

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Low-voltage switchgear and controlgear –
Part 1: General rules**

**Appareillage à basse tension –
Partie 1: Règles générales**



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2020 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

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

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

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

Electropedia - www.electropedia.org

The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC

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

Recherche de publications IEC - webstore.iec.ch/advsearchform

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études,...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: sales@iec.ch.

Electropedia - www.electropedia.org

Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 000 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 16 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

Glossaire IEC - std.iec.ch/glossary

67 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Low-voltage switchgear and controlgear –
Part 1: General rules**

**Appareillage à basse tension –
Partie 1: Règles générales**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 29.130.20

ISBN 978-2-8322-8026-3

**Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

CONTENTS

| | |
|---|----|
| FOREWORD..... | 13 |
| INTRODUCTION..... | 16 |
| 1 Scope..... | 17 |
| 2 Normative references | 17 |
| 3 Terms, definitions, symbols and reference clauses | 21 |
| 3.1 General..... | 21 |
| 3.2 Alphabetical index of definitions..... | 21 |
| 3.3 General terms and definitions | 26 |
| 3.4 Switching devices | 30 |
| 3.5 Parts of switching devices..... | 33 |
| 3.6 Operation of switching devices..... | 39 |
| 3.7 Characteristic quantities | 44 |
| 3.8 Tests | 54 |
| 3.9 Ports..... | 54 |
| 3.10 Symbols and references clauses for characteristics described in this document..... | 54 |
| 4 Classification..... | 55 |
| 5 Characteristics | 55 |
| 5.1 Summary of the characteristics | 55 |
| 5.2 Type of equipment | 56 |
| 5.3 Rated and limiting values for the main circuit..... | 56 |
| 5.3.1 Rated voltages | 56 |
| 5.3.2 Currents | 57 |
| 5.3.3 Rated frequency | 58 |
| 5.3.4 Rated duties | 58 |
| 5.3.5 Characteristics under normal load and overload conditions (see 8.2.4)..... | 60 |
| 5.3.6 Short-circuit characteristics | 61 |
| 5.3.7 Pole impedance of the switching device (Z) | 62 |
| 5.4 Utilization category..... | 62 |
| 5.5 Control circuits | 62 |
| 5.5.1 Electrical / or electronically controlled circuits | 62 |
| 5.5.2 Air-supply control circuits (pneumatic or electro-pneumatic) | 63 |
| 5.6 Auxiliary circuits..... | 63 |
| 5.7 Relays and releases | 63 |
| 5.8 Co-ordination with short-circuit protective devices (SCPD)..... | 63 |
| 6 Product information | 63 |
| 6.1 Nature of information | 63 |
| 6.2 Marking..... | 64 |
| 6.3 Instructions for installation, operation and maintenance, decommissioning and dismantling..... | 65 |
| 6.4 Environmental information | 66 |
| 7 Normal service, mounting and transport conditions..... | 66 |
| 7.1 Normal service conditions | 66 |
| 7.1.1 Ambient air temperature | 66 |
| 7.1.2 Altitude | 67 |
| 7.1.3 Atmospheric conditions..... | 67 |

