	6,3	8,0	9,0	10
800	2,4	4,0	5,6	8,0	10	11	12,5
1 000	3,2	5,0	7,1	10	12,5	14	16
1 250	4,2	6,3	9,0	12,5	16	18	20
1 600	5,6	8,0	11	16	20	22	25
2 000	7,5	10	14	20	25	28	32
2 500	10	12,5	18	25	32	36	40
3 200	12,5	16	22	32	40	45	50
4 000	16	20	28	40	50	56	63
5 000	20	25	36	50	63	71	80
6 300	25	32	45	63	80	90	100
8 000	32	40	56	80	100	110	125
10 000	40	50	71	100	125	140	160
12 500	50	63	90	125			
16 000	63	80	110	160			
20 000	80	100	140	200			
25 000	100	125	180	250			
32 000	125	160	220	320			
40 000	160	200	280	400			
50 000	200	250	360	500			
63 000	250	320	450	600			

Une interpolation linéaire peut être utilisée entre les deux points les plus proches, les **lignes de fuite** minimales calculées étant arrondies au 0,1 mm supérieur ou la valeur de la ligne suivante, la valeur la plus faible étant retenue.

Pour une **isolation renforcée**, un arrondi au 0,1 mm supérieur ou le double de la valeur de la ligne suivante est appliqué après que la valeur calculée pour une **isolation principale** a été doublée.

[a] Les valeurs pour le **degré de pollution** 1 peuvent être utilisées si un échantillon satisfait aux essais de 5.4.1.5.2.

[b] Le groupe de matériaux IIIb n'est pas recommandé pour les applications au **degré de pollution** 3 présentant une **tension de service efficace** au-dessus de 630 V.

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Tableau 18 – Lignes de fuite minimales pour des fréquences supérieures à 30 kHz et jusqu'à 400 kHz en mm

Tension kV	**30 kHz < f ≤ 100 kHz**	**100 kHz < f ≤ 200 kHz**	**200 kHz < f ≤ 400 kHz**
0,1	0,016 7	0,02	0,025
0,2	0,042	0,043	0,05
0,3	0,083	0,09	0,1
0,4	0,125	0,13	0,15
0,5	0,183	0,23	0,25
0,6	0,267	0,38	0,4
0,7	0,358	0,55	0,68
0,8	0,45	0,8	1,1
0,9	0,525	1,0	1,9
1	0,6	1,15	3

Les valeurs pour les **lignes de fuite** du tableau s'appliquent pour le **degré de pollution** 1. Pour le **degré de pollution** 2, un facteur de multiplication de 1,2 et pour le **degré de pollution** 3, un facteur de multiplication de 1,4 doivent être utilisés.

Une interpolation linéaire peut être appliquée, le résultat étant arrondi au chiffre significatif supérieur.

Les données mentionnées au Tableau 18 (tiré du Tableau 2 de l'IEC 60664-4:2005) ne prennent pas en compte l'influence des phénomènes de cheminement. Pour cette raison, le Tableau 17 doit être pris en compte. Par conséquent, si les valeurs du Tableau 18 sont inférieures à celles du Tableau 17, les valeurs du Tableau 17 s'appliquent.

5.4.4 Isolation solide

5.4.4.1 Exigences générales

Les exigences ci-dessous s'appliquent à l'**isolation solide** y compris aux composés et aux matériaux gel utilisés comme isolation.

Il ne doit pas y avoir rupture de l'**isolation solide**:

– en raison de surtensions, y compris les transitoires, qui pénètrent dans l'équipement, et de valeurs crête de la tension qui peuvent être générées à l'intérieur de l'équipement; ni

– en raison de trous d'épingle dans de fines couches d'isolation.

Des revêtements d'émail ne doivent pas être utilisés pour une **isolation principale**, une **isolation supplémentaire** ni une **isolation renforcée** à l'exception de ceux indiqués en G.6.2.

Excepté pour les cartes imprimées, une **isolation solide** doit soit:

– être conforme aux distances minimales à travers l'isolation conformément à 5.4.4.2; ou

– répondre aux exigences et satisfaire aux essais décrits de 5.4.4.3 à 5.4.4.7, selon le cas.

Le verre utilisé comme **isolation solide** doit être conforme à l'essai de choc sur le verre spécifié à l'Article T.9. Les endommagements de la finition, les petits éclats ne réduisant pas les **distances dans l'air** en dessous des valeurs spécifiées, les fissures superficielles et les éléments similaires sont ignorés. Si une fissure apparaît, les **distances dans l'air** et les **lignes de fuite** ne doivent pas être réduites en dessous des valeurs spécifiées.

Pour les cartes imprimées, voir l'Article G.13. Pour les dispositifs de connexion extérieure d'antenne, voir 5.4.5. Pour une **isolation solide** sur le câblage interne, voir 5.4.6.

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5.4.4.2 Distance minimale à travers l'isolation

Sauf lorsqu'un autre paragraphe de l'Article 5 s'applique, les distances à travers l'isolation doivent présenter des dimensions conformes à l'application de l'isolation et comme suit (voir la Figure O.15 et la Figure O.16):

– si la **tension de service** ne dépasse pas les limites de tension applicables à ES2, il n'existe pas d'exigence relative à la distance à travers l'isolation;
– si la **tension de service** dépasse les limites de tension applicables à ES2, les règles suivantes s'appliquent:
  - pour une **isolation principale**, il n'existe pas de distance minimale à travers l'isolation spécifiée;
  - pour une **isolation supplémentaire** ou une **isolation renforcée** composée d'une couche unique, la distance minimale à travers l'isolation doit être de 0,4 mm;
  - pour une **isolation supplémentaire** ou une **isolation renforcée** composée de couches multiples, la distance minimale à travers l'isolation doit être conforme à 5.4.4.6.

5.4.4.3 Isolant constituant une isolation solide

Il n'existe pas de **distance dans l'air** ni de **ligne de fuite** interne minimale si

– l'isolant remplit entièrement le boîtier d'un composant ou d'un sous-ensemble, y compris un dispositif à semi-conducteurs (par exemple, un optocoupleur); et
– le composant ou sous-ensemble répond aux distances minimales à travers l'isolation de 5.4.4.2; et
– un seul échantillon réussit les essais de 5.4.1.5.2.

NOTE Des exemples de traitements de ce type diversement connus comprennent l'enrobage, la mise sous boîtier rempli et l'imprégnation sous vide.

De telles constructions contenant des joints scellés doivent aussi satisfaire à 5.4.4.5.

Les autres exigences relatives aux dispositifs à semi-conducteurs sont indiquées en 5.4.4.4.

Pour les cartes imprimées, voir l'Article G.13 et pour les composants bobinés, voir 5.4.4.7.

La conformité est vérifiée en découpant en sections l'échantillon. Il ne doit pas y avoir de vides apparents dans le matériau isolant.

5.4.4.4 Isolation solide dans des dispositifs à semi-conducteurs

Il n'existe pas de **distance dans l'air** ni de **ligne de fuite** interne minimale, ni de distance minimale à travers l'isolation pour une **isolation supplémentaire** ou une **isolation renforcée** comprenant un isolant remplissant entièrement le boîtier d'un composant à semi-conducteurs (un optocoupleur, par exemple) à condition que le composant:

– satisfasse aux **essais de type** et aux critères d'examen décrits en 5.4.7, ainsi que les **essais individuels de série** de rigidité diélectrique au cours de la fabrication, selon l'essai approprié décrit en 5.4.9.2; ou
– satisfasse à l'Article G.12.

De telles constructions contenant des joints scellés doivent aussi satisfaire à 5.4.4.5.

En variante, un semi-conducteur peut être évalué conformément à 5.4.4.3.

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5.4.4.5 Isolant constituant des joints scellés

Les exigences spécifiées ci-dessous s'appliquent pour le cas où un isolant constitue un joint scellé entre deux parties non conductrices ou entre une autre partie non conductrice et lui-même. Ces exigences ne s'appliquent pas aux optocoupleurs conformes à l'IEC 60747-5-5.

Lorsque le chemin entre des parties conductrices est rempli par un isolant, et que l'isolant constitue un joint scellé entre deux parties non conductrices ou entre une partie non conductrice et lui-même (voir la Figure O.14, la Figure O.15 et la Figure O.16), soit a), soit b) soit c) s'applique.

a) La distance le long du chemin entre les deux parties conductrices ne doit pas être inférieure aux **distances dans l'air** ni aux **lignes de fuite** minimales pour le **degré de pollution** 2. Les exigences relatives à la distance à travers l'isolation décrites en 5.4.4.2 ne s'appliquent pas le long du joint.

b) La distance le long du chemin entre les deux parties conductrices ne doit pas être inférieure aux **distances dans l'air** ni aux **lignes de fuite** minimales pour le **degré de pollution** 1. De plus, un échantillon doit satisfaire à l'essai décrit en 5.4.1.5.2. Les exigences relatives à la distance à travers l'isolation décrites en 5.4.4.2 ne s'appliquent pas le long du joint.

c) Les exigences relatives à la distance à travers l'isolation décrites en 5.4.4.2 s'appliquent entre les parties conductrices le long du joint. De plus, trois échantillons doivent satisfaire à l'essai décrit en 5.4.7.

Pour a) et b) ci-dessus, si les matériaux isolants impliqués appartiennent à des groupes de matériaux différents, le cas le plus défavorable est utilisé. Lorsqu'un groupe de matériaux n'est pas connu, le groupe de matériaux IIIb doit être utilisé.

Pour b) et c) ci-dessus, les essais de 5.4.1.5.2 et de 5.4.7 ne sont pas appliqués aux couches intérieures d'une carte imprimée réalisée en utilisant du prépreg si la température de la carte imprimée mesurée au cours de l'essai thermique décrit en 5.4.1.4 ne dépasse pas 90 °C.

NOTE Les exemples de joints scellés comprennent les suivants:

– deux parties non conductrices scellées ensemble (par exemple, deux couches d'une carte multicouches, voir la Figure O.14) ou la bobine séparée d'un transformateur dont l'élément central est fixé avec de l'adhésif (voir la Figure O.16);

– une isolation enroulée en spirale sur un fil de bobinage, dont l'étanchéité est assurée par un isolant adhésif, est un exemple de PD1; ou

– le joint entre une partie non conductrice (le boîtier) et l'isolant lui-même dans un optocoupleur (voir la Figure O.15).

5.4.4.6 Matériau en fines couches

5.4.4.6.1 Exigences générales

Il n'existe pas d'exigences relatives aux dimensions ni à la construction pour l'isolation dans un matériau en fines couches utilisé comme **isolation principale**.

NOTE Un appareil pour l'exécution de l'essai de rigidité diélectrique sur de fines couches de matériau isolant est décrit à la Figure 29.

L'isolation dans des matériaux en fines couches peut être utilisée pour une **isolation supplémentaire** et une **isolation renforcée**, indépendamment de la distance à travers l'isolation, à condition que:

– deux couches au moins soient utilisées; et

– l'isolation se situe à l'intérieur de l'**enveloppe** de l'équipement; et

– l'isolation ne fasse pas l'objet d'une manipulation ni d'une abrasion au cours de l'entretien par une **personne ordinaire** ou par une **personne avertie**; et

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– les exigences et essais de 5.4.4.6.2 (pour les couches séparables) ou 5.4.4.6.3 (pour les couches non séparables) soient satisfaits.

Il n'est pas nécessaire que les deux couches ou plus soient fixées à la même partie conductrice. Les deux couches ou plus peuvent être:

– fixées à l'une des parties conductrices exigeant une séparation; ou
– partagées entre les deux parties conductrices; ou
– sans fixation sur aucune des parties conductrices.

Pour l'isolation dans trois couches ou plus de matériaux en fines couches non séparables:

– des distances minimales à travers l'isolation ne sont pas nécessaires; et
– il n'est pas nécessaire que les différentes couches d'isolation soient composées du même matériau.

5.4.4.6.2 Matériau en fines couches séparables

Outre les exigences de 5.4.4.6.1, pour:

– une **isolation supplémentaire** composée de deux couches de matériau, chaque couche doit satisfaire à l'essai de rigidité diélectrique pour une **isolation supplémentaire**; ou
– une **isolation supplémentaire** composée de trois couches de matériau, chaque combinaison de deux couches doit satisfaire à l'essai de rigidité diélectrique pour une **isolation supplémentaire**; ou
– une **isolation renforcée** composée de deux couches de matériau, chaque couche doit satisfaire à l'essai de rigidité diélectrique pour une **isolation renforcée**; ou
– une **isolation renforcée** composée de trois couches de matériau, chaque combinaison de deux couches doit satisfaire à l'essai de rigidité diélectrique pour une **isolation renforcée**.

Si plus de trois couches sont utilisées, les couches peuvent être divisées en deux ou trois groupes de couches. Chaque groupe de couches doit satisfaire à l'essai de rigidité diélectrique pour l'isolation appropriée.

Un essai sur une couche ou un groupe de couches n'est pas répété sur une couche ou un groupe identique.

Il n'existe aucune exigence stipulant que toutes les couches de l'isolation ont à présenter les mêmes matériaux et épaisseurs.

5.4.4.6.3 Matériau en fines couches non séparables

Pour une isolation composée de matériaux en fines couches non séparables, en plus des exigences de 5.4.4.6.1, les procédures d'essai indiquées au Tableau 19 s'appliquent. Il n'existe aucune exigence stipulant que toutes les couches de l'isolation ont à présenter les mêmes matériaux et épaisseurs.

La conformité est vérifiée par examen et par les essais spécifiés au Tableau 19.

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Tableau 19 – Essais pour l'isolation dans des couches non séparables

Nombre de couches	Procédure d'essai
Isolation supplémentaire	
Deux couches ou plus:	La procédure d'essai décrite en 5.4.4.6.4 s'applique.
Isolation renforcée	
Deux couches:	La procédure d'essai décrite en 5.4.4.6.4 s'applique.
Trois couches ou plus:	Les procédures d'essai décrites en 5.4.4.6.4 et 5.4.4.6.5 [a] s'appliquent.
NOTE Les essais de 5.4.4.6.5 ont pour objet de s'assurer que le matériau présente une solidité adéquate pour résister aux dommages lorsqu'il est intégré dans des couches intérieures de l'isolation. Par conséquent, les essais ne sont pas appliqués à l'isolation en deux couches. Les essais décrits en 5.4.4.6.5 ne s'appliquent pas à l'**isolation supplémentaire**.	
[a] Lorsque l'isolation fait partie du fil de bobinage, l'essai ne s'applique pas.	

5.4.4.6.4 Procédure d'essai normalisée pour un matériau en fines couches non séparables

Pour les couches non séparables, les essais de rigidité diélectrique s'appliquent conformément à 5.4.9.1 à toutes les couches ensemble. La tension d'essai est:

– *200 % de* U_{essai} *si deux couches sont utilisées; ou*

– *150 % de* U_{essai} *si au moins trois couches sont utilisées,*

où U_{essai} *est la tension d'essai spécifiée en 5.4.9.1 pour une* **isolation supplémentaire** ou une **isolation renforcée**, selon le cas.

NOTE À moins que toutes les couches ne soient composées du même matériau et présentent la même épaisseur, il existe une possibilité que la tension d'essai soit inégalement répartie entre les couches, provoquant la rupture d'une couche qui aurait satisfait à l'essai séparément.

5.4.4.6.5 Essai du mandrin

Les exigences d'essai pour une ***isolation renforcée*** *composée d'au moins trois fines couches isolantes de matériau qui ne sont pas séparables sont spécifiées ci-dessous.*

NOTE L'essai est fondé sur l'IEC 61558-1 et donne les mêmes résultats.

Trois échantillons pour essai, chaque échantillon individuel étant composé d'au moins trois couches de matériau en fines feuilles non séparables formant l'isolation renforcée, sont utilisés. Un échantillon est fixé au mandrin du dispositif d'essai (Figure 25). La fixation doit être réalisée comme représentée à la Figure 26.

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Dimensions en millimètres

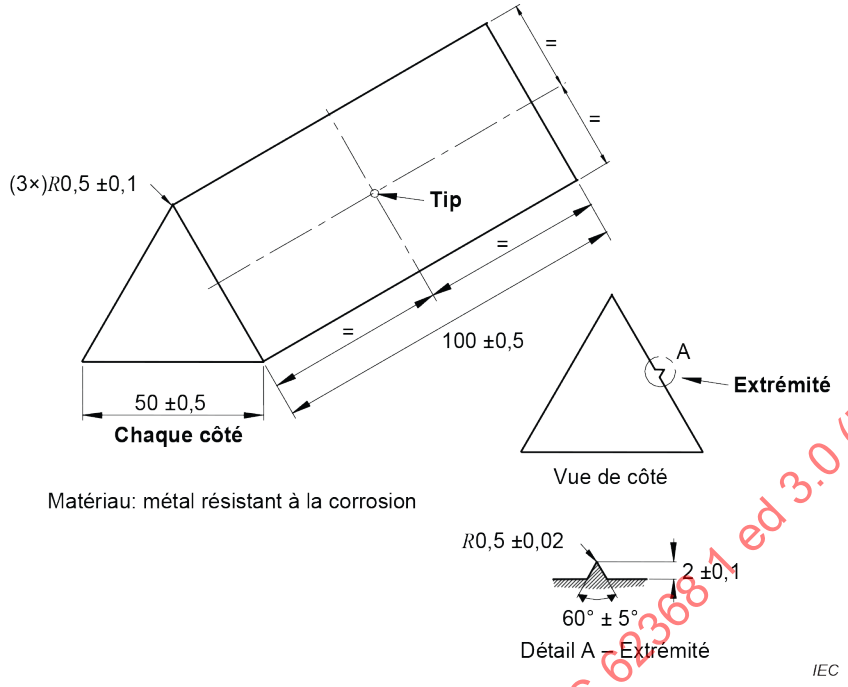


Figure 25 – Mandrin

Dimensions en millimètres

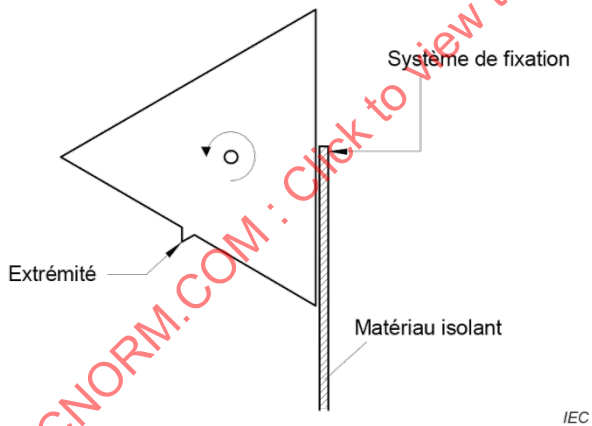
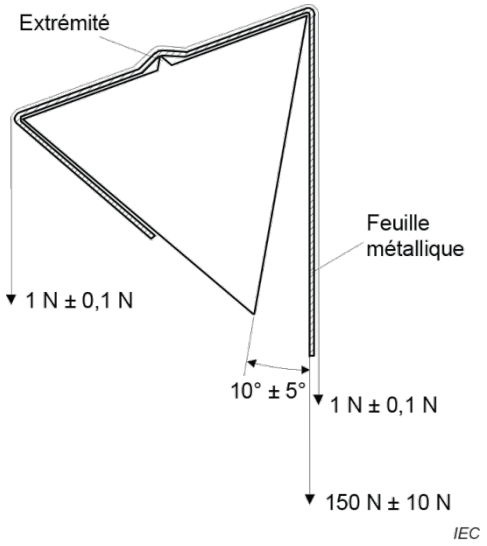


Figure 26 – Position initiale du mandrin



La position finale du mandrin subit une rotation de (230 ± 5) ° par rapport à la position initiale.

Figure 27 – Position finale du mandrin

Une traction est appliquée à l'extrémité libre de l'échantillon, à l'aide d'un dispositif de serrage approprié. Le mandrin subit une rotation:

– *de la position initiale (Figure 26) à la position finale (Figure 27) et inversement;*
– *une deuxième fois de la position initiale à la position finale.*

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Si un échantillon se casse au cours de la rotation là où il est fixé au mandrin ou au dispositif de serrage, cette rupture ne constitue pas un dysfonctionnement. Si un échantillon se casse à tout autre endroit, l'essai a échoué.

Après l'essai décrit ci-dessus, une feuille métallique, d'une épaisseur de (0,035 ± 0,005) mm et d'une longueur minimale de 200 mm, est placée le long de la surface de l'échantillon, retombant de chaque côté du mandrin (voir la Figure 27). La surface de la feuille en contact avec l'échantillon doit être conductrice, non oxydée ou autrement isolée. La feuille est positionnée de telle sorte que ses bords ne soient pas situés à moins de 18 mm des bords de l'échantillon (voir la Figure 28). La feuille est ensuite resserrée par deux poids égaux, un à chaque extrémité, en utilisant des dispositifs de serrage appropriés.

Dimensions en millimètres

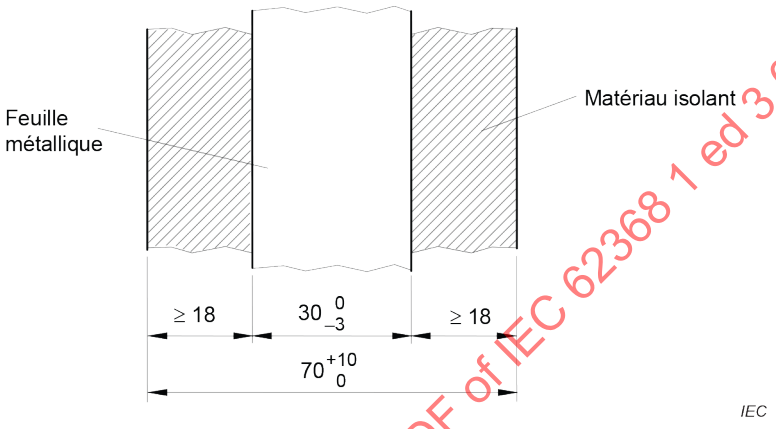


Figure 28 – Position de la feuille métallique sur le matériau isolant

Lorsque le mandrin est en position finale, et dans un délai de 60 s suivant le positionnement final, un essai de rigidité diélectrique est appliqué entre le mandrin et la feuille métallique conformément à 5.4.9.1. La tension d'essai est égale à 150 % de U_{essai}, mais pas inférieure à 5 kV efficace, où U_{essai} est la tension d'essai spécifiée en 5.4.9.1 pour une ***isolation renforcée****, selon le cas.*

L'essai est répété sur les deux autres échantillons.

5.4.4.7 Isolation solide dans les composants bobinés

Une **isolation principale**, une **isolation supplémentaire** ou une **isolation renforcée** dans un composant bobiné peut être assurée par:

– l'isolation sur les composants bobinés (voir l'Article G.5); ou

– l'isolation sur un autre câble (voir l'Article G.6); ou

– une combinaison des deux.

Les composants bobinés contenant des joints scellés doivent aussi satisfaire à 5.4.4.5.

Les transformateurs planaires doivent satisfaire aux exigences de l'Article G.13.

5.4.4.8 Critères de conformité

La conformité aux exigences de 5.4.4.2 à 5.4.4.7 pour l'adéquation d'une isolation solide est vérifiée par examen et mesure, en prenant en compte l'Annexe O, par les essais de rigidité diélectrique de 5.4.9.1 et les essais supplémentaires exigés de 5.4.4.2 à 5.4.4.7, selon le cas.

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5.4.4.9 Exigences relatives à une isolation solide à des fréquences supérieures à 30 kHz

Le caractère approprié d'une **isolation solide** doit être déterminé comme suit:

– Déterminer la valeur de la résistance du champ électrique de rupture du matériau isolant à la fréquence du **réseau d'alimentation** E_P en kV/mm (efficace) pour le matériau isolant. L'une des méthodes suivantes doit être utilisée pour déterminer la valeur de E_P:

  - la valeur déclarée par le fabricant en fonction des données fournies par le fabricant concernant le matériau; ou
  - la valeur issue du Tableau 20; ou
  - la valeur reposant sur l'essai spécifié dans l'IEC 60243-1.

  Le fabricant est chargé de déterminer la valeur.

– Déterminer le facteur de réduction K_R pour la résistance du champ électrique de rupture du matériau isolant à la fréquence applicable du Tableau 21 ou du Tableau 22. Si le matériau ne figure pas au Tableau 21 ou au Tableau 22, utiliser le facteur de réduction moyen indiqué dans la dernière colonne du Tableau 21 ou du Tableau 22, selon le cas.

– Déterminer la valeur de la résistance du champ électrique de rupture à la fréquence applicable E_F en multipliant la valeur E_P par le facteur de réduction K_R.

$$E_F = E_P \times K_R$$

– Déterminer la rigidité diélectrique réelle V_W du matériau isolant en multipliant la valeur E_F par l'épaisseur totale (d en mm) du matériau isolant.

$$V_W = E_F \times d$$

– Pour une **isolation principale** ou une **isolation supplémentaire**, V_W doit dépasser de 20 % la valeur de crête de la **tension de service** haute fréquence mesurée V_{PW}.

$$V_W > 1{,}2 \times V_{PW} / 1{,}41$$

– Pour une **isolation renforcée**, V_W doit dépasser deux fois la valeur de crête de la **tension de service** haute fréquence mesurée V_{PW} de 20 %.

$$V_W > 1{,}2 \times 2 \times V_{PW} / 1{,}41$$

En variante, l'essai de rigidité diélectrique selon 5.4.9.1 peut être appliqué, sauf que la tension d'essai à la fréquence du **réseau d'alimentation** doit être la suivante:

– pour l'**isolation principale**: $1{,}2 \times V_{PW} / K_R$

– pour l'**isolation renforcée** $1{,}2 \times 2 \times V_{PW} / K_R$.

Il ne doit pas y avoir de rupture.

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Tableau 20 – Résistance du champ électrique E_P pour quelques matériaux couramment utilisés

Matériau	Résistance du champ électrique de rupture E_P kV/mm				
	Épaisseur du matériau mm				
	0,75	**0,08**	**0,06**	**0,05**	**0,03**
Porcelaine [a]	9,2	-	-	-	-
Silicium-verre [a]	14	-	-	-	-
Phénolique [a]	17	-	-	-	-
Céramique [a]	19	-	-	-	-
Teflon® [a] [1]	27	-	-	-	-
Mélamine-verre [a]	27	-	-	-	-
Mica [a]	29	-	-	-	-
Papier phénolique [a]	38	-	-	-	-
Polyéthylène [b]	49	-	-	52	-
Polystyrène [c]	55	65	-	-	-
Verre [c]	60	-	-	-	-
Kapton® [a] [2]	303	-	-	-	-
FR530L [a]	33	-	-	-	-
Phénolique chargé de mica [a]	28	-	-	-	-
Laminé verre-silicone [a]	18	-	-	-	-
Acétobutyrate de cellulose [d]	-	-	120	-	210
Polycarbonate [d]	-	-	160	-	270
Triacétate de cellulose [d]	-	-	120	-	210

NOTE Les valeurs manquantes et les valeurs pour les autres matériaux ne figurant pas dans la liste font l'objet d'une enquête

[a] Pour la distribution de la résistance de champ électrique des matériaux spécifiés, la valeur E_P de 0,75 mm d'épaisseur peut être utilisée pour toutes les épaisseurs.

[b] La valeur E_P de 0,05 mm d'épaisseur est utilisée pour l'isolation inférieure ou égale à 0,05 mm. Sinon, la valeur E_P de 0,75 mm est utilisée.

[c] La valeur E_P de 0,08 mm d'épaisseur est utilisée pour l'isolation inférieure ou égale à 0,08 mm. Sinon, la valeur E_P de 0,75 mm est utilisée.

[d] La valeur E_P de 0,03 mm d'épaisseur est utilisée pour l'isolation inférieure ou égale à 0,03 mm. La valeur E_P de 0,06 mm d'épaisseur est utilisée pour l'isolation égale ou inférieure à 0,06 mm et supérieure à 0,03 mm.

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Tableau 21 – Facteurs de réduction pour la valeur de la résistance du champ électrique de rupture E_P à des fréquences plus élevées

Matériau [a]	Fréquence kHz										
	30	100	200	300	400	500	1 000	2 000	3 000	5 000	10 000
	Facteur de réduction K_R										
Porcelaine	0,52	0,42	0,40	0,39	0,38	0,37	0,36	0,35	0,35	0,34	0,30
Silicium-verre	0,79	0,65	0,57	0,53	0,49	0,46	0,39	0,33	0,31	0,29	0,26
Phénolique	0,82	0,71	0,53	0,42	0,36	0,34	0,24	0,16	0,14	0,13	0,12
Céramique	0,78	0,64	0,62	0,56	0,54	0,51	0,46	0,42	0,37	0,35	0,29
Teflon®	0,57	0,54	0,52	0,51	0,48	0,46	0,45	0,44	0,41	0,37	0,22
Mélamine-verre	0,48	0,41	0,31	0,27	0,24	0,22	0,16	0,12	0,10	0,09	0,06
Mica	0,69	0,55	0,48	0,45	0,41	0,38	0,34	0,28	0,26	0,24	0,20
Papier phénolique	0,58	0,47	0,40	0,32	0,26	0,23	0,16	0,11	0,08	0,06	0,05
Polyéthylène	0,36	0,28	0,22	0,21	0,20	0,19	0,16	0,13	0,12	0,12	0,11
Polystyrène	0,35	0,22	0,15	0,13	0,13	0,11	0,08	0,06	0,06	0,06	0,06
Verre	0,37	0,21	0,15	0,13	0,11	0,10	0,08	0,06	0,05	0,05	0,04
Autres matériaux	0,43	0,35	0,30	0,27	0,25	0,24	0,20	0,17	0,16	0,14	0,12
Si la fréquence se situe entre les valeurs d'une des deux colonnes, la valeur du facteur de réduction dans la colonne suivante doit être utilisée ou une interpolation logarithmique peut être utilisée entre l'une des deux colonnes adjacentes avec la valeur calculée arrondie au 0,01 inférieur.											

[a] Ces données correspondent aux matériaux qui ont une épaisseur de 0,75 mm.

Tableau 22 – Facteurs de réduction pour la valeur de la résistance du champ électrique de rupture E_P à des fréquences plus élevées pour les matériaux fins

Matériau fin	Fréquence kHz										
	30	100	200	300	400	500	1 000	2 000	3 000	5 000	10 000
	Facteur de réduction K_R										
Acétobutyrate de cellulose (0,03 mm)	0,67	0,43	0,32	0,27	0,24	0,20	0,15	0,11	0,09	0,07	0,06
Acétobutyrate de cellulose (0,06 mm)	0,69	0,49	0,36	0,30	0,26	0,23	0,17	0,13	0,11	0,08	0,06
Polycarbonate (0,03 mm)	0,61	0,39	0,31	0,25	0,23	0,20	0,14	0,10	0,08	0,06	0,05
Polycarbonate (0,06 mm)	0,70	0,49	0,39	0,33	0,28	0,25	0,19	0,13	0,11	0,08	0,06
Triacétate de cellulose (0,03 mm)	0,67	0,43	0,31	0,26	0,23	0,20	0,14	0,10	0,09	0,07	0,06
Triacétate de cellulose (0,06 mm)	0,72	0,50	0,36	0,31	0,27	0,23	0,17	0,13	0,10	0,10	0,06
Autres matériaux fins	0,68	0,46	0,34	0,29	0,25	0,22	0,16	0,12	0,10	0,08	0,06
Si la fréquence se situe entre les valeurs d'une des deux colonnes, la valeur du facteur de réduction dans la colonne suivante doit être utilisée ou une interpolation logarithmique peut être utilisée entre l'une des deux colonnes adjacentes avec la valeur calculée arrondie au 0,01 inférieur.											

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5.4.5 Isolation des dispositifs de connexion extérieure d'antenne

5.4.5.1 Généralités

L'isolation

– entre le **réseau d'alimentation** et les dispositifs de connexion extérieure d'antenne, et
– entre le **réseau d'alimentation** et les **circuits externes** fournissant des tensions d'alimentation ne provenant pas du **réseau d'alimentation** à d'autres équipements comportant des dispositifs de connexion extérieure d'antenne

doit être capable de supporter les décharges électrostatiques au niveau des dispositifs de connexion extérieure d'antenne.

Cet essai ne s'applique pas aux équipements dont un dispositif de connexion extérieure d'antenne sur l'équipement est connecté à la terre conformément à 5.6.7.

NOTE En Chine, la connexion de la télévision par câble à la borne principale de mise à la **terre de protection** de l'équipement n'est pas autorisée.

5.4.5.2 Méthode d'essai

*L'échantillon est soumis à 50 décharges provenant du générateur d'essai d'interface d'antenne (circuit 3) de l'Article D.2, à pas plus de 12 décharges par minute, avec U_c égal à 10 kV. L'équipement doit être placé sur une surface isolante. La sortie du générateur d'essai d'interface d'antenne doit être connectée aux dispositifs de connexion extérieure d'antenne connectés ensemble et aux bornes du **réseau d'alimentation** connectées ensemble. Si l'équipement comporte des **circuits externes** fournissant des tensions d'alimentation ne provenant pas du **réseau d'alimentation** à d'autres équipements comportant des dispositifs de connexion extérieure d'antenne, l'essai est répété en connectant le générateur aux bornes du **réseau d'alimentation** connectées ensemble et aux bornes du **circuit externe** connectées ensemble. L'équipement n'est pas alimenté pendant ces essais.*

NOTE Le personnel d'essai est averti de ne pas toucher l'équipement au cours de l'essai.

5.4.5.3 Critères de conformité

La conformité est vérifiée en mesurant la résistance d'isolement avec 500 V en courant continu.

L'appareil est considéré comme satisfaisant aux exigences si la résistance d'isolement, mesurée après 1 min, n'est pas inférieure aux valeurs indiquées au Tableau 23.

Tableau 23 – Valeurs pour la résistance d'isolement

Exigences relatives à l'isolation entre les parties	Résistance d'isolement MΩ
Entre les parties séparées par une **isolation principale** ou une **isolation supplémentaire**	2
Entre les parties séparées par une **double isolation** ou une **isolation renforcée**	4

*En variante, la conformité peut être vérifiée par un essai de rigidité diélectrique conformément à 5.4.9.1 pour l'**isolation principale** ou l'**isolation renforcée** selon le cas. La tension d'essai doit correspondre à la plus élevée des tensions d'essai déterminées par les méthodes 1, 2 et 3. Il ne doit pas y avoir de rupture de l'isolation.*

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5.4.6 Isolation du câblage interne en tant que partie d'une protection supplémentaire

Les exigences ci-dessous s'appliquent lorsque l'isolation d'un câblage interne, seule, satisfait aux exigences pour une **isolation principale**, mais ne satisfait pas à celles pour une **isolation supplémentaire**.

Lorsqu'une isolation de fils est utilisée en tant que partie d'un système d'**isolation supplémentaire** et que l'isolation de fils est **accessible** à une **personne ordinaire**:

– il n'est pas nécessaire que l'isolation de fils soit manipulée par la **personne ordinaire**; et
– le fil est placé de telle sorte qu'il soit improbable qu'une **personne ordinaire** tire sur le fil, ou le fil doit être fixé de telle sorte que les points de raccordement ne soient soumis à aucun effort de traction; et
– le fil est dirigé et fixé de telle sorte qu'il ne touche pas les parties conductrices **accessibles** non mises à la terre; et
– l'isolation du fil satisfait à l'essai de rigidité diélectrique de 5.4.9.1 pour l'**isolation supplémentaire**; et
– la distance à travers l'isolation du fil doit être au moins celle indiquée au Tableau 24.

Tableau 24 – Distance à travers l'isolation du câblage interne

Tension de service en cas de défaillance de l'isolation principale		Distance minimale à travers l'isolation
V en valeur crête ou en courant continu	V efficace (sinusoïdale)	mm
> 71 ≤ 350	> 50 ≤ 250	0,17
> 350	> 250	0,31

La conformité est vérifiée par examen, par des mesures et par l'essai de 5.4.9.1.

5.4.7 Essais pour les composants à semi-conducteurs et pour les joints scellés

Trois échantillons sont soumis à la séquence de cycles thermiques décrite en 5.4.1.5.3. Avant de soumettre un joint scellé à l'essai, les enroulements de fils en émail du composant sont remplacés par une feuille métallique ou par quelques tours de fils nu, à proximité du joint scellé.

Les trois échantillons sont ensuite soumis à l'essai comme suit:

– *l'un des échantillons est soumis à l'essai de rigidité diélectrique de 5.4.9.1, immédiatement après la dernière période à (T_1 ± 2) °C au cours du cycle thermique, à cette exception près que la tension d'essai est multipliée par 1,6; et*
– *les autres échantillons sont soumis à l'essai de rigidité diélectrique adapté décrit en 5.4.9.1 après l'épreuve hygroscopique de 5.4.8, à cette exception près que la tension d'essai est multipliée par 1,6.*

La conformité est vérifiée par un essai et par les examens suivants:

À l'exception des joints scellés sur la même surface intérieure d'une carte imprimée, la conformité est vérifiée par examen de la section et le matériau isolant ne doit pas présenter de vides apparents, de trous ou de craquelures.

Dans le cas d'une isolation entre conducteurs sur la même surface intérieure des cartes imprimées et d'une isolation entre conducteurs sur des surfaces différentes de cartes imprimées multicouches, la conformité est vérifiée par examen visuel externe. Il ne doit pas y avoir de délaminage.

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5.4.8 Épreuve hygroscopique

L'épreuve hygroscopique est effectuée pendant 48 h dans une enceinte ou une pièce contenant de l'air et présentant une humidité relative de (93 ± 3) %. La température de l'air, à tous les endroits où les échantillons peuvent être situés, est maintenue à ± 2 °C près à une valeur T comprise entre 20 °C et 30 °C de telle sorte qu'il ne se produise pas de condensation. Au cours de cette épreuve, le composant ou le sous-ensemble n'est pas alimenté.

Dans des conditions tropicales, la durée de l'essai doit être de 120 h à une température de (40 ± 2) °C et une humidité relative de (93 ± 3) %.

Avant l'épreuve hygroscopique, l'échantillon est amené à une température comprise entre la température spécifiée T et (T + 4) °C.

5.4.9 Essai de rigidité diélectrique

5.4.9.1 Procédure d'essai pour un essai de type de l'isolation solide

Sauf spécification contraire, la conformité est vérifiée soit:

- *immédiatement après l'essai de température décrit en 5.4.1.4; ou*
- *si un composant ou un sous-ensemble est soumis à l'essai séparément à l'extérieur de l'équipement, il est amené à la température atteinte par cette partie au cours de l'essai de température décrit en 5.4.1.4 (en étant placé dans un four, par exemple) avant que l'essai de rigidité diélectrique ne soit effectué.*

*Une autre possibilité consiste à soumettre à l'essai le matériau à fines couches pour une **isolation supplémentaire** ou une **isolation renforcée** à la température ambiante.*

*Sauf spécification contraire, la tension d'essai pour la rigidité diélectrique d'une **isolation principale**, d'une **isolation supplémentaire** ou d'une **isolation renforcée** est la valeur la plus élevée des trois méthodes suivantes:*

- *Méthode 1: Déterminer la tension d'essai conformément au Tableau 25 à l'aide de la **tension de tenue exigée** (fondée sur les tensions transitoires du **réseau d'alimentation** en courant alternatif ou du **réseau d'alimentation** en courant continu ou des **circuits externes**).*
- *Méthode 2: Déterminer la tension d'essai conformément au Tableau 26 à l'aide de la crête de la **tension de service** ou des tensions crêtes récurrentes, selon la valeur la plus élevée.*
- *Méthode 3: Déterminer la tension d'essai conformément au Tableau 27 à l'aide de la tension nominale du **réseau d'alimentation** (pour couvrir les **surtensions temporaires**).*

L'isolation est soumise à la tension d'essai la plus élevée comme suit:

- *en appliquant une tension en courant alternatif de forme pratiquement sinusoïdale ayant une fréquence de 50 Hz ou 60 Hz; ou*
- *en appliquant une **tension en courant continu** pendant la durée indiquée ci-dessous.*

*La tension appliquée à l'isolation soumise à l'essai est progressivement élevée de zéro à la tension exigée et maintenue à cette valeur pendant 60 s (pour les **essais individuels de série**, voir 5.4.9.2).*

Si nécessaire, l'isolation est soumise à l'essai en mettant une feuille métallique en contact avec la surface isolante. Cette procédure d'essai est limitée aux zones où l'isolation est susceptible d'être faible (par exemple, où il y a des arêtes vives en métal sous l'isolation). Si possible, des doublures isolantes sont soumises à l'essai séparément. La feuille métallique est placée avec soin de sorte qu'il ne se produise pas de contournement aux arêtes de l'isolation. Lorsqu'une feuille métallique adhésive est utilisée, l'adhésif doit être conducteur.

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Pour éviter l'endommagement des composants ou des isolations qui ne sont pas concernés par l'essai, les circuits intégrés ou les éléments similaires peuvent être déconnectés et une liaison équipotentielle peut être utilisée. Une varistance conforme à l'Article G.8 peut être retirée pendant l'essai.

*Pour les équipements intégrant une **isolation principale** et une **isolation supplémentaire** en parallèle avec une **isolation renforcée**, la tension est appliquée avec soin à l'**isolation renforcée** afin de ne pas surcharger l'**isolation principale** ni l'**isolation supplémentaire**.*

Si des condensateurs sont mis en parallèle avec l'isolation soumise à l'essai (des condensateurs d'antiparasitage, par exemple) et qu'ils peuvent avoir un impact sur les résultats d'essai, des tensions d'essai en courant continu doivent être utilisées.

Il est permis de déconnecter les composants fournissant un chemin en courant continu en parallèle avec l'isolation à soumettre à l'essai, comme les résistances de décharge des condensateurs à filtre et les dispositifs de limitation de tension.

Lorsque l'isolation d'un enroulement de transformateur varie le long de l'enroulement conformément à 5.4.1.6, une méthode d'essai de rigidité diélectrique est utilisée et appliquée selon le type d'isolation le long de l'enroulement.

EXEMPLE Une telle méthode d'essai peut consister en un essai de tension induite appliquée à une fréquence suffisamment élevée pour éviter la saturation du transformateur. La tension d'entrée est élevée à une valeur qui induise une tension de sortie égale à la tension d'essai exigée.

Tableau 25 – Tensions d'essai pour les essais de rigidité diélectrique basés sur les tensions transitoires

Tension de tenue exigée jusque et y compris kV de crête	**Tension d'essai pour l'isolation principale ou l'isolation supplémentaire**	**Tension d'essai pour l'isolation renforcée**
	kV en valeur crête ou en courant continu	
0,33	0,33	0,5
0,5	0,5	0,8
0,8	0,8	1,5
1,5	1,5	2,5
2,5	2,5	4
4	4	6
6	6	8
8	8	12
12	12	18
U_R [a]	U_R [a]	1,5 × U_R [a]
Une interpolation linéaire peut être utilisée entre les deux points les plus proches.		
[a] U_R est une **tension de tenue exigée** supérieure à 12 kV.		