| | | |
|--------|---|----|
| 7.1.4 | Shock and vibration | 68 |
| 7.2 | Conditions during transport and storage..... | 68 |
| 7.3 | Mounting..... | 68 |
| 8 | Constructional and performance requirements..... | 68 |
| 8.1 | Constructional requirements | 68 |
| 8.1.1 | General | 68 |
| 8.1.2 | Materials | 69 |
| 8.1.3 | Current-carrying parts and their connections | 70 |
| 8.1.4 | Clearances and creepage distances | 70 |
| 8.1.5 | Actuator..... | 70 |
| 8.1.6 | Indication of the contact position | 71 |
| 8.1.7 | Additional requirements for equipment suitable for isolation..... | 71 |
| 8.1.8 | Terminals | 73 |
| 8.1.9 | Additional requirements for equipment provided with a neutral pole..... | 74 |
| 8.1.10 | Provisions for protective earthing..... | 74 |
| 8.1.11 | Dedicated enclosures for equipment..... | 76 |
| 8.1.12 | Degrees of protection of enclosed equipment | 76 |
| 8.1.13 | Conduit pull-out, torque and bending with metallic conduits | 76 |
| 8.2 | Performance requirements..... | 77 |
| 8.2.1 | Operating conditions..... | 77 |
| 8.2.2 | Temperature-rise | 78 |
| 8.2.3 | Dielectric properties..... | 79 |
| 8.2.4 | Ability to make, carry and break current under no-load, normal load and overload conditions..... | 82 |
| 8.2.5 | Ability to make, carry and break short-circuit currents..... | 83 |
| 8.2.6 | Pole impedance..... | 83 |
| 8.2.7 | Leakage currents of equipment suitable for isolation..... | 84 |
| 8.3 | Electromagnetic compatibility (EMC)..... | 84 |
| 8.3.1 | General | 84 |
| 8.3.2 | Immunity..... | 84 |
| 8.3.3 | Emission..... | 85 |
| 9 | Tests..... | 85 |
| 9.1 | Kinds of test..... | 85 |
| 9.1.1 | General | 85 |
| 9.1.2 | Type tests..... | 85 |
| 9.1.3 | Routine tests | 86 |
| 9.1.4 | Sampling tests..... | 86 |
| 9.1.5 | Special tests..... | 86 |
| 9.2 | Compliance with constructional requirements..... | 87 |
| 9.2.1 | General | 87 |
| 9.2.2 | Test of materials to abnormal heat and fire..... | 87 |
| 9.2.3 | Equipment | 87 |
| 9.2.4 | Enclosures for equipment | 87 |
| 9.2.5 | Mechanical and electrical properties of terminals..... | 88 |
| 9.2.6 | Verification of the effectiveness of indication of the main contact position of equipment suitable for isolation | 90 |
| 9.2.7 | Vacant..... | 93 |
| 9.2.8 | Conduit pull-out test, torque test and bending test with metallic conduits..... | 93 |
| 9.2.9 | Test of earth continuity for protective earth..... | 94 |

| | | |
|---|--|-----|
| 9.3 | Performance | 94 |
| 9.3.1 | Test sequences | 94 |
| 9.3.2 | General test conditions | 94 |
| 9.3.3 | Performance under no-load, normal load and overload conditions | 96 |
| 9.3.4 | Performance under short-circuit conditions | 109 |
| 9.4 | Tests for EMC | 114 |
| 9.4.1 | General | 114 |
| 9.4.2 | Immunity | 114 |
| 9.4.3 | Emission | 115 |
| Annex A (informative) Harmonisation of utilization categories for low-voltage switchgear and controlgear | | 116 |
| Annex B (Vacant) | | 149 |
| Annex C (normative) Degrees of protection of enclosed equipment | | 150 |
| C.1 | General | 150 |
| C.2 | Object | 150 |
| C.3 | Definitions | 150 |
| C.4 | Designation | 150 |
| C.5 | Degrees of protection against access to hazardous parts and against ingress of solid foreign objects indicated by the first characteristic numeral | 150 |
| C.6 | Degrees of protection against ingress of water indicated by the second characteristic numeral | 150 |
| C.7 | Degrees of protection against access to hazardous parts indicated by the additional letter | 151 |
| C.8 | Supplementary letters | 151 |
| C.9 | Examples of designations with IP Code | 151 |
| C.10 | Marking | 151 |
| C.11 | General requirements for tests | 151 |
| C.12 | Tests for protection against access to hazardous parts indicated by the first characteristic numeral | 152 |
| C.13 | Tests for protection against ingress of solid foreign objects indicated by the first characteristic numeral | 152 |
| C.14 | Tests for protection against water indicated by second characteristic numeral | 153 |
| C.14.1 | Test means | 153 |
| C.14.2 | Test conditions | 153 |
| C.14.3 | Acceptance conditions | 153 |
| C.15 | Tests for protection against access to hazardous parts indicated by additional letter | 153 |
| C.16 | Summary of responsibilities of relevant technical committees | 153 |
| Annex D (informative) Examples of clamping units and relationship between clamping unit and connecting device | | 157 |
| D.1 | Clamping unit in a connecting device | 157 |
| D.2 | Examples of clamping units | 158 |
| Annex E (informative) Description of a method for adjusting the load circuit | | 165 |
| Annex F (informative) Determination of short-circuit power-factor or time-constant | | 167 |
| F.1 | Determination of short-circuit power-factor | 167 |
| F.1.1 | Method I – Determination from DC component | 167 |
| F.1.2 | Method II – Determination with pilot generator | 167 |
| F.2 | Determination of short-circuit time-constant (oscillographic method) | 168 |
| Annex G (informative) Measurement of creepage distances and clearances | | 169 |

| | | |
|-----------------------|---|-----|
| G.1 | Basic principles..... | 169 |
| G.2 | Use of ribs | 169 |
| Annex H (informative) | Correlation between the nominal voltage of the supply system and the rated impulse withstand voltage of equipment | 176 |
| Annex J (informative) | Items subject to agreement between manufacturer and user..... | 178 |
| Annex K (normative) | Procedure to determine reliability data for electromechanical devices used in functional safety applications | 179 |
| K.1 | General..... | 179 |
| K.1.1 | Overview | 179 |
| K.1.2 | Object..... | 179 |
| K.1.3 | General requirements | 179 |
| K.2 | Terms, definitions and symbols | 180 |
| K.2.1 | Terms and definitions | 180 |
| K.2.2 | Symbols | 181 |
| K.3 | Method based on durability test results | 181 |
| K.3.1 | General method..... | 181 |
| K.3.2 | Test requirements..... | 181 |
| K.3.3 | Number of samples..... | 181 |
| K.3.4 | Characterization of a failure mode | 181 |
| K.3.5 | Weibull modelling | 182 |
| K.3.6 | Useful life and upper limit of failure rate..... | 184 |
| K.3.7 | Reliability data..... | 185 |
| K.4 | Data information | 185 |
| K.5 | Example..... | 186 |
| K.5.1 | Test results..... | 186 |
| K.5.2 | Weibull distribution and median rank regression | 186 |
| K.5.3 | Useful life and failure rate..... | 187 |
| Annex L (normative) | Terminal marking and distinctive number | 189 |
| L.1 | General..... | 189 |
| L.2 | Terminal marking of impedances (alphanumeric)..... | 189 |
| L.2.1 | Coils..... | 189 |
| L.2.2 | Electromagnetic releases..... | 190 |
| L.2.3 | Interlocking electromagnets | 190 |
| L.2.4 | Indicating light devices | 191 |
| L.3 | Terminal marking of contact elements for switching devices with two positions (numerical)..... | 191 |
| L.3.1 | Contact elements for main circuits (main contact elements)..... | 191 |
| L.3.2 | Contact elements for auxiliary circuit (auxiliary contact elements)..... | 191 |
| L.4 | Terminal marking of overload protection devices..... | 193 |
| L.5 | Distinctive number | 194 |
| L.6 | Marking of terminals for external associated electronic circuit components, contacts and complete devices | 194 |
| L.6.1 | Marking of terminals for external associated electronic circuit components and contacts | 194 |
| L.6.2 | Marking of terminals for external complete devices..... | 197 |
| Annex M (normative) | Flammability test | 200 |
| M.1 | Hot wire ignition test (HWI) | 200 |
| M.1.1 | Test sample..... | 200 |
| M.1.2 | Description of test apparatus | 200 |

| | | |
|-----------------------|---|-----|
| M.1.3 | Conditioning | 201 |
| M.1.4 | Test procedure | 201 |
| M.2 | Arc ignition test (AI) | 201 |
| M.2.1 | Test sample | 201 |
| M.2.2 | Description of test apparatus | 201 |
| M.2.3 | Conditioning | 202 |
| M.2.4 | Test procedure | 202 |
| M.3 | HWI and AI requirements | 203 |
| Annex N (normative) | Requirements and tests for equipment with protective separation | 204 |
| N.1 | General | 204 |
| N.2 | Terms and definitions | 204 |
| N.3 | Requirements | 206 |
| N.3.1 | General | 206 |
| N.3.2 | Dielectric requirements | 206 |
| N.3.3 | Construction requirements | 206 |
| N.4 | Tests | 207 |
| N.4.1 | General | 207 |
| N.4.2 | Dielectric tests | 207 |
| N.4.3 | Examples of constructional measures | 207 |
| Annex O (informative) | Environmentally conscious design | 209 |
| O.1 | General | 209 |
| O.2 | Object | 209 |
| O.3 | Terms and definitions | 210 |
| O.4 | General considerations | 212 |
| O.5 | Fundamentals requirements of environmentally conscious design (ECD) | 215 |
| O.6 | Environmentally conscious design process (ECD process) | 216 |
| O.6.1 | General | 216 |
| O.6.2 | Process steps of ECD | 216 |
| O.7 | Tools for including ECD in product design and development | 217 |
| O.8 | Relevant ISO technical committees | 217 |
| Annex P (informative) | Terminal lugs for low voltage switchgear and controlgear connected to copper conductor | 218 |
| Annex Q (normative) | Special tests – Tests for environmental categories | 219 |
| Q.1 | General | 219 |
| Q.2 | Classification of equipment | 219 |
| Q.3 | Tests | 220 |
| Q.3.1 | General test conditions | 220 |
| Q.3.2 | Test sequences | 220 |
| Annex R (normative) | Application of the metal foil for dielectric testing on accessible parts during operation or adjustment | 225 |
| R.1 | General | 225 |
| R.2 | Object | 225 |
| R.3 | Definition of zones | 226 |
| R.3.1 | General | 226 |
| R.3.2 | Application of metal foil on accessible parts during normal operation or adjustment | 226 |
| Annex S (normative) | Digital inputs and outputs | 233 |
| S.1 | General | 233 |
| S.2 | Terms and definitions | 233 |