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Tableau 26 – Tensions d'essai pour les essais de rigidité diélectrique basés sur les valeurs crêtes des tensions de service et des tensions crêtes récurrentes

Tension jusque et y compris	Tension d'essai pour l'isolation principale ou l'isolation supplémentaire	Tension d'essai pour l'isolation renforcée
kV de crête	kV en valeur crête ou en courant continu	
0,33	0,43	0,53
0,5	0,65	0,8
0,8	1,04	1,28
1,5	1,95	2,4
2,5	3,25	4
4	5,2	6,4
6	7,8	9,6
8	10,4	12,8
12	15,6	19,2
U_P [a]	1,3 × U_P [a]	1,6 × U_P [a]
Une interpolation linéaire peut être utilisée entre les deux points les plus proches.		
[a] U_P est une tension supérieure à 12 kV.		

Tableau 27 – Tensions d'essai pour les essais de rigidité diélectrique basés sur les surtensions temporaires

Tension nominale du réseau d'alimentation	Tension d'essai pour l'isolation principale ou l'isolation supplémentaire	Tension d'essai pour l'isolation renforcée
V efficace	kV en valeur crête ou en courant continu	
Jusqu'à 250 inclus	2	4
Plus de 250 jusque et y compris 600	2,5	5

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Dimensions en millimètres

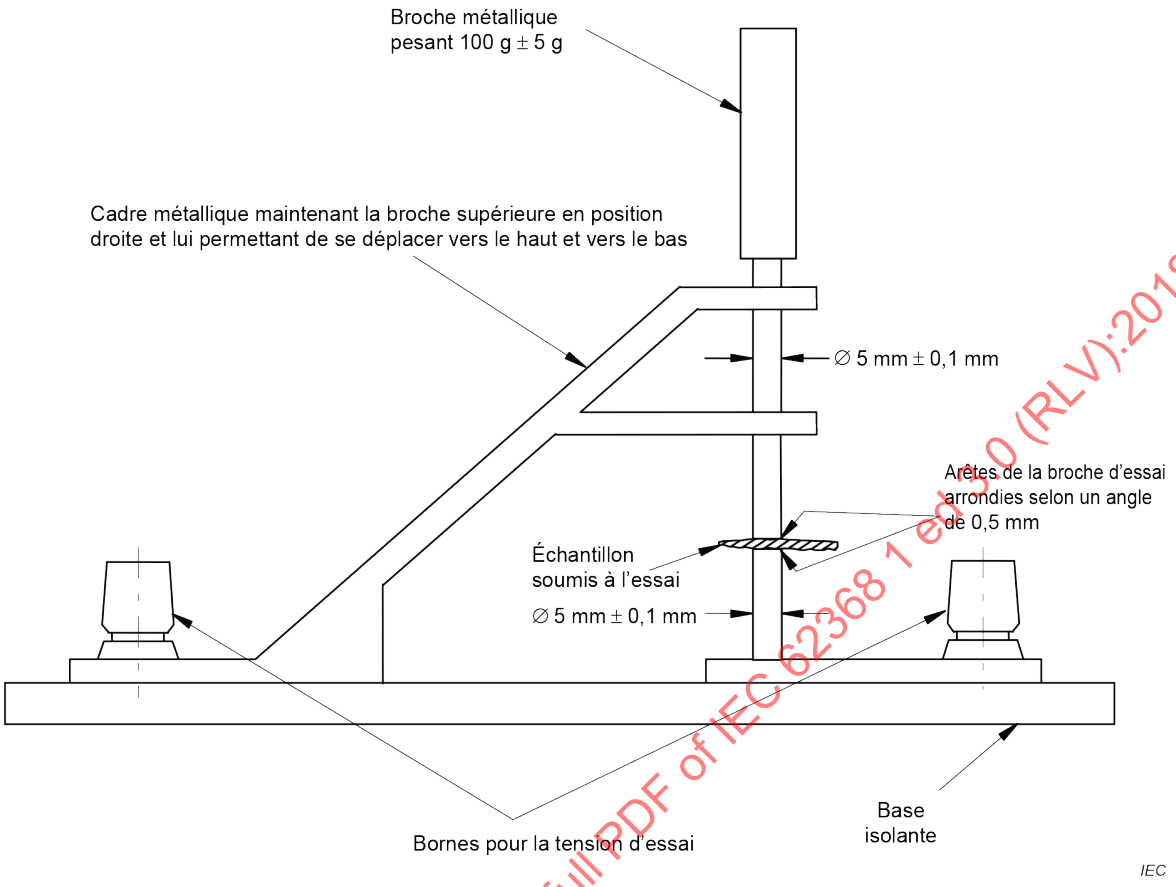


Figure 29 – Exemple d'instrument d'essai de rigidité diélectrique pour une isolation solide

NOTE Les isolations à fines couches peuvent être soumises à l'essai en utilisant l'instrument de la Figure 29. Lors du montage d'essai, vérifier que le diamètre de l'échantillon est de dimension suffisante pour empêcher la rupture autour des arêtes.

Il ne doit pas y avoir de rupture d'isolation pendant l'essai. Il est considéré qu'une rupture d'isolation se produit lorsque le courant qui s'écoule après l'application de la tension d'essai augmente rapidement de manière incontrôlée, c'est-à-dire lorsque l'isolation n'empêche pas le passage du courant. Une décharge en couronne ou un simple contournement momentané n'est pas considéré(e) comme une rupture d'isolation.

5.4.9.2 Procédure d'essai pour les essais individuels de série

Lorsque cela est exigé, les ***essais individuels de série*** *sont réalisés conformément à 5.4.9.1, sauf pour ce qui suit:*

- *l'essai peut être effectué à la température ambiante; et*
- *la durée de l'essai de rigidité diélectrique doit être comprise entre 1 s et 4 s; et*
- *la tension d'essai peut être réduite de 10 %.*

NOTE Les **essais individuels de série** pour l'équipement sont spécifiés dans l'IEC 62911.

Il ne doit pas y avoir de rupture d'isolation pendant l'essai. Il est considéré qu'une rupture d'isolation se produit lorsque le courant qui s'écoule après l'application de la tension d'essai augmente rapidement de manière incontrôlée, c'est-à-dire lorsque l'isolation n'empêche pas le passage du courant. Une décharge en couronne ou un simple contournement momentané n'est pas considéré(e) comme une rupture d'isolation.

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5.4.10 Protections contre les tensions transitoires des circuits externes

5.4.10.1 Exigences

Une séparation électrique appropriée doit être prévue entre les circuits prévus pour être raccordés aux **circuits externes** (voir le Tableau 13, ID 1, Figure 30) et:

a) les parties non conductrices et les parties conductrices non mises à la terre de l'équipement censées être tenues ou maintenues en contact continu avec le corps en utilisation normale (par exemple, un combiné ou un casque de téléphone ou la surface d'un ordinateur portable sur laquelle s'appuie la paume de la main);

b) des parties et des circuits **accessibles**, à l'exception des broches des connecteurs. Cependant, ce type de broches ne doit pas être **accessible** dans les **conditions normales de fonctionnement** au calibre d'essai de la Figure V.3;

c) une autre partie ES1 ou ES2 séparée des circuits prévus pour être raccordés à un **circuit externe**. L'exigence de séparation s'applique indépendamment de l'**accessibilité** ou non de la partie ES1 ou ES2.

Ces exigences ne s'appliquent pas lorsque l'analyse du circuit et l'étude de l'équipement indiquent qu'une protection adéquate est assurée par d'autres moyens (par exemple, entre deux circuits dont chacun a une connexion permanente à la terre de protection).

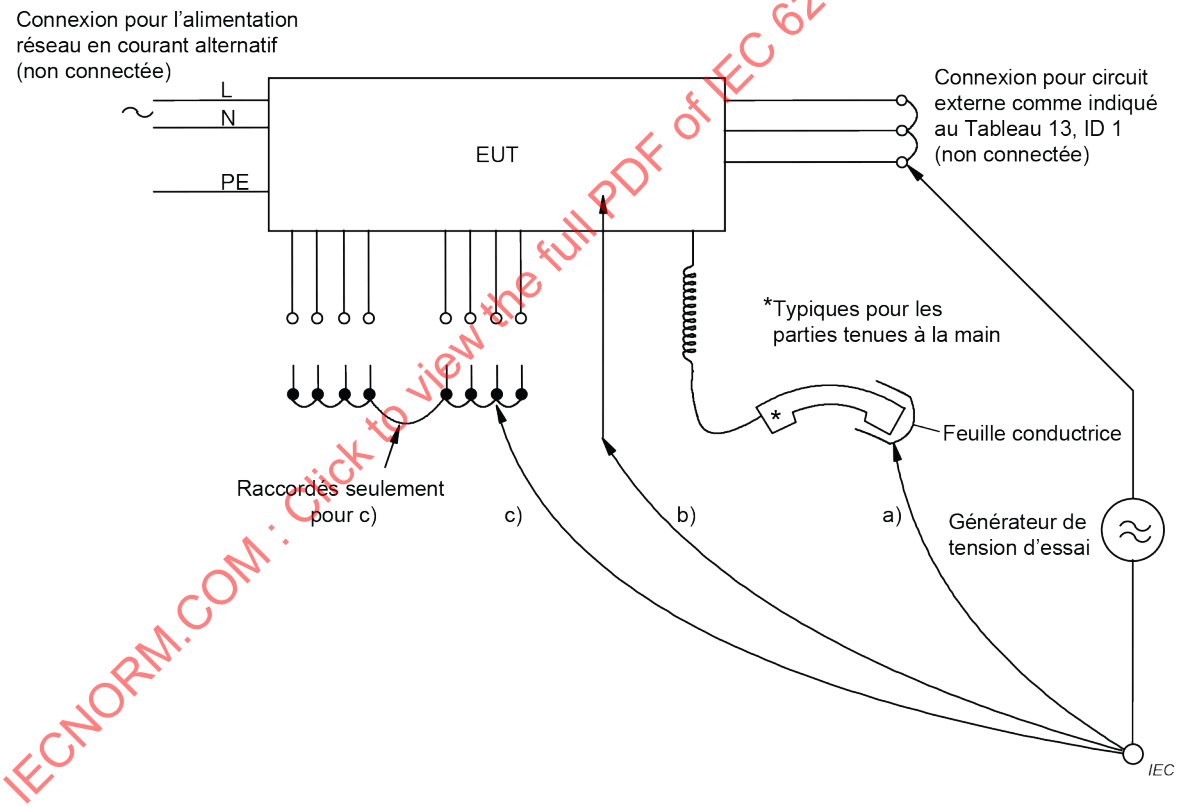


Figure 30 – Points d'application de la tension d'essai

5.4.10.2 Méthodes d'essai

5.4.10.2.1 Généralités

La séparation est vérifiée par l'essai de 5.4.10.2.2 ou de 5.4.10.2.3.

NOTE En Australie, les essais de 5.4.10.2.2 et de 5.4.10.2.3 s'appliquent.

Pendant l'essai:

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– *tous les conducteurs prévus pour être raccordés au **circuit externe** sont raccordés ensemble, y compris les conducteurs qui peuvent être raccordés à la terre dans le **circuit externe**; et*

– *tous les conducteurs prévus pour être raccordés à d'autres **circuits externes** sont raccordés ensemble.*

Tableau 28 – Valeurs pour les essais de rigidité diélectrique

Parties	Essai de choc (voir l'Annexe D)		Essai en régime constant
	U_C	Générateur d'essai	
Parties indiquées en 5.4.10.1 a) [a]	2,5 kV	circuit 1	1,5 kV
Parties indiquées en 5.4.10.1 b) et c) [b]	1,5 kV	circuit 1 [c]	1,0 kV

[a] Les parasurtenseurs ne doivent pas être retirés.

[b] Les parasurtenseurs peuvent être retirés, à condition qu'ils satisfassent à l'essai de choc de 5.4.10.2.2 lorsqu'ils sont soumis à l'essai en tant que composants à l'extérieur de l'équipement.

[c] Pendant cet essai, il est admis qu'un parasurtenseur fonctionne et qu'un claquage se produise dans un tube à décharge dans un gaz (GDT).

5.4.10.2.2 Essai de choc

La séparation électrique est soumise à dix impulsions de polarité alternées comme indiqué dans le Tableau 28. L'intervalle entre les impulsions successives est de 60 s. U_C est la valeur à laquelle il est nécessaire de charger le condensateur.

NOTE En Australie, une valeur U_C = 7,0 kV est utilisée pour les téléphones portatifs et pour les casques, la valeur étant de 2,5 kV pour les autres équipements de 5.4.10.1 a). Le choc de 7 kV simule les coups de foudre dont font l'objet les réseaux ruraux et semi-ruraux classiques.

5.4.10.2.3 Essai en régime constant

La séparation électrique est soumise à un essai de rigidité diélectrique selon 5.4.9.1, avec une valeur de tension conforme au Tableau 28.

NOTE En Australie, l'essai en régime constant est de 3 kV pour 5.4.10.1 a) et de 1,5 kV pour 5.4.10.1 b) et c). Ces valeurs ont été déterminées en tenant compte des tensions induites à basse fréquence provenant du système de distribution d'alimentation électrique.

5.4.10.3 Critères de conformité

Pendant les essais de 5.4.10.2.2 et 5.4.10.2.3:

– *il ne doit pas se produire de rupture de l'isolation; et*

– *à l'exception des indications du Tableau 28, note [c], le parasurtenseur ne doit pas fonctionner ni un claquage ne doit se produire dans un tube à décharge dans un gaz.*

Pour l'essai de rigidité diélectrique, la rupture de l'isolation est considérée comme s'étant produite lorsque le courant qui circule du fait de l'application de la tension d'essai augmente rapidement de manière incontrôlée.

Pour les essais de choc, la rupture de l'isolation est vérifiée selon l'une des deux méthodes suivantes:

– *pendant l'application des impulsions, par observation des oscillogrammes, le fonctionnement du parasurtenseur ou la rupture dans l'isolation est considéré en fonction de la forme d'un oscillogramme;*

– *après l'application de toutes les impulsions, par un essai de résistance d'isolement. La déconnexion des parasurtenseurs est admise en même temps que la mesure de la résistance d'isolement. La tension d'essai est de 500 V en courant continu ou, si les*

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parasurtenseurs sont laissés en place, une tension d'essai en courant continu de 10 % inférieure au fonctionnement du parasurtenseur ou à la tension d'amorçage. La résistance d'isolement ne doit pas être inférieure à 2 MΩ.

5.4.11 Séparation entre des circuits externes et la terre

5.4.11.1 Généralités

Ces exigences s'appliquent uniquement à l'équipement prévu pour être raccordé aux **circuits externes** indiqués au Tableau 13, ID 1.

Ces exigences ne s'appliquent pas:

– aux **équipements reliés en permanence**, ou

– aux **équipements enfichables de type B**; ou

– aux **équipements enfichables de type A stationnaires** qui sont conçus pour être utilisés dans un endroit ayant une liaison équipotentielle (telle qu'un centre de télécommunication, une salle d'ordinateurs dédiée ou une **zone à accès limité**) et dont les instructions d'installation exigent une vérification de la connexion de **mise à la terre de protection** du socle de prise de courant par une **personne qualifiée**; ou

– les **équipements enfichables de type A stationnaires** destinés à être utilisés avec un conducteur de mise à la terre de protection relié en permanence, accompagnés d'instructions d'installation de ce conducteur pour la mise à la terre par une **personne qualifiée**.

5.4.11.2 Exigences

Une séparation doit être prévue entre les circuits prévus pour être raccordés aux **circuits externes** mentionnés ci-dessus et les parties ou circuits qui sont mis à la terre dans certaines applications, soit dans l'équipement soumis à l'essai (EUT), soit par l'intermédiaire d'un autre équipement.

Les dispositifs de protection contre les surtensions (SPD) en parallèle de la séparation entre les circuits ES1 ou ES2 destinés à être raccordés aux **circuits externes** et la terre doivent présenter une tension d'emploi assignée minimale U_{op} (la tension de claquage d'un tube à décharge dans un gaz, par exemple) de:

$$U_{op} = U_{crête} + \Delta U_{sp} + \Delta U_{sa}$$

où

$U_{crête}$ est l'une des valeurs suivantes:

– pour l'équipement destiné à être installé dans une zone où la tension nominale du **réseau d'alimentation** en courant alternatif dépasse 130 V: 360 V;

– pour tous les autres équipements: 180 V.

ΔU_{sp} est la tolérance négative de la tension d'emploi assignée due aux variations de production du dispositif de protection contre les surtensions, obtenue en soustrayant la tension d'emploi assignée minimale de la tension d'emploi assignée nominale. Si cela n'est pas spécifié par le fabricant du SPD, ΔU_{sp} doit être prise égale à 10 % de la tension d'emploi assignée du SPD.

ΔU_{sa} est la variation de la tension d'emploi assignée due au vieillissement du SPD sur la durée de vie prévue de l'équipement, obtenue en soustrayant la tension d'emploi minimale après vieillissement de la tension d'emploi assignée. Si cela n'est pas spécifié par le fabricant du SPD, ΔU_{sa} doit être prise égale à 10 % de la tension d'emploi assignée du SPD.

($\Delta U_{sp} + \Delta U_{sa}$) peut être une seule valeur fournie par le fabricant du composant.

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5.4.11.3 Méthode d'essai et critères de conformité

La conformité est vérifiée par examen et par l'essai de rigidité diélectrique défini en 5.4.9.1 avec une tension d'essai conforme au Tableau 26 pour ***l'isolation principale*** *ou* ***l'isolation supplémentaire*** *en fonction de la* ***tension de tenue exigée*** *pour la tension du* ***réseau d'alimentation*** *de l'équipement.*

Les composants, autres que les condensateurs, qui sont en parallèle de l'isolation, peuvent être enlevés au cours de l'essai de rigidité diélectrique. Les composants laissés en place pendant l'essai ne doivent pas être endommagés.

Si les composants sont retirés, l'essai supplémentaire suivant avec un circuit d'essai conforme à la Figure 31 est effectué avec l'ensemble des composants en place.

Pour l'équipement alimenté par un ***réseau d'alimentation*** *en courant alternatif, l'essai est effectué avec une tension égale à la* ***tension assignée*** *de l'équipement ou à la tension supérieure de la* ***plage de tensions assignées****. Pour l'équipement alimenté par un* ***réseau d'alimentation*** *en courant continu, l'essai est effectué avec une tension égale à la tension nominale la plus élevée du* ***réseau d'alimentation*** *en courant alternatif dans la région où l'équipement doit être utilisé (230 V pour l'Europe ou 120 V pour l'Amérique du Nord, par exemple).*

Le courant passant dans le circuit d'essai de la Figure 31 ne doit pas dépasser 10 mA.

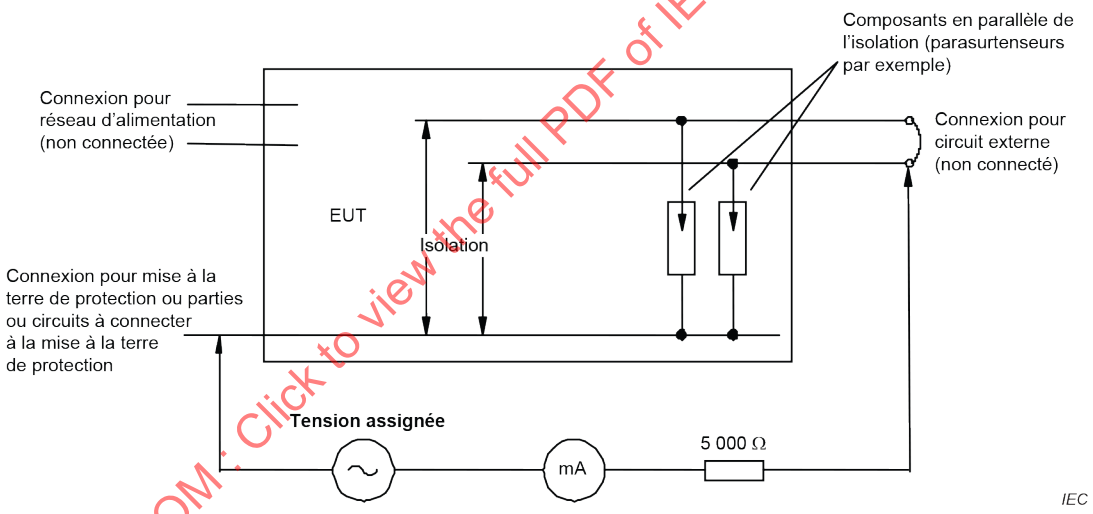


Figure 31 – Essai de séparation entre un circuit externe et la terre

5.4.12 Isolant liquide

5.4.12.1 Exigences générales

Il ne doit pas y avoir rupture de **l'isolant liquide** en raison de surtensions, y compris les transitoires, qui pénètrent dans l'équipement, et de tensions de crête qui peuvent être générées à l'intérieur de l'équipement.

L'**isolant liquide** doit satisfaire à 5.4.12.2 et 5.4.12.3. Le conteneur de l'**isolant liquide** doit satisfaire à 5.4.12.4.

5.4.12.2 Rigidité diélectrique d'un isolant liquide

La rigidité diélectrique de l'**isolant liquide** doit satisfaire à l'essai de rigidité diélectrique de 5.4.9 avec l'**isolant liquide** dans l'équipement.

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5.4.12.3 Compatibilité d'un isolant liquide

L'**isolant liquide** ne doit pas réagir avec les **protections** ni les détériorer, comme:

– l'**isolation solide;** ou

– l'**isolant liquide** lui-même.

*Pour les **isolants liquides** de classification thermique correspondant à la Classe 105 (A) de l'IEC 60085, la conformité est vérifiée en faisant fonctionner l'équipement immergé pendant 60 jours, suivis d'un essai de rigidité diélectrique conforme à 5.4.9. Il ne doit se produire aucune rupture ni aucun dommage ou déformation visible des autres **protections de l'équipement** immergées.*

Pour les classes thermiques supérieures, les exigences de 5.4.1.4.3 sont applicables.

5.4.12.4 Conteneur de l'isolant liquide

Le conteneur de l'**isolant liquide** doit comporter des moyens de détente de pression, dans le cas d'un récipient fermé.

Le conteneur d'**isolant liquide** doit satisfaire à G.15.2.1 s'il s'agit d'un récipient fermé.

Si un **isolant liquide** est également considéré comme une **substance dangereuse**, le conteneur doit également satisfaire aux exigences de 7.2.

La conformité est vérifiée par les essais correspondants.

5.5 Composants comme protections

5.5.1 Généralités

Un composant est considéré comme une **protection** si la classification de la source d'énergie change par suite d'une défaillance du composant.

Un composant utilisé comme **protection** doit:

– satisfaire à toutes les exigences applicables à la **protection** concernée; et

– être utilisé dans les limites de ses valeurs assignées.

NOTE Voir l'Annexe G pour la qualification des composants utilisés comme **protection**.

5.5.2 Condensateurs et cellules RC

5.5.2.1 Exigences générales

Les condensateurs et cellules RC qui servent de **protections** (électriques) doivent être conformes à l'IEC 60384-14. Les cellules RC peuvent être constituées de composants discrets.

Les condensateurs ou cellules RC avec un ou plusieurs condensateurs doivent:

– être conformes à l'Article G.11, cependant, les exigences de l'Article G.11 ne s'appliquent pas au condensateur et cellule RC utilisés comme **protection principale** entre:

  - ES3 isolé du **réseau d'alimentation** et la terre de protection; et
  - ES2 et la terre de protection; et
  - ES2 et ES1;

  et

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– satisfaire à l'essai de rigidité diélectrique de 5.4.9.1, tenant compte de la **tension de service** totale à travers le ou les condensateurs et cellules RC. Les condensateurs conformes à l'IEC 60384-14 n'ont pas besoin d'être soumis à l'essai si:

  - la valeur de crête de la tension d'essai de choc exigée du Tableau G.12; et
  - la valeur efficace de la tension d'essai exigée du Tableau G.12 multipliée par 1,414

  sont supérieures ou égales à la tension d'essai exigée de 5.4.9.1.

  Lorsque plusieurs condensateurs sont utilisés, les tensions d'essai du Tableau G.12 sont multipliées par le nombre de condensateurs utilisés.

Dans les **conditions de premier défaut**, si un condensateur ou une cellule RC comprend plusieurs condensateurs, la tension aux bornes de chacun des condensateurs individuels restants ne doit pas dépasser la valeur assignée des condensateurs individuels appropriés.

NOTE En Norvège, en raison du système d'alimentation IT utilisé, les condensateurs nécessitent d'être assignés pour la tension entre phases applicable (230 V).

Les condensateurs de classe X peuvent être utilisés comme **protections principales** dans des circuits isolés du **réseau d'alimentation**, mais ne doivent pas être utilisés comme:

– **protection principale** dans les circuits connectés au **réseau d'alimentation**; ou
– **protection supplémentaire**.

Les condensateurs de classe X ne doivent pas être utilisés comme **protection renforcée**.

5.5.2.2 Décharge du condensateur après déconnexion d'un connecteur

Lorsqu'une tension de condensateur devient **accessible** après la déconnexion d'un connecteur (le connecteur du **réseau d'alimentation**, par exemple), la tension **accessible** mesurée 2 s après la déconnexion du connecteur doit être conforme:

– aux limites ES1 du Tableau 5 dans les **conditions normales de fonctionnement** pour une **personne ordinaire**; et
– aux limites ES2 du Tableau 5 dans les **conditions normales de fonctionnement** pour une **personne avertie**; et
– aux limites ES2 du Tableau 5 dans les **conditions de premier défaut** pour une **personne ordinaire** et une **personne avertie**.

Une résistance ou un groupe de résistances utilisé(e) comme **protection** contre une décharge du condensateur n'est pas soumis(e) à des **conditions de premier défaut** simulées si la résistance ou le groupe de résistances satisfait à 5.5.6.

Si un circuit intégré qui comprend une fonction de décharge du condensateur (ICX) est utilisé pour satisfaire aux conditions ci-dessus:

– la tension **accessible** (au niveau du connecteur du **réseau d'alimentation**, par exemple) ne doit pas dépasser les limites indiquées ci-dessus en **condition de premier défaut** d'un ICX ou d'un composant du circuit de décharge du condensateur associé; ou
– l'ICX avec les circuits associés tels qu'ils sont fournis dans l'équipement doit satisfaire aux exigences de l'Article G.16. Un composant atténuant les impulsions (comme les varistances et les GDT) est déconnecté; ou
– trois échantillons d'ICX soumis séparément à l'essai doivent satisfaire aux exigences de l'Article G.16.

La mesure est réalisée avec un instrument ayant une impédance d'entrée constituée par une résistance de (100 MΩ ± 5) MΩ en parallèle d'une capacité d'entrée de 25 pF ou moins.

Si un interrupteur (l'interrupteur du **réseau d'alimentation**, par exemple) a une influence sur le résultat d'essai, il est placé dans la position la plus défavorable. La déconnexion du

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connecteur (début de la période de décharge) doit être réalisée lorsque le condensateur d'entrée du dispositif en essai est chargé à sa valeur de crête.

D'autres méthodes donnant un résultat similaire à celui de la méthode ci-dessus peuvent être utilisées.

5.5.3 Transformateurs

Les transformateurs utilisés comme **protection** doivent être conformes à G.5.3.

5.5.4 Optocoupleurs

L'isolation des optocoupleurs utilisés comme **protection** doit satisfaire aux exigences de 5.4 ou de l'Article G.12.

5.5.5 Relais

L'isolation des relais utilisés comme **protection** doit satisfaire aux exigences de 5.4.

5.5.6 Résistances

Les applications de résistances suivantes doivent satisfaire aux essais correspondants indiqués dans le Tableau 29:

– une seule résistance utilisée comme **protection renforcée** ou en parallèle de l'**isolation renforcée**;

– une résistance ou un groupe de résistances servant de **protection** entre un circuit raccordé au **réseau d'alimentation** et un circuit prévu pour être raccordé au câble coaxial;

– les résistances servant de **protection** contre les décharges du condensateur.

NOTE En Finlande, en Norvège et en Suède, les résistances utilisées comme **protection principale** ou en parallèle de l'**isolation principale** dans des **équipements enfichables de type A de classe I** doivent satisfaire aux exigences de l'Article G.10.

De plus, les résistances qui sont en parallèle de l'**isolation principale**, l'**isolation supplémentaire** ou **l'isolation renforcée** doivent satisfaire à chacune des exigences suivantes:

– une résistance unique ou un groupe de résistances doit satisfaire aux exigences relatives à la **distance dans l'air** de 5.4.2 et de **ligne de fuite** de 5.4.3, entre ses extrémités et pour la **tension de service** totale aux bornes de l'isolation (voir la Figure O.4);

– pour un groupe de résistances utilisé comme **protection renforcée** ou en parallèle de l'**isolation renforcée**, la **distance dans l'air** et la **ligne de fuite** sont évaluées comme si chaque résistance était court-circuitée à son tour, à moins que le groupe ne satisfasse aux exigences correspondantes de l'Article G.10.

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Tableau 29 – Présentation des essais pour les applications utilisant des résistances

Utilisation de la résistance	Conditionnement	Essai de résistance	Essai de tension de choc	Essai de choc	Essai de surcharge
	G.10.2	G.10.3	G.10.4	G.10.5	G.10.6
Protection renforcée ou en parallèle de l'**isolation renforcée**	X	X			
Entre un circuit connecté au **réseau d'alimentation** et un câble coaxial	X		X [a]	X [b]	
protection contre les décharges du condensateur	X				X

[a] Pour un **circuit externe** indiqué au Tableau 13, ID 6 et ID 7.

[b] Pour un **circuit externe** indiqué au Tableau 13, ID 3, ID 4 et ID 5.

5.5.7 Dispositifs de protection contre les surtensions (SPD)

Si une varistance est utilisée entre un circuit du **réseau d'alimentation** à la tension ES3 et la **mise à la terre de protection**:

– la connexion à la terre doit être conforme à 5.6.7; et

– la varistance doit être conforme à l'Article G.8.

Si une varistance est utilisée entre la phase et le neutre ou entre les phases, elle doit être conforme à l'Article G.8.

Lorsqu'un SPD esf utilisé entre le **réseau d'alimentation** et la **mise à la terre de protection**, il doit comprendre une varistance et un tube à décharge dans un gaz (GDT) connectés en série, avec application des spécifications suivantes:

– la varistance doit être conforme à l'Article G.8;

– le tube à décharge dans un gaz doit satisfaire:

- à l'essai de rigidité diélectrique de 5.4.9.1 pour l'**isolation principale**; et
- aux exigences relatives aux **distances dans l'air** et **lignes de fuite** externes de 5.4.2 et 5.4.3 respectivement pour l'**isolation principale**.

NOTE 1 Des exemples de SPD sont les MOV, les varistances et les tubes à décharge dans un gaz. Une varistance est parfois appelée VDR ou varistance à oxyde métallique (MOV).

Les exigences ci-dessus ne s'appliquent pas aux SPD reliés à une terre fiable (voir 5.6.7).

NOTE 2 Le présent document ne stipule pas l'exigence selon laquelle les parasurtenseurs nécessitent d'être conformes à une norme particulière sur les composants. Cependant, l'attention est attirée sur la série de normes IEC 61643, notamment:

– IEC 61643-21 (parafoudres dans les applications de télécommunications)

– IEC 61643-311 (tubes à décharge dans un gaz)

– IEC 61643-321 (diodes à avalanche)

– IEC 61643-331 (varistances à oxyde métallique).

– IEC 61643-341 (parafoudres à thyristor, TSS).

NOTE 3 Les SPD placés entre un **circuit externe** et la terre ne sont pas considérés comme une **protection**. Les exigences relatives à ces SPD sont traitées en 5.4.11.2.

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5.5.8 Isolation entre le réseau d'alimentation et un circuit externe composé d'un câble coaxial

L'isolation entre le **réseau d'alimentation** et la connexion à un câble coaxial, y compris la résistance en parallèle sur cette isolation, doit être en mesure de résister aux surtensions provenant du **circuit externe** et du **réseau d'alimentation**.

Cette exigence ne s'applique à aucun des équipements suivants:

– un équipement à usage intérieur, fourni avec une antenne (intégrée) encastrée et sans connexion à un câble coaxial; ou

– un équipement connecté à une terre fiable conformément à 5.6.7.

La combinaison de l'isolation et de la résistance est soumise à l'essai après le conditionnement de G.10.2 comme indiqué ci-dessous:

– *pour l'équipement prévu pour être raccordé à un câble coaxial connecté à une antenne extérieure, l'essai de surtension de G.10.4; ou*

– *pour l'équipement prévu pour être raccordé à un autre câble coaxial, l'essai de choc de G.10.5; ou*

– *pour l'équipement prévu pour être raccordé à une antenne extérieure et à d'autres connexions coaxiales, l'essai de surtension de G.10.4 et l'essai de choc de G.10.5.*

À l'issue des essais:

– *l'isolation doit être conforme à 5.4.5.3 et la résistance peut être retirée au cours de cet essai; et*

– *les résistances doivent être conformes à G.10.3 à moins que des données disponibles ne démontrent la conformité des résistances.*

5.5.9 Protection des socles de prise de courant d'un matériel pour installation extérieure

Un dispositif à courant différentiel résiduel (DDR) dont le courant différentiel de fonctionnement assigné ne dépasse par 30 mA doit être utilisé dans le **réseau d'alimentation** pour les socles de prise de courant d'usage général.

Le DDR doit faire partie intégrante du **matériel pour installation extérieure** ou de l'installation du bâtiment. Si le DDR ne fait pas partie intégrante de l'équipement, les instructions doivent indiquer les exigences d'installation du DDR.

La conformité est vérifiée par examen.

5.6 Conducteur de protection

5.6.1 Généralités

Dans les **conditions normales de fonctionnement**, un **conducteur de protection** peut servir:

– de **protection principale** pour éviter que les parties conductrices **accessibles** dépassent les limites de ES1; et

– de moyen de limiter les tensions transitoires dans un circuit mis à la terre.

Dans les **conditions de premier défaut**, un **conducteur de protection** peut servir de **protection supplémentaire** pour éviter que les parties conductrices **accessibles** dépassent les limites de ES2.

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5.6.2 Exigences relatives aux conducteurs de protection

5.6.2.1 Exigences générales

Les **conducteurs de protection** ne doivent contenir aucun interrupteur, aucun appareil limiteur de courant et aucun dispositif de protection contre les surintensités.

Le courant admissible des **conducteurs de protection** doit être approprié pour la durée du courant de défaut dans les **conditions de premier défaut**.

Les **conducteurs de protection** doivent établir un contact plus tôt et une déconnexion plus tard que les connexions d'alimentation dans chacun des cas suivants:

– un connecteur (sur un câble) ou un connecteur lié à une partie ou à un sous-ensemble qui peut être retiré par une personne autre qu'une **personne qualifiée**;

NOTE Il appartient aux bonnes pratiques que cette construction s'applique également lorsqu'il est attendu qu'une **personne qualifiée** remplace les parties et les ensembles alimentés alors que l'équipement est opérationnel.

– une fiche sur un câble d'alimentation;

– un connecteur.

La soudure ne doit pas constituer le seul moyen d'assurer une fixation mécanique d'un **conducteur de protection**.

L'extrémité d'un **conducteur de protection** doit être conçue de sorte qu'il soit peu probable qu'elle puisse se desserrer pendant les opérations d'entretien autres que celles du conducteur lui-même. Une seule borne peut être utilisée pour connecter plusieurs **conducteurs de liaison de protection**. L'extrémité d'un **conducteur de** mise à la **terre de protection** ne doit pas servir à sécuriser un composant ou une partie autre que le **conducteur de liaison de protection**.

Une seule borne pour fil électrique (terminaison) de type à vis ou à goujon peut être utilisée pour sécuriser le **conducteur de** mise à la **terre de protection** et le **conducteur de liaison de protection** de l'équipement muni d'un **câble d'alimentation fixé à demeure**. Dans ce cas, la terminaison du **conducteur** de mise à la **terre de protection** doit être séparée par un écrou de celle du **conducteur de liaison de protection**. Le **conducteur** de mise à la **terre de protection** doit se trouver en bas de la pile, de manière à ce que la connexion soit retirée en dernier.

5.6.2.2 Couleur de l'isolation

L'isolation du **conducteur de mise à la terre de protection** doit être de couleur jaune/verte.

Si un **conducteur de liaison de protection** est isolé, l'isolation doit être de couleur jaune/verte à l'exception des deux cas suivants:

– pour une tresse de mise à la terre, l'isolation, si fournie, peut être transparente;

– un **conducteur de liaison de protection** dans des ensembles tels que des câbles en ruban, des barres omnibus, des câblages imprimés, etc., peut être de n'importe quelle couleur à condition qu'il n'y ait aucun risque de mauvaise interprétation de l'utilisation du conducteur.

La conformité est vérifiée par examen.

5.6.3 Exigences relatives aux conducteurs de mise à la terre de protection

Les dimensions des **conducteurs de mise à la terre de protection** doivent être conformes aux valeurs minimales applicables aux conducteurs, spécifiées au Tableau G.7.

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NOTE 1 Pour les **équipements reliés en permanence** équipés d'une ou de plusieurs bornes pour le raccordement au **réseau d'alimentation**, il est fait référence aux exigences nationales applicables aux installations dans les bâtiments pour les dimensions du **conducteur de mise à la terre de protection**.

NOTE 2 L'IEC 60364-5-54 peut être aussi utilisée pour déterminer la dimension de conducteur minimale.

Pour les équipements connectés par un câble alimenté par le **réseau d'alimentation** en courant continu, la connexion de **mise à la terre de protection** peut être assurée par une borne séparée.

Un **conducteur de mise à la terre de protection** servant de **protection renforcée** peut être employé sur un **équipement enfichable de type B** ou sur un **équipement relié en permanence** uniquement et doit:

– être inclus dans et protégé par un câble d'alimentation gainé conforme à G.7.1 et pas plus léger que les cordons renforcés spécifiés à l'Annexe C de l'IEC 62440:2008; ou

– avoir une dimension de conducteur minimale non inférieure à 4 mm^2 s'il n'est pas protégé contre les dommages matériels; ou

– avoir une dimension de conducteur minimale non inférieure à 2,5 mm^2 s'il est protégé contre les dommages matériels; ou

– être protégé par un conduit prévu pour être raccordé à l'équipement et avoir une dimension minimale conforme au Tableau 30.

NOTE 3 Pour les câbles d'alimentation du **réseau d'alimentation**, voir aussi l'Article G.7.

NOTE 4 Une enveloppe de cordon renforcé est considérée comme adaptée à la protection contre les dommages matériels.

Tableau 30 – Dimensions des conducteurs de mise à la terre de protection des protections renforcées pour les équipements reliés en permanence

Protection assurée par	Dimension minimale de conducteur de mise à la terre de protection mm^2
Conduit souple non métallique	4
Conduit souple métallique	2,5
Conduit métallique non flexible	1,5
Le **conducteur de mise à la terre de protection** est destiné à être installé par une **personne qualifiée**.	

Un **conducteur de mise à la terre de protection** servant de **double protection** peut être utilisé sur un **équipement enfichable de type B** ou sur un **équipement relié en permanence** uniquement et doit être constitué de deux **conducteurs de mise à la terre de protection** indépendants:

*La conformité est vérifiée par examen et mesure des dimensions du **conducteur de mise à la terre de protection** selon le Tableau 30 ou le Tableau G.7, selon le cas.*

5.6.4 Exigences relatives aux conducteurs de liaison de protection

5.6.4.1 Exigences

Les **conducteurs de liaison de protection** de parties nécessitant d'être mises à la terre pour des raisons de sécurité doivent satisfaire à l'une des exigences suivantes:

– les dimensions minimales des conducteurs indiquées au Tableau G.7; ou

– si le **courant assigné** de l'équipement ou les **caractéristiques assignées du courant de protection** du circuit sont supérieurs à 25 A, les dimensions minimales des conducteurs indiquées au Tableau 31; ou

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– si le **courant assigné** de l'équipement et les **caractéristiques assignées du courant de protection** du circuit ne dépassent pas 25 A; soit
  - les dimensions minimales des conducteurs indiquées au Tableau 31; ou
  - l'essai de court-circuit limité de l'Annexe R; ou
– pour les composants uniquement, ne pas être inférieur aux conducteurs alimentant le composant.

Si le **courant assigné** de l'équipement n'est pas déclaré par le fabricant, il est égal à la valeur calculée de la **puissance assignée** divisée par la **tension assignée**.

NOTE Les **caractéristiques assignées du courant de protection** sont utilisées au Tableau 31 et dans l'essai de 5.6.6.2.

Tableau 31 – Dimensions minimales du conducteur de liaison de protection des conducteurs en cuivre

La plus petite des deux valeurs: courant assigné de l'équipement ou caractéristiques assignées du courant de protection du circuit à l'étude A **jusque et y compris**	**Dimensions minimales des conducteurs**	
	Section mm^2	**AWG** [section en mm^2]
3	0,3	22 [0,324]
6	0,5	20 [0,519]
10	0,75	18 [0,8]
13	1,0	16 [1,3]
16	1,25	16 [1,3]
25	1,5	14 [2]
32	2,5	12 [3]
40	4,0	10 [5]
63	6,0	8 [8]
80	10	6 [13]
100	16	4 [21]
125	25	2 [33]
160	35	1 [42]
190	50	0 [53]
230	70	000 [85]
260	95	0000 [107]
		kcmil [section en mm^2]
300	120	250 [126]
340	150	300 [152]
400	185	400 [202]
460	240	500 [253]

NOTE Les dimensions AWG et kcmil sont données à titre informatif uniquement. Les sections concernées ont été arrondies uniquement pour indiquer des chiffres significatifs. AWG signifie American Wire Gage et le terme "cmil" fait référence aux mils circulaires pour un mil circulaire égal à (diamètre en mils)^2. Ces termes sont communément utilisés pour désigner les dimensions des câbles en Amérique du Nord.

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5.6.4.2 Détermination des caractéristiques assignées du courant de protection

5.6.4.2.1 Réseau d'alimentation comme source

Lorsque la source est le **réseau d'alimentation**, les **caractéristiques assignées du courant de protection** du circuit est la caractéristique assignée du dispositif de protection contre les surintensités fourni dans l'installation du bâtiment ou faisant partie de l'équipement.

Si le dispositif de protection contre les surintensités est fourni dans l'installation du bâtiment, alors:

– pour un **équipement enfichable de type A**, la **caractéristique assignée du courant de protection** est la caractéristique assignée d'un dispositif de protection contre les surintensités fourni comme élément externe à l'équipement (dans le câblage du bâtiment, dans la fiche de raccordement au **réseau d'alimentation** ou dans un tiroir d'équipement, par exemple), avec un courant minimal de 16 A;

NOTE 1 Dans la majorité des pays, 16 A est considéré comme une valeur appropriée pour la **caractéristique assignée du courant de protection** du circuit alimenté par le **réseau d'alimentation**.