| | | |
|-----------------------|--|-----|
| S.3 | Functional requirements..... | 233 |
| S.3.1 | Rated values and operating ranges | 233 |
| S.3.2 | Digital I/Os | 234 |
| S.4 | Verification of input/output requirements | 242 |
| S.4.1 | General | 242 |
| S.4.2 | Verification of digital inputs..... | 243 |
| S.4.3 | Verification of digital outputs..... | 243 |
| S.4.4 | Behaviour of the equipment | 244 |
| S.5 | General information to be provided by the manufacturer | 245 |
| S.5.1 | Information on digital inputs (current sinking)..... | 245 |
| S.5.2 | Information on digital outputs for alternating currents (current sourcing)..... | 245 |
| S.5.3 | Information on digital outputs for direct current (current sourcing)..... | 246 |
| S.6 | Digital input standard operating range equations..... | 246 |
| Annex T (normative) | Extended functions within electronic overload relays | 248 |
| T.1 | Object..... | 248 |
| T.1.1 | General | 248 |
| T.1.2 | Ground/earth fault detection function | 248 |
| T.2 | Terms and definitions..... | 248 |
| T.3 | Classification of electronic overload relays..... | 249 |
| T.4 | Types of relays with ground/earth fault detection function..... | 249 |
| T.5 | Performance requirements..... | 249 |
| T.5.1 | Limits of operation of ground/earth fault electronic overload relays | 249 |
| T.5.2 | Limits of operation of ground/earth fault current sensing electronic relays Type CII(-A and -B)..... | 250 |
| T.5.3 | Limits of operation of voltage asymmetry relays..... | 250 |
| T.5.4 | Limits of operation of phase reversal relays..... | 250 |
| T.5.5 | Limits of operation of current balance relays | 250 |
| T.5.6 | Limits of operation of over-voltage relays and releases..... | 250 |
| T.6 | Tests | 251 |
| T.6.1 | Limits of operation of ground/earth fault current sensing electronic relays Types CII and CII (-A and -B)..... | 251 |
| T.6.2 | Verification of inhibit function of ground/earth fault current sensing electronic relays Type CII (-A and -B)..... | 251 |
| T.6.3 | Current asymmetry relays..... | 251 |
| T.6.4 | Voltage asymmetry relays..... | 251 |
| T.6.5 | Phase reversal relays | 251 |
| T.6.6 | Over-voltage relays | 252 |
| T.7 | Routine and sampling tests | 252 |
| Annex U (informative) | Examples of control circuit configurations | 253 |
| U.1 | External control device..... | 253 |
| U.1.1 | Definition | 253 |
| U.1.2 | Diagrammatic representation of an external control device | 253 |
| U.1.3 | Parameters of an external control device | 253 |
| U.2 | Control circuit configurations..... | 254 |
| U.2.1 | Equipment with external control supply | 254 |
| U.2.2 | Equipment with several external control supplies | 254 |
| U.2.3 | Equipment with bus interface (may be combined with other circuit configurations)..... | 255 |
| Annex V (informative) | Power management with switchgear and controlgear for electrical energy efficiency..... | 256 |

| | | |
|---------------------|--|-----|
| V.1 | General..... | 256 |
| V.2 | Object..... | 256 |
| V.3 | Terms and definitions..... | 256 |
| V.4 | Electrical energy efficiency and safety | 257 |
| V.5 | Principles on electrical energy efficiency (system approach)..... | 257 |
| V.5.1 | General | 257 |
| V.5.2 | Strategy of energy management | 257 |
| V.5.3 | Power management with automation and control | 257 |
| V.6 | Energy efficiency application..... | 258 |
| V.6.1 | Saving of semiconductor losses..... | 258 |
| V.6.2 | Power factor correction..... | 258 |
| V.6.3 | Load shedding..... | 258 |
| V.6.4 | Motor control for fixed speed applications..... | 258 |
| Annex W (normative) | Procedure to establish material declaration | 259 |
| W.1 | General..... | 259 |
| W.2 | Object..... | 259 |
| W.3 | Reference document..... | 259 |
| W.4 | Terms and definitions..... | 259 |
| W.5 | Material declaration requirements | 260 |
| W.5.1 | General reporting requirements | 260 |
| W.5.2 | Additional reporting requirements | 261 |
| W.6 | Example of material declaration made according to W.5 | 261 |
| Annex X (normative) | Co-ordination between circuit-breaker or CPS and another short-circuit protective device associated in the same circuit | 267 |
| X.1 | General..... | 267 |
| X.2 | Object..... | 267 |
| X.3 | General requirements for the co-ordination of a circuit-breaker or CPS with another SCPD..... | 268 |
| X.3.1 | General considerations | 268 |
| X.3.2 | Take-over current I_B | 268 |
| X.3.3 | Behaviour of C_{11} association with another SCPD | 268 |
| X.4 | Type and characteristics of the associated SCPD | 268 |
| X.5 | Verification of selectivity | 269 |
| X.5.1 | General | 269 |
| X.5.2 | Consideration of selectivity by desk study..... | 269 |
| X.5.3 | Selectivity determined by test..... | 270 |
| X.6 | Verification of back-up protection..... | 271 |
| X.6.1 | Determination of the take-over current..... | 271 |
| X.6.2 | Verification of back-up protection..... | 271 |
| X.6.3 | Tests for verification of back-up protection | 271 |
| X.6.4 | Results to be obtained | 272 |
| Bibliography..... | | 278 |
| Figure 1 | – Test equipment for flexion test (see 9.2.5.3 and Table 5) | 131 |
| Figure 2 | – Gauges of form A and form B (see 9.2.5.5.2 and Table 7)..... | 131 |
| Figure 3 | – Diagram of the test circuit for the verification of making and breaking capacities of a single-pole equipment on single-phase AC or on direct current (see 9.3.3.5.2)..... | 132 |