NOTE 2 Au Canada et aux États-Unis, la **caractéristique assignée du courant de protection** du circuit alimenté par le **réseau d'alimentation** est prise égale à 20 A.

NOTE 3 Au Royaume-Uni et en Irlande, la **caractéristique assignée du courant de protection** est prise égale à 13 A. Il s'agit de la caractéristique assignée la plus importante du fusible utilisé dans la fiche de raccordement au **réseau d'alimentation**.

NOTE 4 En France, dans certains cas, la **caractéristique assignée du courant de protection** du circuit alimenté par le **réseau d'alimentation** est prise égale à 20 A à la place de 16 A.

– pour un **équipement enfichable de type B** et un **équipement relié en permanence,** la **caractéristique assignée du courant de protection** est la caractéristique assignée maximale du dispositif de protection contre les surintensités spécifiée dans les instructions d'installation de l'équipement devant être fourni comme élément externe à l'équipement.

5.6.4.2.2 Source autre que le réseau d'alimentation

Si la source est une alimentation externe avec un courant maximal limité, par construction, par l'impédance interne de la source (comme un transformateur protégé par impédance), la **caractéristique assignée du courant de protection** du circuit est le courant le plus élevé disponible à partir de cette alimentation sur une charge quelconque.

Lorsque le courant maximal de la source d'alimentation externe est limité par des composants électroniques dans la source, la **caractéristique assignée du courant de protection** doit être considérée comme le courant de sortie maximal sur une charge résistive quelconque, y compris un court-circuit. Si le courant est limité par une impédance, un fusible, un dispositif à coefficient de température positif ou un disjoncteur, le courant est mesuré 60 s après l'application de la charge. Si le courant est limité par d'autres moyens, le courant est mesuré 5 s après l'application de la charge.

5.6.4.2.3 Circuit interne comme source

Lorsque la source est un circuit à l'intérieur de l'équipement, la **caractéristique assignée du courant de protection** du circuit est:

– la caractéristique assignée du dispositif de protection contre les surintensités si le courant est limité par un dispositif de protection contre les surintensités; ou

– le courant de sortie maximal, si le courant est limité par l'impédance de la source de l'alimentation. Le courant de sortie est mesuré avec une charge résistive quelconque, y compris un court-circuit, mesuré 60 s après l'application de la charge, si le courant est limité par impédance ou si le dispositif de limitation du courant est un fusible, un disjoncteur ou un dispositif à coefficient de température positif, ou 5 s dans les autres cas.

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5.6.4.2.4 Dispositifs de limitation de courant et de protection contre les surintensités

Un dispositif de limitation du courant (dispositif à coefficient de température positif, CTP) ou un dispositif de protection contre les surintensités (un fusible ou un disjoncteur) ne doit pas être connecté en parallèle avec un autre composant susceptible d'être défaillant en situation de faible résistance.

5.6.4.3 Critères de conformité

*La conformité est vérifiée par examen et mesure des dimensions du **conducteur de liaison de protection** conformément au Tableau 31 ou au Tableau G.7 et par l'essai de 5.6.6 ou de l'Annexe R selon le cas.*

5.6.5 Bornes des conducteurs de protection

5.6.5.1 Exigences

Les bornes de connexion des **conducteurs de mise à la terre de protection** doivent être conformes aux valeurs minimales applicables aux conducteurs, spécifiées au Tableau 32.

Les bornes de connexion des **conducteurs de liaison de protection** doivent satisfaire à l'un des éléments suivants:

– les dimensions minimales des bornes données au Tableau 32; ou

– si soit le **courant assigné** de l'équipement ou les **caractéristiques assignées du courant de protection** du circuit dépassent 25 A, les dimensions de borne de pas plus d'une taille inférieures aux valeurs indiquées au Tableau 32; ou

– si à la fois le **courant assigné** de l'équipement et les **caractéristiques assignées du courant de protection** du circuit ne dépassent pas 25 A; soit

  - les dimensions de borne de pas plus d'une taille inférieure aux valeurs indiquées au Tableau 32; ou
  - l'essai de court-circuit limité de l'Annexe R;

  ou

– pour les composants uniquement, ne pas être inférieures aux dimensions de borne alimentant le composant.

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Tableau 32 – Dimensions des bornes pour les conducteurs de protection

Dimension de conducteur mm² (du Tableau G.7)	Diamètre de filetage nominal minimal mm		Section mm²	
	Type pilier ou à tige	Type à vis [a]	Type pilier ou à tige	Type à vis [a]
1	3,0	3,5	7	9,6
1,5	3,5	4,0	9,6	12,6
2,5	4,0	5,0	12,6	19,6
4	4,0	5,0	12,6	19,6
6	5,0	5,0	19,6	19,6
10 [b]	6,0	6,0	28	28
16 [b]	7,9	7,9	49	49

[a] "Type à vis" désigne une borne qui fixe le conducteur sous la tête d'une vis, avec ou sans rondelle.

[b] En variante aux exigences du présent tableau, le **conducteur de mise à la terre de protection** peut être fixé à des connecteurs spéciaux ou à des moyens de serrage adaptés (par exemple, une fourche renversée ou une pression en boucle fermée, un organe de serrage, un organe de serrage à selle serre-fils, un organe de serrage à capot taraudé; etc.) qui sont fixés par une vis et un mécanisme d'écrou au châssis en métal de l'équipement. La somme des sections transversales de la vis et de l'écrou ne doit pas être inférieure à trois fois la section transversale de la dimension du conducteur du Tableau 31 ou du Tableau G.7, selon le cas. Les bornes doivent être conformes à l'IEC 60998-1 et à l'IEC 60999-1 ou l'IEC 60999-2.

La conformité est vérifiée par examen et mesures des dimensions des bornes de protection conformément au Tableau 32, l'essai de 5.6.6 ou l'Annexe R, selon le cas.

5.6.5.2 Corrosion

Les parties conductrices en contact au niveau de la borne principale de **mise à la terre de protection**, des bornes de liaison de protection et des connexions doivent être choisies conformément à l'Annexe N de telle sorte que la différence de potentiel entre deux métaux différents est de 0,6 V ou moins.

La conformité est vérifiée par examen des matériaux des conducteurs, des bornes et des parties associées et par détermination de la différence de potentiel.

5.6.6 Résistance du système de liaison de protection

5.6.6.1 Exigences

Les **conducteurs de liaison de protection** et leurs extrémités ne doivent pas avoir de résistance excessive.

NOTE Un système de liaison de protection dans l'équipement comprend un seul conducteur ou une combinaison de parties conductrices, reliant une borne principale de **mise à la terre de protection** à une partie de l'équipement qui est à mettre à la terre pour des raisons de sécurité.

Les **conducteurs de liaison de protection** qui répondent, sur toute leur longueur, aux dimensions minimales de conducteurs du Tableau G.7 et dont les bornes répondent toutes aux dimensions minimales du Tableau 32 sont considérés comme conformes, sans essai.

Sur les équipements où la connexion de terre de protection à un sous-ensemble ou à un organe séparé s'effectue au moyen d'un conducteur dans un câble multiconducteur qui alimente également ce sous-ensemble ou cet organe, et lorsque le câble est protégé par un dispositif de protection assigné adapté qui prend en compte la dimension du conducteur, la résistance du **conducteur de liaison de protection** dans ce câble n'est pas incluse dans la mesure.

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5.6.6.2 Méthode d'essai

Le courant d'essai peut être alternatif ou continu et la tension d'essai ne doit pas dépasser 12 V. Les mesures sont réalisées entre la borne principale de ***mise à la terre de protection*** *et le point de l'équipement qui est à mettre à la terre.*

La résistance du ***conducteur de mise à la terre de protection*** *et d'un conducteur mis à la terre dans d'autres câblages externes n'est pas incluse dans les mesures. Cependant, si le* ***conducteur de mise à la terre de protection*** *est fourni avec l'équipement, il peut être inclus dans le circuit d'essai, mais les mesures de chute de tension sont réalisées uniquement entre la borne principale de* ***mise à la terre de protection*** *et la partie devant être mise à la terre.*

Il y a lieu de s'assurer que la résistance de contact entre l'extrémité de la sonde d'essai et la partie conductrice en essai n'influence pas les résultats de l'essai. Le courant d'essai et la durée de l'essai sont les suivants:

a) *Pour les équipements alimentés par le* ***réseau d'alimentation****, si la* ***caractéristique assignée du courant de protection*** *du circuit soumis à l'essai est inférieure ou égale à 25 A, le courant d'essai correspond à 200 % de la* ***caractéristique assignée du courant de protection*** *appliquée pendant 2 min.*

b) *Pour les équipements alimentés par le* ***réseau d'alimentation*** *en courant alternatif, si la* ***caractéristique assignée du courant de protection*** *du circuit soumis à l'essai dépasse 25 A, le courant d'essai correspond à 200 % de la* ***caractéristique assignée du courant de protection*** *ou est de 500 A, selon la plus petite valeur, et la durée de l'essai est telle qu'indiquée au Tableau 33.*

Tableau 33 – Durée de l'essai, équipements connectés au réseau d'alimentation

Caractéristique assignée du courant de protection du circuit A jusque et y compris	Durée de l'essai min
30	2
60	4
100	6
200	8
supérieur à 200	10

c) *Une alternative à b) consiste à baser les essais sur les caractéristiques temps-courant du dispositif de protection contre les surintensités qui limite le courant de défaut dans le* ***conducteur de liaison de protection****. Ce dispositif est soit celui qui équipe l'EUT, soit celui qui est spécifié dans les instructions d'installation pour être fourni à l'extérieur de l'équipement. Les essais sont réalisés à 200 % de la* ***caractéristique assignée du courant de protection****, pour la durée correspondant à 200 % des caractéristiques temps-courant. Si la durée pour 200 % n'est pas indiquée, le point le plus proche des caractéristiques temps-courant peut être utilisé.*

d) *Pour les équipements alimentés par un* ***réseau d'alimentation*** *en courant continu, si la* ***caractéristique assignée du courant de protection*** *du circuit soumis à l'essai dépasse 25 A, le courant d'essai et la durée sont tels que spécifiés par le fabricant.*

e) *Pour un équipement alimenté par un* ***circuit externe****, le courant d'essai représente 1,5 fois le courant maximal disponible à partir du* ***circuit externe*** *ou 2 A, selon la valeur la plus grande, pendant une durée de 2 min. Pour les parties connectées au* ***conducteur de liaison de protection*** *afin de limiter les transitoires ou de limiter le* ***courant de contact*** *avec un* ***circuit externe*** *et ne dépassant pas un niveau ES2 dans les* ***conditions de premier défaut****, l'essai est réalisé conformément à la méthode d'essai et aux critères de a), b), c) ou d), en fonction de la source d'alimentation.*

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5.6.6.3 Critères de conformité

*Si les **caractéristiques assignées du courant de protection** ne dépassent pas 25 A, la résistance du système de liaison de protection, calculée à partir de la chute de tension, ne doit pas dépasser 0,1 Ω.*

*Si les **caractéristiques assignées du courant de protection** dépassent 25 A, la chute de tension dans le système de protection ne doit pas dépasser 2,5 V.*

5.6.7 Connexion fiable d'un conducteur de mise à la terre de protection

Pour les **équipements reliés en permanence**, la mise à la terre est considérée comme fiable.

Pour les équipements reliés par cordon au **réseau d'alimentation**, la mise à la terre est également considérée comme fiable pour:

– les **équipements enfichables de type B**; ou

– les **équipements enfichables de type A stationnaires**

- qui sont conçus pour être utilisés dans un emplacement ayant une liaison équipotentielle (telle qu'un centre de télécommunications, une salle d'ordinateurs dédiée ou une **zone à accès limité**); et
- dont les instructions d'installation exigent une vérification de la connexion de **mise à la terre de protection** du socle de prise de courant par une **personne qualifiée**; ou

– les **équipements enfichables de type A stationnaires**

- destinés à être utilisés avec un **conducteur de mise à la terre de protection** relié en permanence; et
- accompagnés d'instructions d'installation de ce conducteur à la terre du bâtiment par une **personne qualifiée**.

Pour les équipements connectés à un **circuit externe** (voir le Tableau 13), numéros d'identification 1, 2, 3, 4 et 5, la mise à la terre est considérée comme étant fiable pour les **équipements enfichables de type A** et les **équipements enfichables de type B** destinés à être utilisés avec:

– un **conducteur de mise à la terre de protection** relié en permanence; et

– accompagnés d'instructions d'installation de ce conducteur à la terre du bâtiment par une **personne qualifiée**.

5.6.8 Mise à la terre pour des raisons fonctionnelles

Si un **conducteur de mise à la terre de protection** du câble d'alimentation du **réseau d'alimentation** est utilisé uniquement pour établir la **mise à la terre pour des raisons fonctionnelles**:

– les exigences en matière de dimension de conducteur (voir G.7.2) s'appliquent au conducteur de mise à la terre du cordon d'alimentation du **réseau d'alimentation**; et

– le marquage de l'**équipement de classe II** avec la **mise à la terre pour des raisons fonctionnelles** doit être utilisé comme indiqué en F.3.6.2; et

– le socle de connecteur, s'il est utilisé, doit satisfaire aux exigences de **distance dans l'air** et de **ligne de fuite** pour la **double isolation** ou l'**isolation renforcée**.

NOTE 1 Certains socles de connecteur d'**équipement de classe I** ne présentent pas une isolation suffisante pour servir de **double isolation** ou d'**isolation renforcée** entre les phases et la borne de **mise à la terre de protection**. Les équipements utilisant un tel socle ne sont pas considérés comme des **équipements de classe II**.

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NOTE 2 En Norvège, les équipements connectés à la fiche de raccordement au **réseau d'alimentation** mise à la terre sont classés parmi les **équipements de classe I**. Voir les exigences de marquage du pays à la note 4.1.15. Le symbole IEC 60417-6092 (voir F.3.6.2) est accepté.

5.7 Tension de contact présumée, courant de contact et courant du conducteur de protection

5.7.1 Généralités

Les mesures de la **tension de contact présumée**, du **courant de contact** et du **courant du conducteur de protection** sont effectuées sur l'EUT alimenté à la tension d'alimentation la plus défavorable (voir B.2.3).

5.7.2 Dispositifs de mesure et réseaux

5.7.2.1 Mesure du courant de contact

Pour les mesures de **courant de contact**, l'instrument utilisé pour mesurer U_2 et U_3, spécifiés respectivement à la Figure 4 et la Figure 5 de l'IEC 60990:2016, doit indiquer la tension de crête. Si la forme d'onde du **courant de contact** est sinusoïdale, un instrument indiquant la valeur efficace peut être utilisé.

5.7.2.2 Mesure de la tension

Les équipements ou parties d'équipements qui, dans l'application prévue, sont destinés à être mis à la terre mais qui ne sont pas reliés à la terre tels qu'ils sont fournis, doivent être reliés à la terre pendant la mesure à l'endroit où la **tension de contact présumée** est la plus élevée.

5.7.3 Montage de l'équipement, connexions d'alimentation et connexions de mise à la terre

Le montage de l'équipement, les connexions d'alimentation de l'équipement et la mise à la terre de l'équipement doivent être conformes à l'Article 4, à 5.3 et à 5.4 de l'IEC 60990:2016.

Les équipements pourvus d'une connexion à la terre indépendante du **conducteur de mise à la terre de protection** doivent être soumis à l'essai avec cette connexion déconnectée.

Dans un système, les équipements interconnectés, raccordés individuellement au **réseau d'alimentation** doivent être soumis à l'essai séparément.

Les systèmes d'équipements interconnectés avec une seule connexion au **réseau d'alimentation** doivent être soumis à l'essai comme un seul équipement.

NOTE 1 Les systèmes d'équipements interconnectés sont spécifiés plus en détail à l'Annexe A de l'IEC 60990:2016.

L'essai des équipements conçus pour avoir des connexions multiples au **réseau d'alimentation**, où une seule connexion à la fois est exigée, doit être effectué sur chacune des connexions tandis que les autres connexions sont déconnectées.

L'essai des équipements conçus pour avoir des connexions multiples au **réseau d'alimentation**, où plus d'une connexion est exigée, doit être effectué sur chacune des connexions tandis que les autres connexions sont connectées, avec les **conducteurs de mise à la terre de protection** connectés entre eux. Si le **courant de contact** dépasse la limite spécifiée en 5.2.2.2, le **courant de contact** doit être mesuré individuellement.

NOTE 2 Il n'est pas nécessaire que l'EUT fonctionne normalement pendant cet essai.

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5.7.4 Parties accessibles non mises à la terre

Dans les **conditions normales de fonctionnement**, les **conditions anormales de fonctionnement** et les **conditions de premier défaut** (sauf pour un défaut de **protection**), la tension de contact ou le **courant de contact** doit être mesuré à partir de toutes les parties conductrices **accessibles** non mises à la terre. Le **courant de contact** (courants [a] et [b] du Tableau 4) doit être mesuré selon 5.1, 5.4 et 6.2.1 de l'IEC 60990:2016.

Dans les **conditions de premier défaut** d'une **protection principale** ou d'une **protection supplémentaire** appropriée, y compris 6.2.2.2 de l'IEC 60990:2016, la tension de contact ou le **courant de contact** doit être mesuré à partir de toutes les parties conductrices **accessibles** non mises à la terre. Le **courant de contact** (courant [b] du Tableau 4) doit être mesuré avec le réseau spécifié à la Figure 5 de l'IEC 60990:2016.

Pour une partie **accessible** non conductrice, l'essai est réalisé avec une feuille métallique (voir 5.2.1 de l'IEC 60990:2016).

5.7.5 Parties conductrices accessibles mises à la terre

Au moins une partie conductrice **accessible** mise à la terre doit être soumise à l'essai de **courant de contact** après un défaut de connexion d'alimentation conformément à 6.1 et 6.2.2 de l'IEC 60990:2016, à l'exception de 6.2.2.8. À l'exception de ce qui est permis en 5.7.6, le **courant de contact** ne doit pas dépasser les limites de ES2 spécifiées en 5.2.2.2.

Le paragraphe 6.2.2.3 de l'IEC 60990:2016 ne s'applique pas aux équipements munis d'un interrupteur ou d'un autre **dispositif de déconnexion** qui déconnecte tous les pôles de l'alimentation.

NOTE Un connecteur est un exemple de **dispositif de déconnexion**.

5.7.6 Exigences lorsque le courant de contact dépasse les limites de ES2

Lorsque le **courant de contact** dépasse les limites de ES2 (5.2.2.2) dans les conditions de défaut d'alimentation spécifiées en 6.2.2.2 de l'IEC 60990:2016, toutes les conditions ci-dessous s'appliquent:

– le **courant du conducteur de protection** mesuré selon l'Article 8 de l'IEC 60990:2016 ne doit pas dépasser 5 % du courant d'entrée mesuré dans les **conditions normales de fonctionnement**;

– la construction du circuit du **conducteur de mise à la terre de protection** et de ses connexions doivent avoir:

  - un **conducteur de mise à la terre de protection** servant de **protection renforcée** tel que spécifié en 5.6.3 ou deux **conducteurs de mise à la terre de protection** indépendants servant de **double protection**, et
  - une connexion fiable à la **mise à la terre de protection** tel que spécifié en 5.6.7;

– le fabricant doit indiquer la valeur du **courant du conducteur de protection** dans les instructions d'installation si le courant dépasse 10 mA;

– une **protection par instructions** doit être prévue conformément à l'Article F.5, à l'exception du fait que l'élément 3 est facultatif. Les éléments de la **protection par instructions** doivent être comme suit:

  - élément 1a:  , IEC 60417-6042 (2010-11); et

    , IEC 60417-6173 (2012-10); et

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, IEC 60417-5019 (2006-08)

- élément 2: "Attention" ou mot ou texte équivalent, et "Courant de contact élevé" ou texte équivalent;
- élément 3: facultatif
- élément 4: "Connecter à la terre avant de connecter à l'alimentation" ou texte équivalent.

Les éléments de la **protection par instructions** nécessitant d'être placés sur l'équipement doivent être fixés sur l'équipement à côté de sa connexion d'alimentation.

NOTE Au Danemark, les instructions d'installation doivent être apposées sur l'équipement si le **courant du conducteur de protection** dépasse les limites de 3,5 mA en courant alternatif ou 10 mA en courant continu

5.7.7 Tension de contact présumée et courant de contact associés aux circuits externes

5.7.7.1 Courant de contact provenant de câbles coaxiaux

Si l'équipement est raccordé à des **circuits externes** avec un câble coaxial et si un tel raccordement est susceptible d'engendrer un danger, le fabricant doit fournir des instructions pour connecter le blindage du câble coaxial à la terre conformément à 6.2 g) et 6.2 l) de l'IEC 60728-11:2016.

NOTE 1 En Norvège et en Suède, l'écran du réseau de télédistribution n'est en général pas mis à la terre à l'entrée du bâtiment et il n'existe généralement pas de système de liaison équipotentielle dans le bâtiment. Par conséquent, la **mise à la terre de protection** de l'installation du bâtiment nécessite d'être isolée de l'écran d'un réseau de distribution par câble.

Il est cependant admis d'assurer l'isolation à l'extérieur de l'équipement par un adaptateur ou un câble d'interconnexion à isolation galvanique, qui peut être fourni par exemple par un revendeur.