| | |
|--|-----|
| Figure 4 – Diagram of the test circuit for the verification of making and breaking capacities of a two-pole equipment on single-phase AC or on direct current (see 9.3.3.5.2) | 133 |
| Figure 5 – Diagram of the test circuit for the verification of making and breaking capacities of a three-pole equipment (see 9.3.3.5.2) | 134 |
| Figure 6 – Diagram of the test circuit for the verification of making and breaking capacities of a four-pole equipment (see 9.3.3.5.2) | 135 |
| Figure 7 – Schematic illustration of the recovery voltage across contacts of the first phase to clear under ideal conditions (see 9.3.3.5.2, item e))..... | 136 |
| Figure 8 – Diagram of a load circuit adjustment method | 137 |
| Figure 9 – Diagram of the test circuit for the verification of short-circuit making and breaking capacities of a single-pole equipment on single-phase AC or on direct current (see 9.3.4.1.2) | 138 |
| Figure 10 – Diagram of the test circuit for the verification of short-circuit making and breaking capacities of a two-pole equipment on single-phase AC or on direct current (see 9.3.4.1.2) | 139 |
| Figure 11 – Diagram of the test circuit for the verification of short-circuit making and breaking capacities of a three-pole equipment (see 9.3.4.1.2)..... | 140 |
| Figure 12 – Diagram of the test circuit for the verification of short-circuit making and breaking capacities of a four-pole equipment (see 9.3.4.1.2) | 141 |
| Figure 13 – Example of short-circuit making and breaking test record in the case of a single-pole equipment on single-phase AC (see 9.3.4.1.8)..... | 142 |
| Figure 14 – Verification of short-circuit making and breaking capacities on direct current (see 9.3.4.1.8) | 143 |
| Figure 15 – Determination of the prospective breaking current when the first calibration of the test circuit has been made at a current lower than the rated breaking capacity (see 9.3.4.1.8, item b))..... | 144 |
| Figure 16 – Actuator test force (see 9.2.6.2.1 and Table 17) | 145 |
| Figure D.1 – Clamping unit in a connecting device..... | 157 |
| Figure D.2 – Screw clamping units | 158 |
| Figure D.3 – Pillar clamping units | 159 |
| Figure D.4 – Stud clamping units | 160 |
| Figure D.5 – Saddle clamping units..... | 161 |
| Figure D.6 – Lug clamping units..... | 162 |
| Figure D.7 – Mantle clamping units | 163 |
| Figure D.8 – Screwless-type clamping units (sketches)..... | 164 |
| Figure E.1 – Determination of the actual value of the factor γ | 166 |
| Figure G.1 – Measurement of ribs | 170 |
| Figure G.2 – Creepage distance across the fixed and moving insulation of contact carriers | 170 |
| Figure G.3 – Example 1 | 171 |
| Figure G.4 – Example 2 | 171 |
| Figure G.5 – Example 3 | 171 |
| Figure G.6 – Example 4 | 172 |
| Figure G.7 – Example 5 | 172 |
| Figure G.8 – Example 6 | 172 |
| Figure G.9 – Example 7 | 173 |
| Figure G.10 – Example 8 | 173 |

| | |
|--|-----|
| Figure G.11 – Example 9 | 174 |
| Figure G.12 – Example 10 | 174 |
| Figure G.13 – Example 11 | 175 |
| Figure K.1 – Plot of Weibull median rank regression | 188 |
| Figure M.1 – Test fixture for hot wire ignition test..... | 200 |
| Figure M.2 – Circuit for arc ignition test | 202 |
| Figure N.1 – Example of application with component connected between separated circuits | 208 |
| Figure O.1 – Conceptual relationship between provisions in product standards and the environmental impacts associated with the product during its life cycle | 214 |
| Figure O.2 – Overview of ECD process | 215 |
| Figure P.1 – Dimensions | 218 |
| Figure R.1 – Operating mechanism outside the enclosure..... | 227 |
| Figure R.2 – Application of the metallic foil to operating areas around switch actuator | 228 |
| Figure R.3 – Example of finger protected location for hazardous-live-parts in push-button vicinity | 229 |
| Figure R.4 – Example I of application of the foil | 229 |
| Figure R.5 – Example II of application of the foil | 230 |
| Figure R.6 – Example III of application of the foil | 230 |
| Figure R.7 – Application of metal foil on holes and grooves | 231 |
| Figure R.8 – Operating space for actuation by rotary means | 232 |
| Figure S.1 – I/O parameters..... | 235 |
| Figure S.2 – <i>U-I</i> operation regions of current-sinking inputs..... | 236 |
| Figure S.3 – Temporary overload waveform for digital AC outputs | 239 |
| Figure S.4 – Temporary overload waveform for digital DC outputs | 242 |
| Figure T.1 – Test circuit for the verification of the operating characteristic of a ground/earth fault current sensing electronic relay | 252 |
| Figure U.1 – Diagrammatic representation of an external control device | 253 |
| Figure U.2 – Single supply and control input | 254 |
| Figure U.3 – Separate supply and control inputs | 254 |
| Figure U.4 – Equipment with several external control supplies | 254 |
| Figure U.5 – Equipment with bus interface | 255 |
| Figure W.1 – Example of Main and Business information, graphical representation of the XML code..... | 263 |
| Figure W.2 – Example of product information, graphical representation of the XML code | 264 |
| Figure W.3 – Example of declarable substances information, graphical representation of the XML code..... | 265 |
| Figure W.4 – Example of material classes information, graphical representation of the XML code | 266 |
| Figure X.1 – Overcurrent co-ordination between a circuit-breaker or CPS and a fuse or back-up protection by a fuse: operating characteristics | 273 |
| Figure X.2 – Total selectivity between two circuit-breakers or a circuit-breaker and a CPS | 274 |
| Figure X.3 – Back-up protection by a circuit-breaker or CPS – Operating characteristics | 275 |

| | |
|--|-----|
| Figure X.4 – Example of test circuit for conditional short-circuit breaking capacity tests showing cable connections for a 3-pole circuit-breaker or CPS (C ₁) | 276 |
| Figure X.5 – Example of test circuit for the verification of selectivity | 277 |
| | |
| Table 1 – Nominal cross-sections of round copper conductors and approximate relationship between mm ² and AWG/kcmil sizes (see 8.1.8.2) | 116 |
| Table 2 – Temperature-rise limits of terminals (see 8.2.2.2 and 9.3.3.3.4) | 117 |
| Table 3 – Temperature-rise limits of accessible parts (see 8.2.2.3 and 9.3.3.3.4)..... | 117 |
| Table 4 – Tightening torques for the verification of the mechanical strength of screw-type terminals (see 9.2.5.2 and 9.3.2.1) | 118 |
| Table 5 – Test values for flexion and pull-out tests for round copper conductors (see 9.2.5.4.1) | 119 |
| Table 6 – Test values for pull-out test for flat copper conductors (see 9.2.5.4.2) | 119 |
| Table 7 – Maximum conductor cross-sections and corresponding gauges (see 9.2.5.5.1) | 120 |
| Table 8 – Relationship between conductor cross-section and diameter | 121 |
| Table 9 – Test copper conductors for test currents up to 400 A inclusive (see 9.3.3.3.4)..... | 122 |
| Table 10 – Test copper conductors for test currents above 400 A and up to 800 A inclusive (see 9.3.3.3.4) | 123 |
| Table 11 – Test copper bars for test currents above 400 A and up to 3 150 A inclusive (see 9.3.3.3.4) | 123 |
| Table 12 – Impulse withstand test voltages | 124 |
| Table 13 – Minimum clearances in air | 124 |
| Table 14 – Test voltages across the open contacts of equipment suitable for isolation..... | 125 |
| Table 15 – Minimum creepage distances | 125 |
| Table 16 – Values of power-factors and time-constants corresponding to test currents, and ratio <i>n</i> between peak and RMS values of current (see 9.3.4.3, item a))..... | 126 |
| Table 17 – Actuator test force (see 9.2.6.2.1) | 127 |
| Table 18 – Tolerances on test quantities (see 9.3.4.3, item a)) | 127 |
| Table 19 – Dielectric test voltage corresponding to the rated insulation voltage | 127 |
| Table 20 – Test values for conduit pull-out test (see 9.2.8.2) | 128 |
| Table 21 – Test values for conduit bending test (see 9.2.8.3)..... | 128 |
| Table 22 – Test values for conduit torque test (see 9.2.8.2 and 9.2.8.4) | 128 |
| Table 23 – Tests for EMC – Immunity (see 9.4.1)..... | 129 |
| Table 24 – Acceptance criteria when EM disturbances are present | 130 |
| Table 25 – Cross-sectional area of a copper protective conductor..... | 130 |
| Table A.1 – Utilization categories used in the IEC 60947 series | 146 |
| Table C.1 – IP Codes (1 of 3) | 154 |
| Table G.1 – Minimum widths of grooves..... | 169 |
| Table H.1 – Correspondence between the nominal voltage of the supply system and the equipment rated impulse withstand voltage, in case of overvoltage protection by surge-arresters according to IEC 60099-1 | 177 |
| Table K.1 – Failure modes of devices | 182 |
| Table K.2 – Example of 15 sorted ascending times to failure of contactors | 186 |
| Table K.3 – Example median rank calculation | 187 |

Table M.1 – HWI and AI characteristics for materials necessary to retain current carrying parts in position..... 203

Table M.2 – HWI and AI characteristics for materials other than those covered by Table M.1 203

Table P.1 – Examples of terminal lugs for low voltage switchgear and controlgear connected to copper conductors 218

Table Q.1 – Test sequences (1 of 4) 221

Table S.1 – Rated values and operating ranges of incoming power supply..... 234

Table S.2 – Standard operating ranges for digital inputs (current sinking) 237

Table S.3 – Rated values and operating ranges for current sourcing digital AC outputs 238

Table S.4 – Rated values and operating ranges (direct current) for current-sourcing digital DC outputs 241