Le manuel de l'utilisateur doit alors comporter les informations suivantes ou analogues rédigées en norvégien ou en suédois respectivement, en fonction du pays dans lequel l'équipement est destiné à être utilisé:

"L'appareil connecté à la **mise à la terre de protection** de l'installation du bâtiment par la connexion du réseau d'alimentation ou par d'autres appareils avec une connexion à la **mise à la terre de protection** – et à un réseau de télédistribution au moyen d'un câble coaxial, peut dans certains cas créer un danger d'incendie. Par conséquent, la connexion à un réseau de télédistribution doit être équipée d'un dispositif assurant l'isolation électrique en dessous d'une certaine gamme de fréquences (isolation galvanique, voir l'IEC 60728-11)."

NOTE 2 En Norvège, du fait des réglementations applicables aux installations de distribution de télévision par câble, et en Suède, un isolant galvanique doit assurer l'isolation électrique en dessous 5 MHz. L'isolation doit supporter une valeur de rigidité diélectrique de 1,5 kV efficace, 50 Hz ou 60 Hz, pendant 1 minute.

Traduction en norvégien (le texte en suédois est également accepté en Norvège):

"Apparater som er koplet til beskyttelsesjord via nettplugg og/eller via annet jordtilkoplet utstyr – og er tilkoplet et koaksialbasert kabel-TV nett, kan forårsake brannfare. For å unngå dette skal det ved tilkopling av apparater til kabel-TV nett installeres en galvanisk isolator mellom apparatet og kabel-TV nettet."

Traduction en suédois:

"Apparater som är kopplad till skyddsjord via jordat vägguttag och/eller via annan utrustning och samtidigt är kopplad till kabel-TV nät kan i vissa fall medföra risk för brand. För att undvika detta skall vid anslutning av apparaten till kabel-TV nät galvanisk isolator finnas mellan apparaten och kabel-TV nätet.".

5.7.7.2 Tension de contact présumée et courant de contact associés aux câbles conducteurs à paires

Pour les circuits destinés à être connectés à des **circuits externes** comme ceux décrits en ID 1 du Tableau 13:

– la **tension de contact présumée** doit être conforme à ES2; ou
– le **courant de contact** ne doit pas dépasser 0,25 mA.

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Les exigences ci-dessus ne s'appliquent pas si les **circuits externes** correspondants sont reliés à un **conducteur de mise à la terre de protection**.

La conformité est vérifiée par mesure selon 5.7.2 et 5.7.3 en utilisant la configuration de mesure de la Figure 32 pour les équipements monophasés et celle de la Figure 33 pour les équipements triphasés.

NOTE Pour les autres systèmes de distribution de puissance, voir l'IEC 60990:2016.

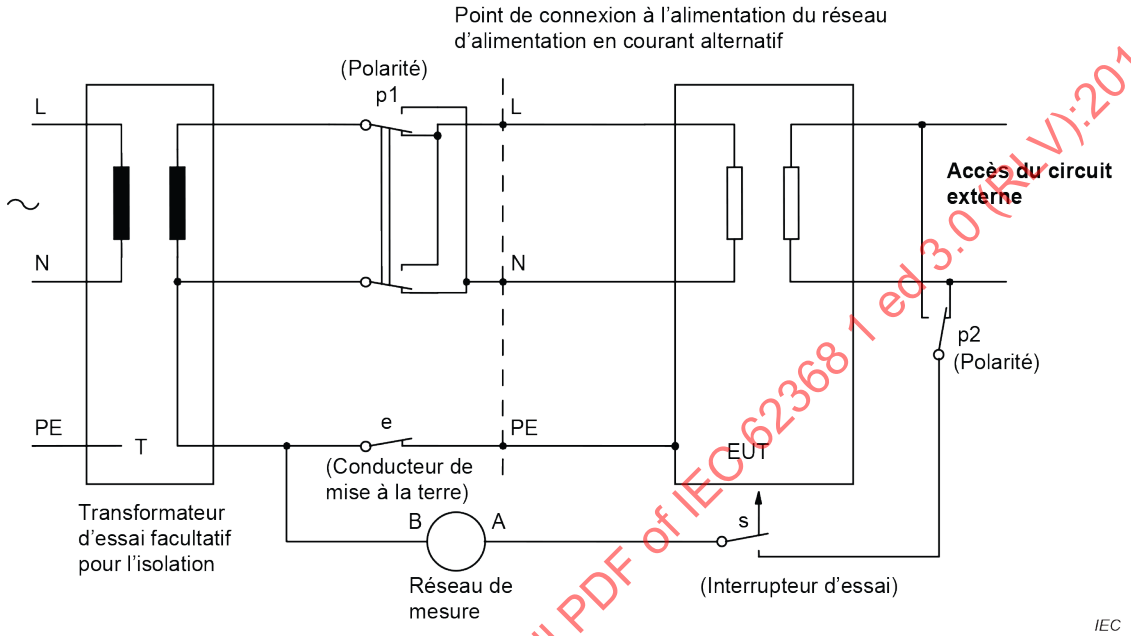


Figure 32 – Circuit d'essai pour le courant de contact d'équipement monophasé

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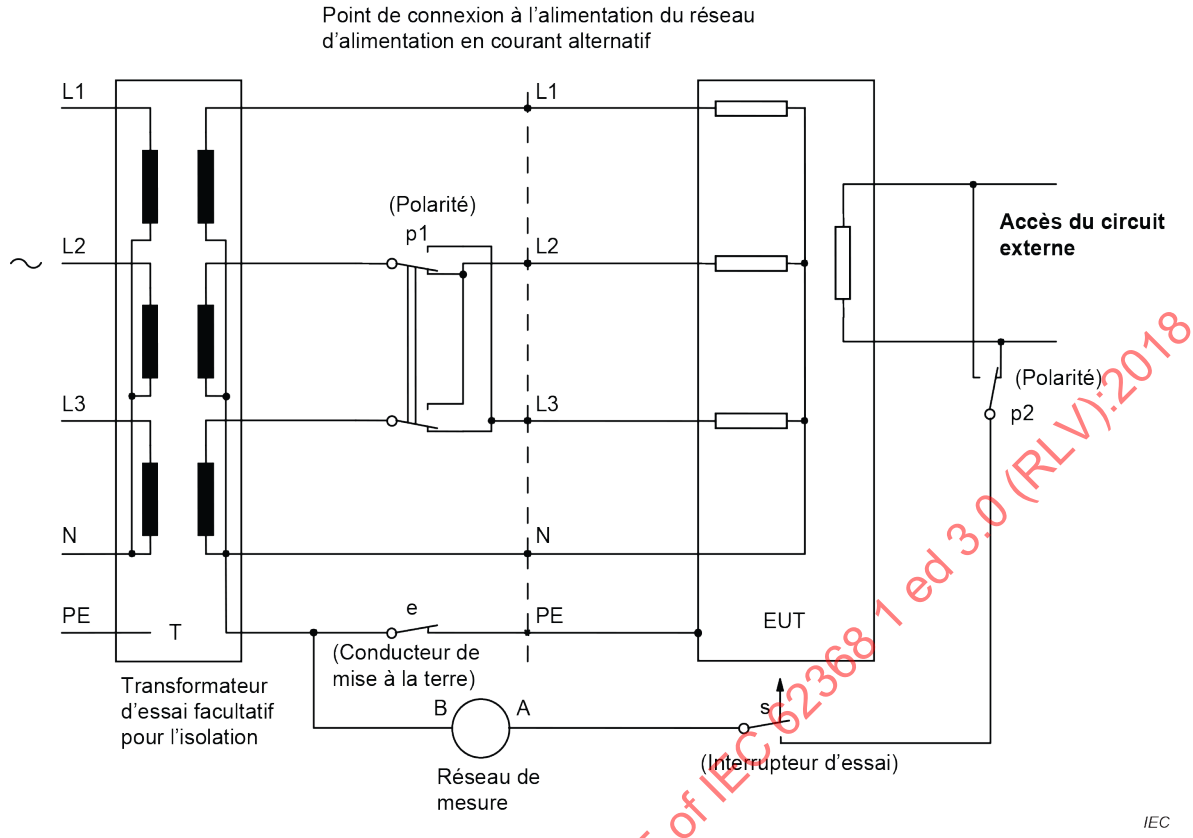


Figure 33 – Circuit d'essai pour le courant de contact d'équipement triphasé

5.7.8 Somme des courants de contact provenant de circuits externes

Les exigences ci-dessous spécifient dans quel cas un **conducteur de mise à la terre de protection** relié en permanence est nécessaire pour l'**équipement enfichable de type A** ou l'**équipement enfichable de type B**, au cas où la connexion au **réseau d'alimentation** viendrait à être interrompue.

Les exigences s'appliquent uniquement aux équipements destinés à être connectés à un **circuit externe** comme indiqué au Tableau 13, numéros d'identification 1, 2, 3 et 4.

NOTE Ces types de **circuits externes** sont généralement des réseaux de télécommunication.

La somme des **courants de contact** provenant d'équipements à **circuits externes** multiples ne doit pas dépasser les limites de ES2 (voir Tableau 4).

Les abréviations suivantes sont utilisées:

– I_1: **courant de contact** reçu d'un autre équipement via un réseau externe;

– $S(I_1)$: somme des **courants de contact** reçus de tous les autres équipements via un réseau externe;

– I_2: **courant de contact** créé par le **réseau d'alimentation** de l'équipement.

Par hypothèse, chaque circuit de l'équipement connecté à un **circuit externe** doit recevoir 0,25 mA (I_1) de l'autre équipement, à moins que le courant venant de l'autre équipement ait une valeur connue plus faible.

Les exigences suivantes, a) ou b) suivant le cas, doivent être satisfaites:

a) Les équipements connectés à un **circuit externe** mis à la terre

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Pour les équipements dans lesquels chaque circuit pouvant être connecté à un **circuit externe** est connecté à une borne pour le **conducteur de mise à la terre de protection** de l'équipement, les éléments suivants doivent être pris en compte:

1) Si $S(I_1)$ (à l'exclusion de I_2) dépasse les limites de ES2 du Tableau 4:
   - l'équipement doit être prévu pour une connexion permanente à la terre de protection en plus du **conducteur de mise à la terre de protection** dans le cordon d'alimentation de l'**équipement enfichable de type A** ou de l'**équipement enfichable de type B**; et
   - les instructions d'installation doivent spécifier l'installation d'une connexion permanente à la terre de protection avec une section d'au moins 2,5 mm^2 en cas de protection mécanique ou à défaut 4,0 mm^2; et
   - fournir un marquage conforme à 5.7.6 et à l'Article F.3.
2) Ce type d'équipement doit être conforme à 5.7.6. La valeur de I_2 doit être utilisée pour calculer la limite de 5 % du courant d'entrée par phase spécifiée en 5.7.6.
3) La somme de $S(I_1)$ et I_2 doit satisfaire aux limites du Tableau 4.

La conformité au point a) est vérifiée par examen et, si nécessaire, par essai.

Si l'équipement est prévu pour une connexion permanente à la terre de protection conformément au point 1) ci-dessus, il n'est pas nécessaire d'effectuer des mesures, sauf que I_2 doit être conforme aux exigences pertinentes de 5.7.

*Les essais de **courant de contact**, si nécessaire, sont réalisés en utilisant l'instrument de mesure adapté décrit dans l'IEC 60990:2016, à la Figure 5, ou tout autre instrument donnant les mêmes résultats. Une source (par exemple, une source de courant alternatif couplée capacitivement de la même phase et fréquence de lignes que le **réseau d'alimentation**) est appliquée à chaque **circuit externe** et ajustée de sorte que 0,25 mA ou le courant venant d'un autre équipement d'une valeur connue plus faible, soit disponible pour circuler au sein de ce **circuit externe**. Le courant circulant dans le conducteur de terre est alors mesuré.*

b) Les équipements connectés à un **circuit externe** non mis à la terre

Si chaque circuit de l'équipement qui peut être connecté à un **circuit externe** n'a pas de connexion commune, le **courant de contact** de chaque circuit ne doit pas dépasser les limites de ES2 du Tableau 4.

Si tous les circuits de l'équipement qui peuvent être connectés à un **circuit externe** ou à un groupe d'accès ont une connexion commune, le **courant de contact** total provenant de chaque connexion commune ne doit pas dépasser les limites de ES2 du Tableau 4.

La conformité au point b) est vérifiée par examen et, s'il y a des points de connexion communs, par l'essai suivant.

*Une source de courant alternatif couplée capacitivement des mêmes fréquence et phase que le **réseau d'alimentation** en courant alternatif est appliquée à chaque circuit de l'équipement qui peut être connecté à un **circuit externe** de sorte que 0,25 mA, ou le courant venant d'un autre équipement d'une valeur connue plus faible, soit disponible pour circuler au sein de ce circuit. Les points de connexion commune sont soumis à l'essai conformément à 5.7.3, que les points soient **accessibles** ou non.*

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5.8 Protection contre le retour de tension en entrée dans les alimentations de secours par batterie

Une alimentation de secours par **batterie** qui fait partie intégrante de l'équipement et qui est capable de générer un retour de tension en entrée doit empêcher une valeur supérieure à ES1 sur les bornes du **réseau d'alimentation** après l'interruption de la puissance du **réseau d'alimentation**.

Il ne doit exister aucun danger au niveau des bornes du **réseau d'alimentation** lors d'une mesure réalisée 1 s après la mise hors tension du **réseau d'alimentation** pour l'**équipement enfichable de type A**, 5 s pour l'**équipement enfichable de type B** ou 15 s pour les **équipements reliés en permanence**, en utilisant les instruments de mesure décrits en 5.7.2.

Si la tension en circuit ouvert mesurée ne dépasse les limites de ES1, il n'est pas nécessaire de mesurer le **courant de contact**.

*La conformité est vérifiée par examen de l'équipement et du schéma des circuits correspondant, par des mesures et par des **conditions de premier défaut** conformément à B.4.*

NOTE 1 Pour les normes relatives à l'alimentation de secours par **batterie** ne faisant pas partie intégrante de l'équipement, voir les normes relatives aux ASI (l'IEC 62040-1, par exemple). Pour les interrupteurs de transfert, voir IEC 62310-1:2005.

NOTE 2 Voir également les informations explicatives de l'IEC TR 62368-2.

Si un entrefer est utilisé comme **protection contre le retour de tension en entrée**, les exigences de 5.4.2 pour les **distances dans l'air** et de 5.4.3 pour les **lignes de fuite** s'appliquent en plus de celles qui suivent:

– la sortie de l'alimentation de secours par **batterie**, en **mode de fonctionnement en autonomie**, peut être considérée comme un circuit sans transitoire de Catégorie de Surtension I (à confirmer par le fabricant);

– Les **distances dans l'air** et les **lignes de fuite** doivent satisfaire aux exigences du degré de pollution 2, ou supérieur si cela est attendu dans l'emplacement d'installation prévu;

– L'**isolation renforcée** doit être appliquée entre l'entrée et la sortie de l'unité si, en **mode de fonctionnement en autonomie**, tous les pôles d'entrée ne sont pas isolés par le dispositif de **protection contre le retour de tension en entrée**. Dans tous les autres cas, l'**isolation principale** doit être appliquée.

La conformité est vérifiée par examen.

6 Incendie d'origine électrique

6.1 Généralités

Pour réduire la probabilité de blessures ou de dommages matériels résultant d'un incendie d'origine électrique survenant dans l'équipement, l'équipement doit être muni des **protections** spécifiées à l'Article 6.

6.2 Classification des sources de puissance (PS) et des sources potentielles d'incendie (PIS)

6.2.1 Généralités

Les sources de chaleur électriques peuvent être classifiées en niveaux de puissance disponibles PS1, PS2 et PS3 (voir 6.2.2.4, 6.2.2.5 et 6.2.2.6) pouvant causer le chauffage résistif des composants et des connexions. Ces sources d'alimentation sont basées sur l'énergie disponible pour un circuit.

Dans une source de puissance, une **PIS** (source potentielle d'incendie) peut survenir à cause d'un arc électrique au niveau de connexions rompues ou de l'ouverture des contacts (**source potentielle d'incendie causé par la formation d'un arc électrique**) ou à cause de composants dissipant plus de 15 W (**source potentielle d'incendie causé par un phénomène résistif**).

Selon la classification de la source de puissance de chaque circuit, une ou plusieurs **protections** sont exigées, soit pour réduire la probabilité d'inflammation, soit pour réduire la probabilité de propagation du feu au-delà de l'équipement.

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6.2.2 Classifications du circuit de source de puissance

6.2.2.1 Généralités

Un circuit électrique est classifié PS1, PS2 ou PS3, selon la puissance électrique disponible pour le circuit depuis la source de puissance

La classification de la source de puissance électrique doit être déterminée en mesurant la puissance maximale dans chacune des conditions suivantes:

– pour les circuits de charge: une source de puissance dans les **conditions normales de fonctionnement** comme spécifié par le fabricant dans le cas de défaut le plus défavorable (voir 6.2.2.2);
– pour les circuits de source de puissance: le cas de défaut le plus défavorable de la source de puissance dans le circuit de charge normale spécifié (voir 6.2.2.3).

La puissance est mesurée aux points X et Y de la Figure 34 et de la Figure 35.

6.2.2.2 Mesure de la puissance pour le cas de défaut de charge le plus défavorable

Avec référence à la Figure 34:

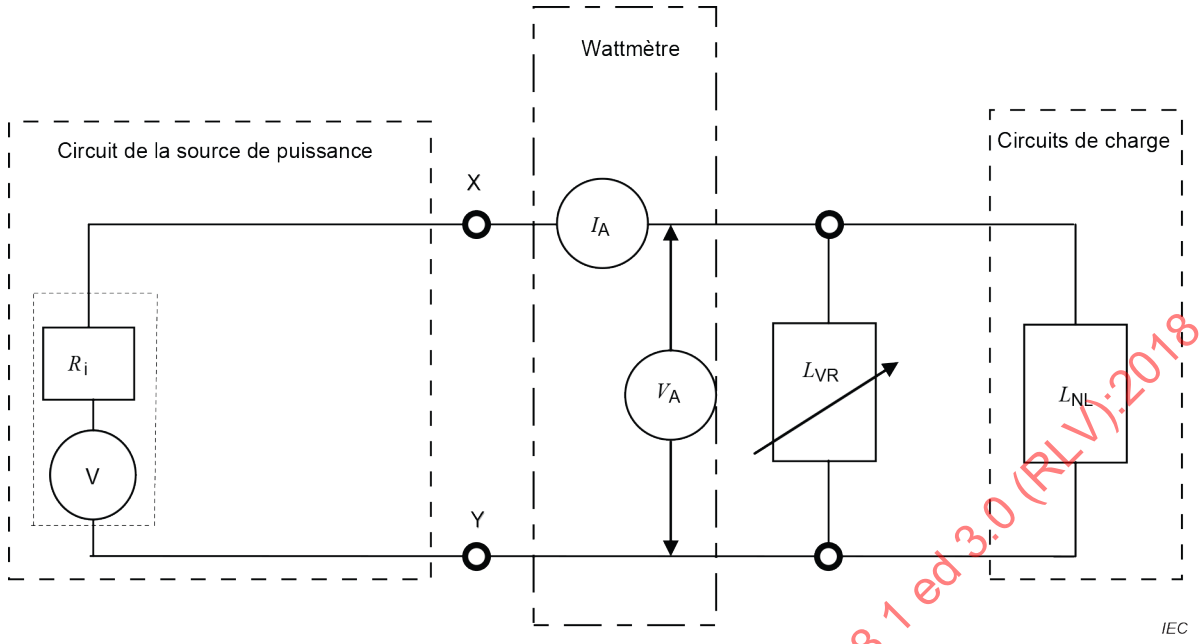
– *la mesure peut être réalisée sans le circuit de charge, L_{NL} connecté, à moins que la puissance maximale ne dépende de la connexion de la charge;*
– *Aux points X et Y, insérer un wattmètre (ou un voltmètre, V_A et un ampèremètre, I_A).*
– *connecter une résistance variable, L_{VR}, comme indiqué;*
– *ajuster la résistance variable, L_{VR}, pour une puissance maximale. Mesurer la puissance maximale et classifier la source de puissance conformément à 6.2.2.4, 6.2.2.5 ou 6.2.2.6.*

Si un dispositif de protection contre les surintensités fonctionne lors de l'essai, la mesure doit être répétée à 125 % de la valeur assignée du courant du dispositif de protection contre les surintensités.

Si un dispositif ou circuit de limitation de puissance fonctionne lors de l'essai, la mesure doit être répétée au point juste en dessous du courant auquel le dispositif ou circuit de limitation de puissance fonctionne.

Lors de l'évaluation des accessoires connectés via les câbles de l'équipement, l'impédance du câble peut être prise en compte pour déterminer la PS1 ou PS2 côté accessoire.

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Légende

V source de tension

R_i résistance interne de la source de puissance

I_A courant de la source de puissance

V_A tension aux points où l'énergie de la source de puissance est déterminée

L_{VR} charge de résistance variable

L_{NL} charge normale

Figure 34 – Mesure de la puissance dans le cas de défaut de charge le plus défavorable

6.2.2.3 Mesure de la puissance dans le cas de défaut le plus défavorable de la source de puissance

Avec référence à la Figure 35:

- *Aux points X et Y, insérer un wattmètre (ou un voltmètre, V_A et un ampèremètre, I_A).*
- *Dans le circuit de la source de puissance, simuler les **conditions de premier défaut** qui créent la puissance maximale dans le circuit en cours de classification. Tous les composants appropriés dans les circuits de la source de puissance doivent être court-circuités ou déconnectés un par un à chaque mesure.*
- *Les équipements comportant des amplificateurs audio doivent également être soumis à l'essai dans les conditions anormales de fonctionnement comme spécifié à l'Article E.3.*
- *Mesurer la puissance maximale tel que spécifié et classifier les circuits alimentés par la source de puissance conformément à 6.2.2.4, 6.2.2.5 ou 6.2.2.6.*

Si un dispositif de protection contre les surintensités fonctionne lors de l'essai, la mesure doit être répétée à 125 % de la valeur assignée du courant du dispositif de protection contre les surintensités.

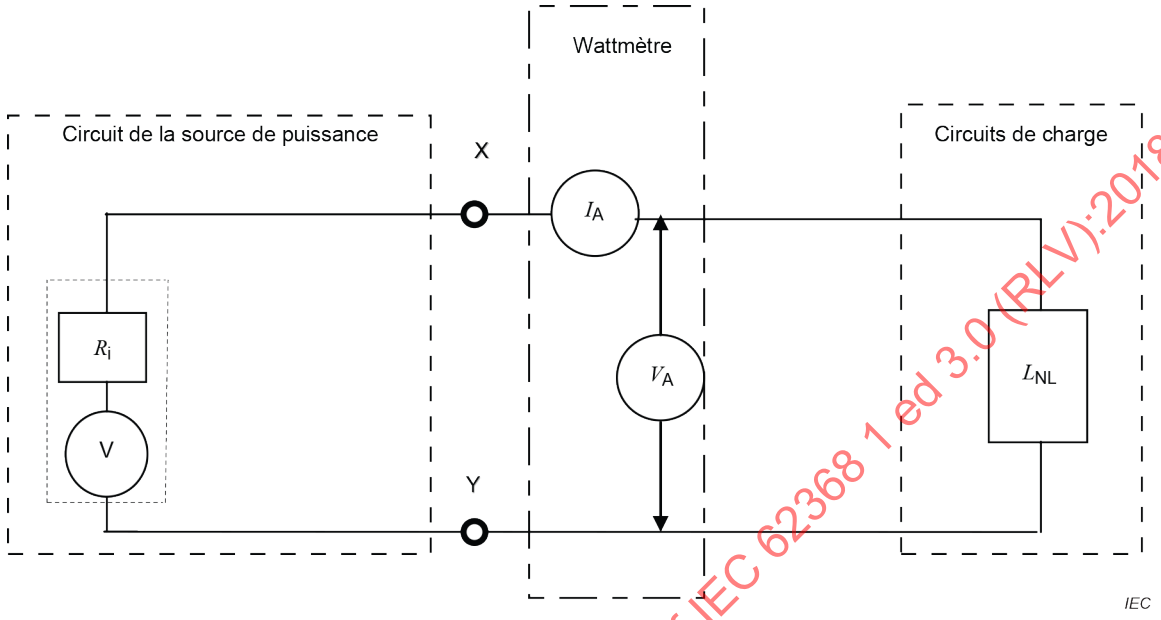
Si un dispositif ou circuit de limitation de puissance fonctionne lors de l'essai, la mesure doit être répétée au point juste en dessous du courant auquel le dispositif ou circuit de limitation de puissance fonctionne.

Lorsque les essais sont répétés, une résistance variable peut être utilisée pour simuler le composant défaillant.

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Afin d'éviter d'endommager les composants de la charge normale, une résistance (égale à la charge normale) peut être substituée à la charge normale.

NOTE Des expériences peuvent être utilisées pour identifier le premier défaut du composant qui produit l'énergie maximale.



Légende

V source de tension

R_i résistance interne de la source de puissance

I_A courant de la source de puissance

V_A tension aux points où l'énergie de la source de puissance est déterminée

L_{NL} charge normale

Figure 35 – Mesure de la puissance dans le cas de défaut le plus défavorable de la source de puissance

6.2.2.4 PS1

PS1 est un circuit où la source de puissance (voir la Figure 36) mesurée conformément à 6.2.2, ne dépasse pas 15 W mesurés après 3 s.

La puissance disponible des **circuits externes**, décrite au Tableau 13, numéro d'identification 1 et 2, est considérée comme étant limitée à PS1.

6.2.2.5 PS2

PS2 est un circuit où la source de puissance (voir la Figure 36) mesurée conformément à 6.2.2:

– dépasse les limites de PS1; et

– ne dépasse pas 100 W mesurée après 5 s.

6.2.2.6 PS3

PS3 est un circuit dont la source de puissance dépasse les limites de PS2, ou tout circuit dont la source de puissance n'a pas été classifiée (voir la Figure 36).

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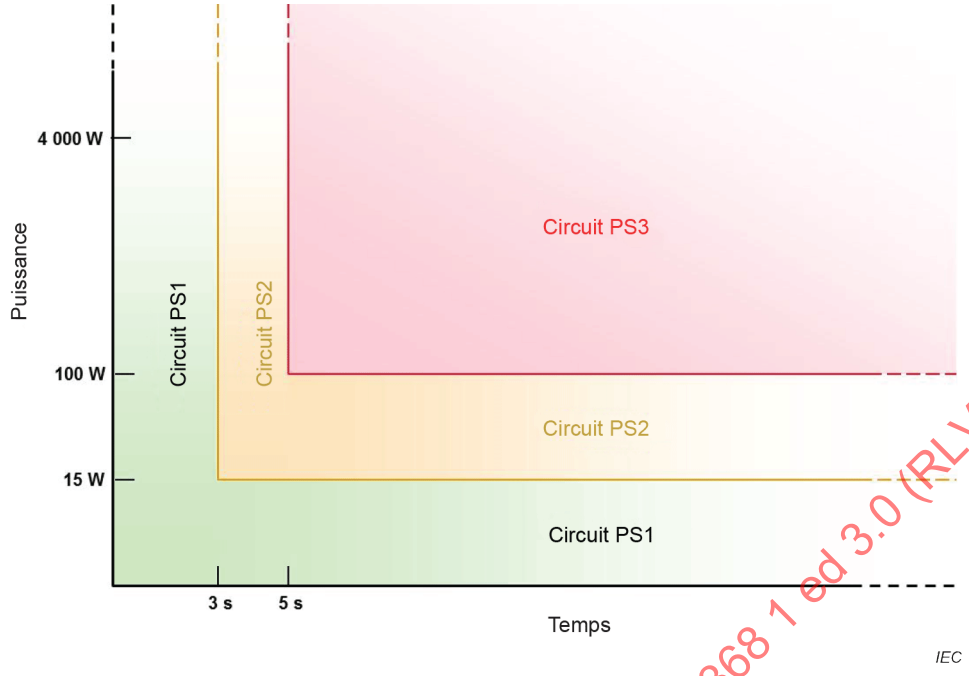


Figure 36 – Représentation de la classification des sources de puissance

6.2.3 Classification des sources potentielles d'incendie

6.2.3.1 Source potentielle d'incendie causé par la formation d'un arc électrique

Une **source potentielle d'incendie causé par la formation d'un arc électrique** est une zone (du circuit) qui présente les caractéristiques suivantes:

– une tension de circuit ouvert (mesurée après 3 s) aux bornes d'un conducteur ouvert ou un contact électrique ouvert dépassant 50 V, valeur de crête en courant alternatif ou continu; et

– le produit de la valeur de crête de la tension de circuit ouvert (V_p) et de la valeur efficace du courant mesuré (I_{eff}) dépasse 15 (soit, $V_p \times I_{eff} > 15$) dans chacun des cas suivants:

- un contact, tel qu'un interrupteur ou un connecteur;
- une terminaison, telle qu'une extrémité sertie, à ressort ou soudée;
- l'ouverture d'un conducteur, tel qu'une piste de carte imprimée, causée par des **conditions de premier défaut**. Cette condition ne s'applique pas si des circuits de protection électroniques ou des mesures de construction supplémentaires sont utilisés pour réduire la probabilité qu'un tel défaut ne devienne une **source potentielle d'incendie causé par la formation d'un arc électrique**.

Une **source potentielle d'incendie causé par la formation d'un arc électrique** est considérée comme inexistante dans un circuit PS1 à cause des limites de la source de puissance.

NOTE 1 Un conducteur ouvert dans un circuit électrique comprend les interruptions susceptibles de se produire dans des impressions conductrices sur des cartes imprimées.

Les connexions fiables ou redondantes ne sont pas considérées comme des **sources potentielles d'incendie causé par la formation d'un arc électrique**.

Les connexions redondantes constituent toutes sortes de connexions parallèles doubles ou multiples pour lesquelles, en cas de défaillance d'une connexion, les connexions restantes sont toujours capables de supporter l'intégralité de la puissance.

Les connexions fiables sont les connexions considérées comme non ouvrables.

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NOTE 2 Les connexions pouvant être considérées comme fiables sont:

– les trous métallisés et les pastilles sur une carte imprimée qui sont entièrement métallisées;

– les rivets/œillets tubulaires soudés;

– les sertissures usinées ou les connexions enroulées.

NOTE 3 D'autres moyens permettant d'éviter l'apparition d'une **source potentielle d'incendie causé par la formation d'un arc électrique** peuvent aussi être utilisés.

NOTE 4 Une défaillance de connexion causée par des phénomènes de fatigue thermique peut être évitée en sélectionnant des composants dont le coefficient d'expansion thermique est similaire à celui du matériau des cartes imprimées, en tenant compte de l'emplacement où se trouve le composant par rapport à la direction des fibres du matériau des cartes.

6.2.3.2 Source potentielle d'incendie causé par un phénomène résistif

Une **source potentielle d'incendie causé par un phénomène résistif** correspond à une partie d'un circuit PS2 ou PS3 qui:

– dissipe plus de 15 W mesurés après 30 s dans les **conditions normales de fonctionnement**; ou

NOTE Pendant les 30 premières secondes, il n'y a pas de limite.

– dans les **conditions de premier défaut**:

- dissipe plus de 100 W mesurés pendant 30 s, en omettant les trois premières secondes, suivant immédiatement l'introduction du défaut, si des circuits électroniques, des régulateurs ou des dispositifs CTP sont utilisés; ou
- dissipe plus de 15 W mesurés 30 s après l'introduction du défaut.

Une **source potentielle d'incendie causé par un phénomène résistif** est considérée comme inexistante dans un circuit PS1 à cause des limites de la source de puissance.

6.3 Protections contre les incendies dans les conditions normales de fonctionnement et les conditions anormales de fonctionnement

6.3.1 Exigences

Dans les **conditions normales de fonctionnement** et les **conditions anormales de fonctionnement**, les **protections principales** suivantes sont exigées:

– une inflammation ne doit pas se produire; et

– aucune partie de l'équipement ne doit atteindre une température supérieure à 90 % de la limite de température d'inflammation spontanée, en Celsius, de la partie telle que définie par l'ISO 871. Lorsque la température d'inflammation spontanée du matériau n'est pas connue, la température doit être limitée à 300 °C; et

NOTE Actuellement, le présent document ne spécifie aucune exigence relative aux poussières ou aux liquides inflammables autres que les **isolants liquides**.

– Les **matières combustibles** pour les composants et autres parties (y compris les **enveloppes électriques**, les **enveloppes mécaniques** et les parties décoratives) hors de l'**enveloppe ignifuge** doivent satisfaire:

- **matériau de classe HB75** si l'épaisseur significative la plus fine de ce matériau est < 3 mm; ou
- **matériau de classe HB40** si l'épaisseur significative la plus fine de ce matériau est ≥ 3 mm; ou
- **matériau plastique cellulaire de classe HBF**; ou
- doivent satisfaire à l'essai au fil incandescent à 550 °C selon l'IEC 60695-2-11.

Ces exigences ne s'appliquent pas:

- aux parties ayant un volume inférieur à 1 750 mm^3;

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- aux parties d'une masse de **matériau combustible** inférieure à 4 g;
- alimentations, **matériaux consommables**, supports et matériaux d'enregistrement;
- aux parties qui nécessitent des propriétés particulières pour remplir des fonctions prévues, telles que les rouleaux en caoutchouc synthétique, les tubes d'encre et les matériaux exigeant des caractéristiques optiques; et
- aux engrenages, cames, courroies, roulements et autres parties pouvant apporter au feu, une contribution négligeable comme combustible, y compris les étiquettes, pieds de fixation, capuchons de clés, boutons et similaires.

6.3.2 Critères de conformité

*La conformité est vérifiée par examen des fiches techniques et par un essai dans les **conditions normales de fonctionnement** conformément à l'Article B.2 et dans les **conditions anormales de fonctionnement** conformément à l'Article B.3. Les températures des matériaux sont mesurées en continu jusqu'à ce qu'un équilibre thermique soit atteint.*

NOTE Voir B.1.5 pour plus de détails sur l'équilibre thermique.

*Les **protections principales** limitant la température qui sont conformes aux exigences applicables du présent document ou de la norme du dispositif de sécurité applicable doivent être présentes dans le circuit en cours d'évaluation.*

6.4 Protections contre les incendies dans les conditions de premier défaut

6.4.1 Généralités

Le présent paragraphe définit les méthodes de **protection** possibles pouvant être utilisées pour réduire la probabilité d'inflammation ou de propagation du feu dans les **conditions de premier défaut**.

Il existe deux méthodes de protection. Toutes deux peuvent être appliquées à différentes parties du même équipement.

– **Réduire la probabilité d'inflammation:** l'équipement est conçu de telle manière que dans les **conditions de premier défaut**, aucune partie ne doit s'enflammer. Cette méthode peut être utilisée pour un circuit dont la puissance disponible en régime permanent ne dépasse pas 4 000 W. Les exigences et essais adaptés sont détaillés en 6.4.2 et 6.4.3.
  - Les **équipements enfichables de type A** sont considérés comme n'excédant pas la valeur en régime permanent de 4 000 W.
  - Les **équipements enfichables de type B** et les **équipements reliés en permanence** sont considérés comme n'excédant pas la valeur en régime permanent de 4 000 W si le produit de la tension nominale du **réseau d'alimentation** et de la **caractéristique assignée du courant** du dispositif de protection contre les surintensités de l'installation ($V_{\text{réseau d'alimentation}} \times I_{\text{max}}$) ne dépasse pas 4 000 W.

– **Contrôler la propagation du feu:** sélection et application des **protections supplémentaires** pour les composants, le câblage, les matériaux et les mesures de construction qui réduisent la propagation du feu et, le cas échéant, par l'utilisation d'une deuxième **protection supplémentaire**, telle qu'une **enveloppe ignifuge** (contre le feu). Cette méthode peut être utilisée pour tout type d'équipement. Les exigences adaptées sont détaillées en 6.4.4, 6.4.5 et 6.4.6.

6.4.2 Réduction de la probabilité d'inflammation en conditions de premier défaut dans les circuits PS1

Aucune **protection supplémentaire** n'est exigée pour la protection contre PS1. Un PS1 est censé ne pas pouvoir fournir assez d'énergie pour que les matériaux atteignent les températures d'inflammation.

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6.4.3 Réduction de la probabilité d'inflammation en conditions de premier défaut dans les circuits PS2 et PS3

6.4.3.1 Exigences

La probabilité d'inflammation dans les **conditions de premier défaut** dans les circuits PS2 et PS3 lorsque la puissance disponible ne dépasse pas 4 000 W (voir 6.4.1) doit être réduite à l'aide des **protections supplémentaires** suivantes, selon le cas:

NOTE Pour les circuits PS3, lorsque la puissance disponible dépasse 4 000 W, voir 6.4.6.

– une **source potentielle d'incendie causé par la formation d'un arc électrique** ou une **source potentielle d'incendie causé par un phénomène résistif** doit être séparée tel que spécifié en 6.4.7, la surface extérieure accessible de l'équipement étant censée être recouverte d'un matériau combustible;

– les dispositifs de protection faisant office de **protection** doivent satisfaire à G.3.1 à G.3.4 ou aux normes de composants IEC applicables;

– les moteurs et transformateurs doivent satisfaire à G.5.3, G.5.4 ou aux normes de composants IEC applicables;

– les varistances doivent satisfaire à G.8.2; et

– les composants associés au **réseau d'alimentation** doivent satisfaire aux normes de composants IEC applicables et aux exigences d'autres parties du présent document.

De plus, les essais de 6.4.3.2 s'appliquent.

EXEMPLES Les composants associés au **réseau d'alimentation** incluent les cordons d'alimentation, les connecteurs, les composants de filtrage CEM, les interrupteurs, etc.

6.4.3.2 Méthode d'essai

Les conditions de l'Article B.4 susceptibles de causer une inflammation sont appliquées tour à tour. Un défaut indirect peut interrompre ou court-circuiter un composant. En cas de doute, l'essai doit être répété deux autres fois en remplaçant les composants afin de vérifier que le feu n'est pas entretenu.

*L'équipement fonctionne dans les **conditions de premier défaut** et les températures des matériaux sont surveillées en continu jusqu'à ce que l'équilibre thermique soit atteint.*

*Si un conducteur s'ouvre lors d'une simulation des **conditions de premier défaut**, le conducteur doit être mis en parallèle et la simulation de **condition de premier défaut** doit être poursuivie. Dans tous les autres cas, si les **conditions de premier défaut** appliquées provoquent une interruption du courant avant qu'un état stable ait été atteint, la température est mesurée immédiatement après l'interruption.*

NOTE 1 Voir B.1.5 pour plus de détails sur l'équilibre thermique.

NOTE 2 Un échauffement peut être observé après l'interruption du courant, à cause de l'inertie thermique.

*Si la température est limitée par un fusible dans une **condition de premier défaut**:*

– *un fusible conforme à la série IEC 60127 doit s'ouvrir dans un délai de 1 s; ou*

– *un fusible non conforme à la série IEC 60127 doit s'ouvrir dans un délai de 1 s à trois reprises; ou*

– *le fusible doit satisfaire à l'essai suivant.*

*Le fusible est court-circuité et le courant qui serait passé à travers le fusible dans les **conditions de premier défaut** correspondantes est mesuré.*

Si le courant du fusible reste inférieur à 2,1 fois la caractéristique assignée du courant du fusible, les températures sont mesurées après qu'un état stable ait été atteint.

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Si le courant atteint immédiatement 2,1 fois la caractéristique assignée du courant du fusible ou plus, ou si cette valeur est atteinte après un temps égal au temps maximal de préarc pour l'établissement du courant approprié à travers le fusible considéré, le fusible et le court-circuit sont retirés après un temps supplémentaire correspondant au temps maximal de préarc du fusible considéré, et les températures sont immédiatement mesurées.

Si la résistance du fusible influence la valeur du courant dans le circuit correspondant, la valeur maximale de la résistance du fusible doit être prise en compte lors de la détermination de la valeur du courant.

Les conducteurs des cartes imprimées sont soumis à l'essai en appliquant les ***conditions de premier défaut*** *correspondantes de B.4.4.*

6.4.3.3 Critères de conformité

La conformité est vérifiée par examen, essais et mesures. Voir B.4.8 pour les critères de conformité.

6.4.4 Contrôle de la propagation du feu dans les circuits PS1

Aucune **protection supplémentaire** n'est exigée pour la protection contre PS1. Un PS1 est censé ne pas pouvoir fournir assez d'énergie pour que les matériaux atteignent les températures d'inflammation.

6.4.5 Contrôle de la propagation du feu dans les circuits PS2

6.4.5.1 Généralités

Pour réduire la probabilité de propagation du feu des circuits PS2 aux **matériaux combustibles** à proximité, les circuits qui satisfont aux exigences de l'Annexe Q sont considérés comme des circuits PS2.

6.4.5.2 Exigences

Une **protection supplémentaire** est nécessaire pour contrôler la propagation du feu à partir d'une **PIS** potentielle vers les autres parties de l'équipement (voir ci-dessous).

Les conducteurs et les dispositifs constituant une **PIS** doivent satisfaire à ce qui suit:

– les cartes imprimées doivent être constituées de **matériaux de classe V-1** ou de **matériaux de classe VTM-1**; et

– l'isolation et l'enrobage des fils doivent être conformes à 6.5.1.

Les moteurs doivent satisfaire à G.5.4.

Les transformateurs doivent satisfaire à G.5.3.

Tous les autres composants d'un circuit PS2 doivent satisfaire à un des points suivants:

– être montés sur des **matériaux de classe V-1** ou des **matériaux de classe VTM-1**; ou

– être composés d'un **matériau de classe V-2**, d'un **matériau de classe VTM-2** ou d'un **matériau cellulaire de classe HF-2**; ou

– satisfaire aux exigences de l'Article S.1; ou

– avoir une taille inférieure à 1 750 mm^3; ou

– avoir une masse de **matériau combustible** inférieure à 4 g; ou

– être séparés d'une **PIS** d'après les exigences de 6.4.7; ou

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– satisfaire aux exigences d'inflammabilité de la norme de composant IEC correspondante; ou

– être dans une **enveloppe** étanche de 0,06 m^3 ou moins, composée entièrement de **matériaux non combustibles** et sans ouvertures de ventilation; ou

– le composant ne doit pas s'enflammer pendant les **conditions de premier défaut** tel que spécifié en 6.4.3.2.

Si les matériaux et parties suivants ne sont pas séparés d'une **PIS** conformément aux exigences de 6.4.7, les matériaux et parties ne doivent pas s'enflammer pendant les **conditions de premier défaut** tel que spécifié en 6.4.3.2:

– alimentations, **matériaux consommables**, supports et matériaux d'enregistrement; et

– parties qui nécessitent des propriétés particulières pour remplir des fonctions prévues, telles que les rouleaux en caoutchouc synthétique, les tubes d'encre et les matériaux exigeant des caractéristiques optiques.

6.4.5.3 Critères de conformité

La conformité est vérifiée par essai ou par examen de l'équipement et fiches techniques des matériaux.