Table S.5 – Overload and short-circuit tests for digital outputs..... 244

Table T.1 – Tripping time of ground/earth fault electronic overload relays 249

Table W.1 – Example of main and business information in tabular form 262

Table W.2 – Example of product information in tabular form..... 263

Table W.3 – Example of declarable substances information in tabular form 264

Table W.4 – Example of material classes information in tabular form 266

INTERNATIONAL ELECTROTECHNICAL COMMISSION

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –**Part 1: General rules****FOREWORD**

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

International Standard IEC 60947-1 has been prepared by subcommittee 121A: Low-voltage switchgear and controlgear, of IEC technical committee 121: Switchgear and controlgear and their assemblies for low voltage.

This sixth edition cancels and replaces the fifth edition published in 2007, Amendment 1:2010 and Amendment 2:2014. This edition constitutes a technical revision.

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

- DC values testing improvement;
- update of EMC tests;
- Annex B deletion;
- update of requirements for environmental tests (Table Q.1);
- improvement of Annex R (new examples);

- deletion of digital input Type 2, and introduction of Type 3 in Annex S;
- example for materials declaration (Annex W);
- new Annex X (co-ordination between short-circuit protective devices associated in the same circuit) created.

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

| FDIS | Report on voting |
|---------------|------------------|
| 121A/337/FDIS | 121A/344/RVD |

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

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

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

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

5.3.6.4 Rated conditional short-circuit current (I_q , alternatively I_{cc}) (North America)

6.2 Marking (USA and Canada)

8.1.3 Current-carrying parts and their connections (USA)

8.1.7.1 Additional constructional requirements (USA)

8.1.10.1 (North America)

9.2.6.2.2 Dependent power operation (USA)

9.2.6.2.3 Independent power operation (Canada and USA)

Figure 4 (USA and Canada)

Figure 5 (USA and Canada)

Figure 10 (USA and Canada)

Figure 11 (USA and Canada)

Figure X.4 (USA and Canada)

Figure X.5 (USA and Canada)

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

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

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

INTRODUCTION

The purpose of this document is to harmonize as far as practicable all rules and requirements of a general nature applicable to low-voltage switchgear and controlgear in order to obtain uniformity of requirements and tests throughout the corresponding range of equipment and to avoid the need for testing to different standards.

All those parts of the various equipment standards which can be considered as general have therefore been gathered in this document together with specific subjects of wide interest and application, e.g. temperature-rise, dielectric properties, etc.

For each type of low-voltage switchgear and controlgear, only two main documents are necessary to determine all requirements and tests:

- 1) this document, referred to as "Part 1" or "IEC 60947-1" in the specific standards covering the various types of low-voltage switchgear and controlgear;
- 2) the relevant equipment standard hereinafter referred to as the "relevant product standard" or "product standard of this series".

For a general rule to apply to a specific product standard, it will be explicitly referred to by the latter, by quoting the relevant clause or subclause number of this document followed by "IEC 60947-1" e.g. "7.2.3 of IEC 60947-1:20xx".

A specific product standard will only deviate from the general rules when there is substantial technical justification.

NOTE All references to "product standards" in this document means "product standards of IEC 60947 series".

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 1: General rules

1 Scope

This document applies, when required by the relevant product standard, to low-voltage switchgear and controlgear hereinafter referred to as "equipment" or "device" and intended to be connected to circuits, the rated voltage of which does not exceed 1 000 V AC or 1 500 V DC.

This document states the general rules and common safety requirements for low-voltage switchgear and controlgear, including:

- definitions;
- characteristics;
- information supplied with the equipment;
- normal service, mounting and transport conditions, decommissioning and dismantling;
- constructional and performance requirements;
- verification of characteristics and performance;
- energy efficiency aspects (see Annex V);
- environmental aspects.

This document does not apply to:

- low-voltage switchgear and controlgear assemblies which are dealt with in IEC 61439 series, as applicable;
- terminals for connection of aluminium conductors;

NOTE Terminals for aluminium conductors are under consideration for the next revision.

- use within explosive atmospheres (see IEC 60079 series);
- software and firmware requirements for functional safety application (see IEC 61508-3);
- cyber security aspects (see IEC 62443 series).

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 60038:2009, *IEC standard voltages*

IEC 60068-1:2013, *Environmental testing – Part 1: General and guidance*

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

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

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