6.4.6 Contrôle de la propagation du feu dans un circuit PS3

La propagation du feu dans les circuits PS3 doit être contrôlée en appliquant toutes les **protections supplémentaires** suivantes:

– les conducteurs et dispositifs dans un circuit PS3 doivent satisfaire aux exigences de 6.4.5;

– les dispositifs soumis à la formation d'arc ou au changement de résistance de contact (par exemple, les connecteurs enfichables) doivent être conformes à l'une des spécifications suivantes:

  - être constitués d'un **matériau de classe V-1**; ou
  - satisfaire aux exigences d'inflammabilité de la norme de composant IEC correspondante; ou
  - satisfaire aux exigences de l'Article S.1; ou
  - être montés sur des **matériaux de classe V-1** ou **des matériaux de classe VTM-1** et présenter un volume ne dépassant pas 1 750 mm^3 ou une masse de **matières combustibles** inférieure à 4 g; et

– en fournissant une **enveloppe ignifuge** conforme à 6.4.8.

À l'intérieur des **enveloppes ignifuges** (contre le feu), les **matériaux combustibles** qui ne satisfont pas aux exigences d'inflammabilité pour les circuits PS2 et PS3 doivent être conformes à l'essai d'inflammabilité de l'Article S.1 ou doivent être composés de **matériaux de classe V2**, de **matériaux de classe VTM-2** ou de **matériaux cellulaires de classe HF-2**. Ces exigences ne s'appliquent pas:

– aux parties ayant un volume inférieur à 1 750 mm^3;

– aux parties d'une masse de **matériau combustible** inférieure à 4 g;

– alimentations, **matériaux consommables**, supports et matériaux d'enregistrement;

– aux parties qui nécessitent des propriétés particulières pour remplir des fonctions prévues, telles que les rouleaux en caoutchouc synthétique, les tubes d'encre et les matériaux exigeant des caractéristiques optiques;

– aux engrenages, cames, courroies, roulements et autres parties pouvant apporter au feu, une contribution négligeable comme combustible, y compris les étiquettes, pieds de fixation, capuchons de clés, boutons et similaires. et

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– aux tubes pour systèmes pour air ou pour fluide, conteneurs pour poudres ou liquides et aux parties de matériau plastique cellulaire, à condition qu'ils soient de **classe HB75** si l'épaisseur significative la plus fine du matériau est < 3 mm, ou de **classe HB40** si l'épaisseur significative la plus fine du matériau est ≥ 3 mm ou de **matériau cellulaire de classe HBF** ou ayant satisfait à l'essai au fil incandescent à 550 °C conformément à l'IEC 60695-2-11.

Une **enveloppe ignifuge** (contre le feu) n'est pas nécessaire pour les composants et matériaux suivants:

– l'isolation et l'enrobage des fils conformes à 6.5.1.
– les composants, y compris les connecteurs, satisfaisant aux exigences de 6.4.8.2.1 qui remplissent une ouverture dans une **enveloppe ignifuge** (contre le feu);
– les fiches et connecteurs qui font partie intégrante d'un câble d'alimentation ou d'un câble d'interconnexion, conformes à 6.4.9, G.4.1 et G.7;
– les moteurs conformes à G.5.4; et
– les transformateurs conformes à G.5.3.

La conformité est vérifiée par examen des fiches techniques des matériaux ou par essai, ou les deux.

6.4.7 Séparation des matériaux combustibles d'une PIS

6.4.7.1 Généralités

Lorsque cela est exigé, les exigences de séparation minimales entre une **PIS** et des **matériaux combustibles** afin de réduire la probabilité de feu entretenu ou de propagation du feu peuvent être remplies soit par une séparation par la distance (6.4.7.2), soit par une séparation à l'aide d'une barrière contre le feu (6.4.7.3).

Des exigences complémentaires relatives à une **enveloppe ignifuge** ou une barrière contre le feu en **matériau combustible** située à moins de 13 mm d'une **source potentielle d'incendie causé par la formation d'un arc électrique** ou de 5 mm d'une **source potentielle d'incendie causé par un phénomène résistif** sont spécifiées en 6.4.8.4.

6.4.7.2 Séparation par la distance

Les **matériaux combustibles**, sauf les matériaux sur lesquels se trouve la **PIS**, doivent être séparés d'une **source potentielle d'incendie causé par la formation d'un arc électrique** ou une **source potentielle d'incendie causé par un phénomène résistif** conformément à la Figure 37 et à la Figure 38.

Les matériaux de base des cartes imprimées, sur lesquels se situe une **source potentielle d'incendie causé par la formation d'un arc électrique**, doivent être constitués de **matériaux de classe V-1**, de **matériaux de classe VTM-1** ou de **matériaux cellulaires de classe HF-1**.

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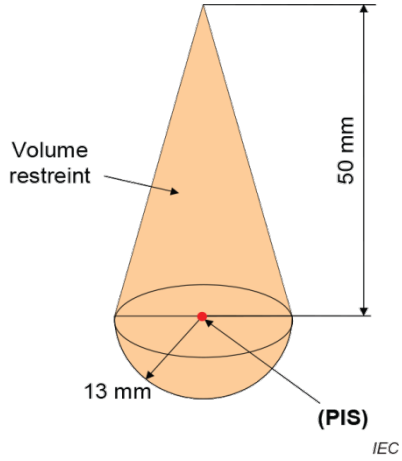
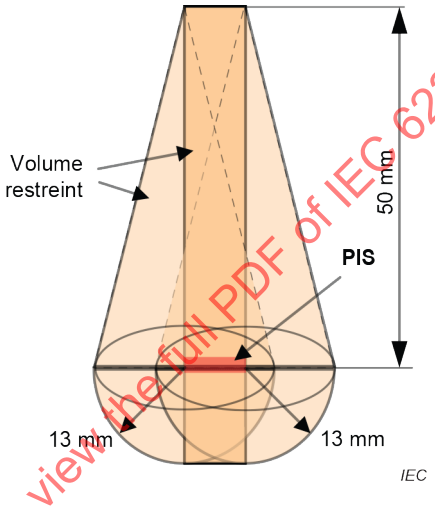


Figure 37 – Exigences minimales de séparation d'une source potentielle d'incendie (PIS)



NOTE Cette figure peut être utilisée pour:

– une **source potentielle d'incendie causé par la formation d'un arc électrique** constituée de pistes ou de zones sur des cartes imprimées;

– les zones de composants d'une **source potentielle d'incendie causé par un phénomène résistif**. Les mesures sont réalisées à partir de l'élément de dissipation de puissance le plus proche du composant concerné. Si, dans la pratique, il n'est pas possible de définir immédiatement la partie de dissipation de l'énergie, alors la surface extérieure du composant est utilisée.

Figure 38 – Exigences étendues de séparation d'une source potentielle d'incendie (PIS)

Si la distance entre une **source potentielle d'incendie** et des **matériaux combustibles** est inférieure à la distance spécifiée à la Figure 37 et à la Figure 38 suivant les cas, les **matériaux combustibles** doivent:

– avoir un volume inférieur à 1 750 mm^3;

– avoir une masse de **matériau combustible** inférieure à 4 g; ou

– satisfaire:

  - aux exigences d'inflammabilité de la norme de composant IEC correspondante; ou
  - être constitués de **matériaux de classe V-1**, de **matériaux de classe VTM-1** ou de **matériaux cellulaires de classe HF-1** ou être conformes à l'IEC 60695-11-5. Les sévérités sont identifiées à l'Article S.2.

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6.4.7.3 Séparation par une barrière contre le feu

Les **matériaux combustibles** doivent être séparés d'une **source potentielle d'incendie causé par la formation d'un arc électrique** ou d'une **source potentielle d'incendie causé par un phénomène résistif** par une barrière contre le feu telle que définie en 6.4.8.2.1 (voir la Figure 39).

Les cartes imprimées ne sont pas considérées comme une barrière contre le feu pour une **source potentielle d'incendie causé par la formation d'un arc électrique** située sur la même carte. Les cartes imprimées conformes à 6.4.8 peuvent être considérées comme des barrières contre le feu pour une **source potentielle d'incendie causé par la formation d'un arc électrique** située sur une carte différente.

Des cartes imprimées peuvent être considérées comme une barrière contre le feu pour une **source potentielle d'incendie causé par un phénomène résistif** à condition que les conditions suivantes soient remplies:

– La carte imprimée doit:
  - être conforme à l'essai d'inflammabilité de l'Article S.1 tel qu'utilisé dans l'application; ou
  - être composée d'un **matériau de classe V-1**, d'un **matériau de classe VTM-1** ou d'un **matériau cellulaire de classe HF-1**;
– dans un volume restreint, les composants doivent satisfaire aux exigences d'inflammabilité de la norme de composant correspondante et aucun autre matériau de classe assignée inférieure à la **classe V-1** ne doit être monté sur la même face de la carte imprimée que la **source potentielle d'incendie causé par un phénomène résistif**; et
– dans le volume restreint, la carte imprimée ne doit pas comporter de conducteurs PS2 ou de conducteurs PS3 (à l'exception des conducteurs qui alimentent le circuit en question). Cela s'applique aussi bien à chacune des faces de la carte imprimée qu'à ses couches internes.

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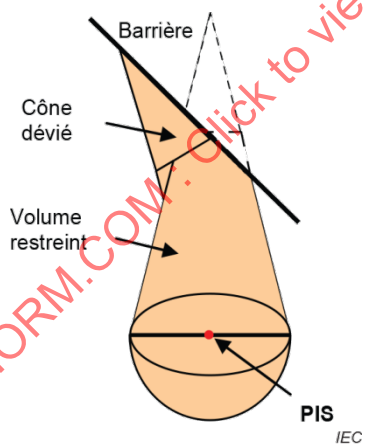


Figure 39a – Représentation d'une barrière oblique

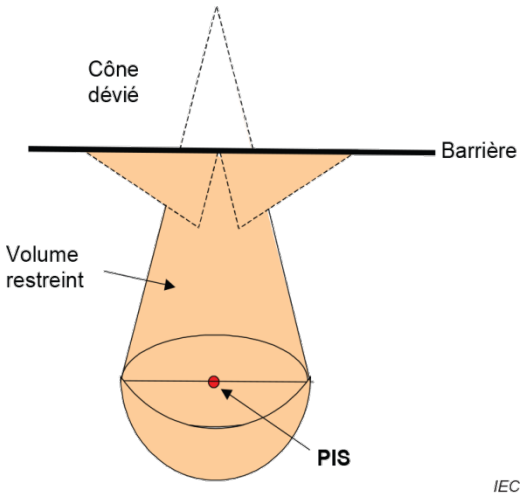


Figure 39b – Représentation d'une barrière horizontale

NOTE 1 Le volume de la flamme est quasi constant. Par conséquent, la forme de la flamme dépend de la position et de la forme de la barrière. Différentes formes de barrière peuvent engendrer différentes formes de flamme et donner lieu à des exigences différentes sur la barrière et la zone restreinte.

NOTE 2 Les dimensions sont identiques à la Figure 37 et à la Figure 38 mais, à l'exception de ce qui est indiqué en 6.4.8.4, la distance entre la barrière et la **source potentielle d'incendie** n'est pas importante.

Figure 39 – Exigences sur la déviation de la barrière par rapport à une source potentielle d'incendie lorsqu'une barrière contre le feu est utilisée

6.4.7.4 Critères de conformité

La conformité est vérifiée par examen ou par mesure ou par les deux.

6.4.8 Enveloppes ignifuges (contre le feu) et barrières contre le feu

6.4.8.1 Généralités

La fonction de **protection** de l'**enveloppe ignifuge** (contre le feu) et de la barrière contre le feu consiste à freiner la propagation du feu à travers l'**enveloppe** ou la barrière.

L'**enveloppe ignifuge** (contre le feu) peut être une **enveloppe** générale ou peut être à l'intérieur de l'**enveloppe** générale. Il n'est pas nécessaire que l'**enveloppe ignifuge** (contre le feu) ait une fonction exclusive, mais elle peut fournir d'autres fonctions en plus de celles d'une **enveloppe ignifuge** (contre le feu).

6.4.8.2 Propriétés du matériau des enveloppes ignifuges (contre le feu) et des barrières contre le feu

6.4.8.2.1 Exigences pour une barrière contre le feu

Une barrière contre le feu doit être conforme aux exigences de l'Article S.1.

Ces exigences ne s'appliquent pas, à condition que le matériau soit:

– constitué d'un **matériau non combustible** (par exemple, métal, verre, céramique, etc.); ou

– constitué d'un **matériau de classe V-1** ou d'un **matériau de classe VTM-1**.

6.4.8.2.2 Exigences pour une enveloppe ignifuge (contre le feu)

Pour les circuits dont la puissance disponible ne dépasse pas 4 000 W (voir 6.4.1), l'**enveloppe ignifuge** (contre le feu) doit:

– satisfaire aux exigences de l'Article S.1; ou

– être constituée d'un **matériau non combustible** (par exemple, métal, verre, céramique, etc.); ou

– être constituée d'un **matériau de classe V-1**.

Pour les circuits dont la puissance disponible ne dépasse pas 4 000 W, une **enveloppe ignifuge** (contre le feu) doit:

– satisfaire aux exigences de l'Article S.5; ou

– être constituée d'un **matériau non combustible** (par exemple, métal, verre, céramique, etc.); ou

– être constituée d'un **matériau de classe 5VA** ou d'un **matériau de classe 5VB**.

Les matériaux des composants qui remplissent une ouverture dans une **enveloppe ignifuge** (contre le feu) ou à monter dans une telle ouverture doivent:

– satisfaire aux exigences d'inflammabilité de la norme de composant IEC correspondante; ou

– être constitués d'un **matériau de classe V-1**; ou

– satisfaire à l'Article S.1.

6.4.8.2.3 Critères de conformité

La conformité est vérifiée par examen des fiches techniques applicables ou par essai.

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*La **classe d'inflammabilité du matériau** est vérifiée dans l'épaisseur significative la plus fine utilisée.*

6.4.8.3 Exigences de construction pour une enveloppe ignifuge (contre le feu) et une barrière contre le feu

6.4.8.3.1 Ouvertures dans les enveloppes ignifuges (contre le feu) et les barrières contre le feu

Les dimensions des ouvertures dans une **enveloppe ignifuge** (contre le feu) ou dans une barrière contre le feu doivent être telles que le feu et les produits de combustion passant à travers les ouvertures ne sont pas susceptibles d'enflammer le matériau se trouvant à l'extérieur de l'**enveloppe** ou sur le côté d'une barrière contre le feu à l'opposé de la **source potentielle d'incendie**.

Les ouvertures auxquelles ces propriétés s'appliquent sont liées à l'endroit ou l'emplacement où se trouvent la **source potentielle d'incendie** et les **matériaux combustibles**. Les emplacements des ouvertures liées à la propriété de la flamme sont présentés à la Figure 41 et à la Figure 42.

Quelle que soit l'orientation de l'équipement, l'orientation de la flamme de la **source potentielle d'incendie** est toujours verticale. Si l'équipement a au moins deux orientations dans les **conditions normales de fonctionnement**, les propriétés d'ouverture s'appliquent pour chaque orientation possible.

Les exigences relatives à l'**enveloppe ignifuge** (contre le feu) d'un **accumulateur au lithium** sont spécifiées en M.4.3.

Les ouvertures sur le dessus, latérales et dans le fond doivent être déterminées selon la Figure 40, en tenant compte de toutes les orientations d'utilisation possible (voir également 4.1.6).

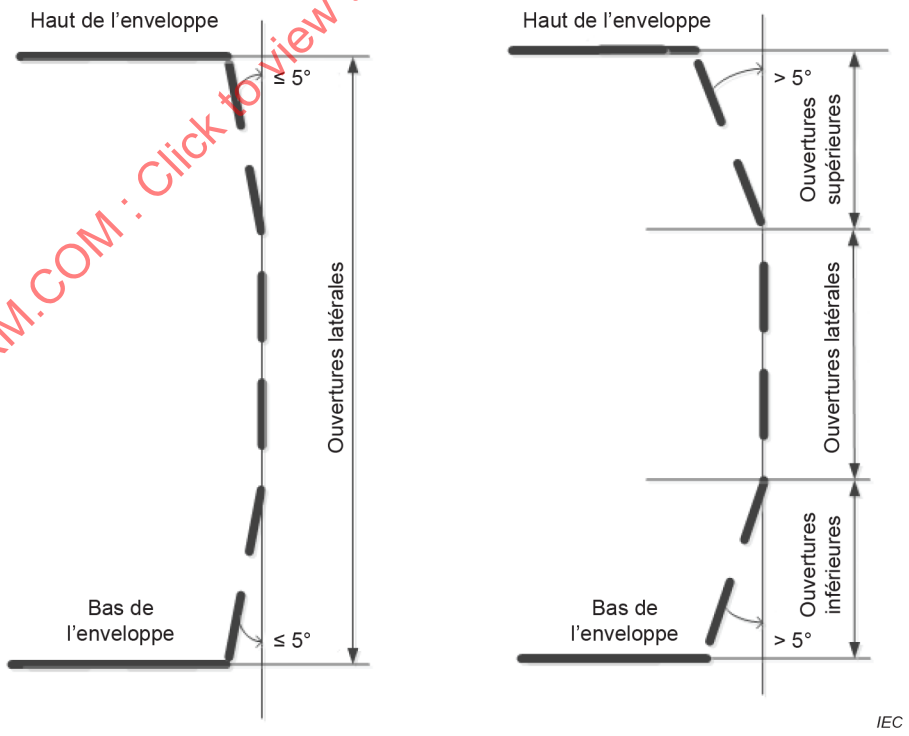


Figure 40 – Détermination des ouvertures sur le dessus, dans le fond et latérales

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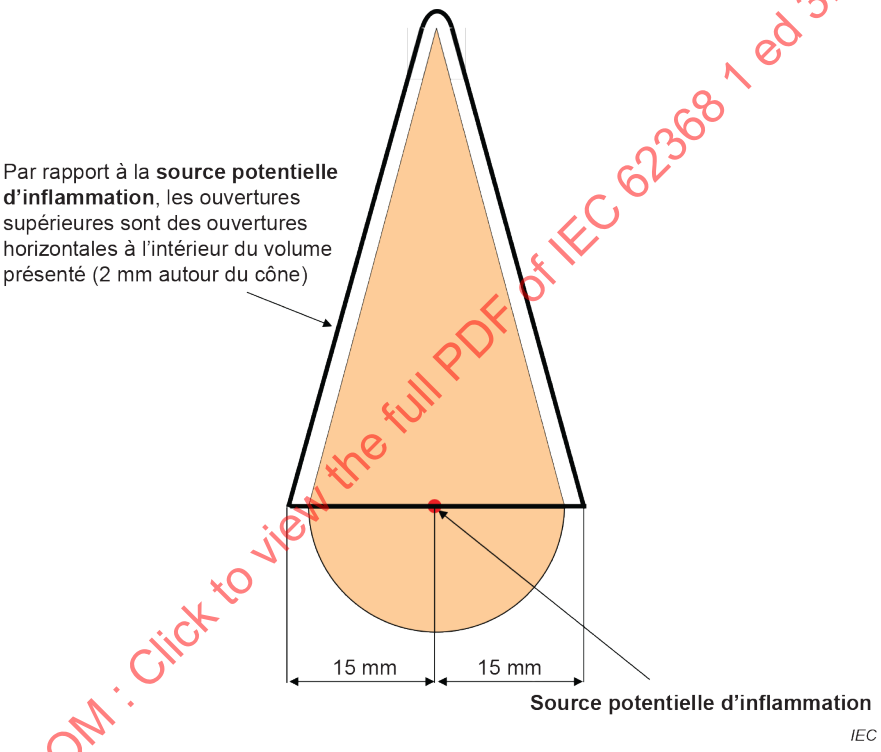
6.4.8.3.2 Dimensions d'une barrière contre le feu

Les bords des barrières contre le feu doivent s'étendre au-delà du volume restreint (voir la Figure 39).

6.4.8.3.3 Ouvertures sur le dessus et propriétés des ouvertures sur le dessus

Les propriétés des ouvertures sur le dessus d'une **enveloppe ignifuge** (contre le feu) doivent s'appliquer aux ouvertures sur une surface horizontale ou une surface présentant une inclinaison de plus de 5 degrés par rapport à la verticale (voir la Figure 40) au-dessus d'une **source potentielle d'incendie** située dans un circuit PS3 comme représenté à la Figure 41. Les propriétés des ouvertures sur le dessus d'une barrière contre le feu doivent s'appliquer aux ouvertures au-dessus d'une **source potentielle d'incendie** (voir la Figure 41).

Les ouvertures qui aboutissent dans le volume défini à la Figure 41 doivent être conformes à l'Article S.2.



NOTE Les dimensions du cône sont identiques à celles de la Figure 37 et de la Figure 38.

Figure 41 – Ouvertures sur le dessus

Aucun essai n'est exigé à condition que les ouvertures ne dépassent pas:

– *5 mm dans toutes les dimensions; ou*

– *1 mm de largeur, quelle que soit la longueur.*

6.4.8.3.4 Ouvertures dans le fond et propriétés des ouvertures dans le fond

Les propriétés des ouvertures dans le fond d'une **enveloppe ignifuge** (contre le feu) et d'une barrière contre le feu doivent s'appliquer aux ouvertures sur une surface horizontale ou une surface présentant une inclinaison de plus de 5 degrés par rapport à la verticale (voir la Figure 40) au-dessous d'une **source potentielle d'incendie** située dans un circuit PS3 comme représenté à la Figure 42. Les ouvertures sur les autres surfaces sous la **source potentielle d'incendie** doivent être considérées comme des sources latérales, et les dispositions de 6.4.8.3.5 s'appliquent.

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