

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Low-voltage switchgear and controlgear –
Part 5-1: Control circuit devices and switching elements – Electromechanical
control circuit devices**

**Appareillage à basse tension –
Partie 5-1: Appareils et éléments de commutation pour circuits de commande –
Appareils électromécaniques pour circuits de commande**



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2024 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 Secretariat
3, rue de Varembé
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 It also gives information on projects, replaced and withdrawn publications.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.

IEC Products & Services Portal - products.iec.ch

Discover our powerful search engine and read freely all the publications previews, graphical symbols and the glossary. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org

The world's leading online dictionary on electrotechnology, containing more than 22 500 terminological entries in English and French, with equivalent terms in 25 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

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.

IEC Products & Services Portal - products.iec.ch

Découvrez notre puissant moteur de recherche et consultez gratuitement tous les aperçus des publications, symboles graphiques et le glossaire. Avec un abonnement, vous aurez toujours accès à un contenu à jour adapté à vos besoins.

Electropedia - www.electropedia.org

Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 500 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 25 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.



IEC 60947-5-1

Edition 5.0 2024-03

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Low-voltage switchgear and controlgear –
Part 5-1: Control circuit devices and switching elements – Electromechanical
control circuit devices**

**Appareillage à basse tension –
Partie 5-1: Appareils et éléments de commutation pour circuits de commande –
Appareils électromécaniques pour circuits de commande**

**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	9
1 Scope	11
2 Normative references	12
3 Terms, definitions, symbols and abbreviated terms	14
3.1 Terms and definitions	14
3.1.1 General	14
3.1.2 Basic terms and definitions	14
3.1.3 Terms and definitions concerning automatic control switches	16
3.1.4 Terms and definitions concerning manually operated control switches	16
3.1.5 Terms and definitions concerning parts of control switches	18
3.1.6 Terms and definitions concerning operation of contactor relays	21
3.1.7 Terms and definitions concerning operation of pilot switches	21
3.1.8 Terms and definitions concerning operation of rotary switches	22
3.1.9 Terms and definitions concerning operation of mechanically operated control switches	22
3.1.10 Terms and definitions concerning reed contact magnetic switches	25
3.1.11 Terms and definitions concerning Class II control circuit devices	26
3.1.12 Terms and definitions concerning control circuit devices with integrally connected cables	26
3.1.13 Terms and definitions concerning semiconductor switching elements	27
3.1.14 Terms and definitions concerning indicator lights, indicating towers and audible signalling devices	27
3.1.15 Terms and definitions concerning control switches with direct opening action	28
3.1.16 Terms and definitions concerning digital communication interface	28
3.1.17 Alphabetical index of definitions	29
3.2 Symbols and abbreviated terms	33
4 Classification	33
4.1 Contact elements	33
4.2 Control switches	35
4.3 Control circuit devices	35
4.4 Time delay switching elements	35
4.5 Control switch mounting	35
5 Characteristics	35
5.1 Summary of characteristics	35
5.1.1 General	35
5.1.2 Operation of a control switch	35
5.2 Type of control circuit device or switching element	36
5.2.1 Kind of control circuit device	36
5.2.2 Kind of switching elements	36
5.2.3 Number of poles	36
5.2.4 Kind of current	36
5.2.5 Interrupting medium	36
5.2.6 Operating conditions	37
5.3 Rated and limiting values for switching elements	37
5.3.1 General	37
5.3.2 Rated voltages (of a switching element)	37

5.3.3	Currents	37
5.3.4	Rated frequency	38
5.3.5	Vacant	38
5.3.6	Characteristics under normal and abnormal load conditions	38
5.3.7	Short-circuit characteristics – Rated conditional short-circuit current	40
5.4	Utilization categories for switching elements	40
5.5	Control circuits	40
5.6	Vacant	41
5.7	Vacant	41
5.8	Vacant	41
5.9	Vacant	41
5.10	Electrically separated contact elements	41
5.11	Actuating quantities for pilot switches	41
5.12	Pilot switches having two or more contact elements	41
6	Product information	41
6.1	Nature of information	41
6.2	Marking	43
6.2.1	General	43
6.2.2	Terminal identification and marking	43
6.2.3	Functional markings	43
6.2.4	Emergency stop	43
6.2.5	Operating diagram	43
6.2.6	Time delay markings	44
6.3	Instructions for installation, operation and maintenance, decommissioning and dismantling	45
6.4	Environmental information	45
6.4.1	Environmentally conscious design process (ECD process)	45
6.4.2	Procedure to establish material declaration	45
6.5	Additional information	45
7	Normal service, mounting and transport conditions	46
7.1	Normal service conditions	46
7.1.1	Ambient air temperature	46
7.1.2	Altitude	46
7.1.3	Atmospheric conditions	46
7.1.4	Shock and vibration	46
7.2	Conditions during transport and storage	46
7.3	Mounting	46
7.3.1	General	46
7.3.2	Mounting of single hole mounted devices	46
8	Constructional and performance requirements	48
8.1	Constructional requirements	48
8.1.1	General	48
8.1.2	Materials	48
8.1.3	Current-carrying parts and their connections	49
8.1.4	Clearances and creepage distances	49
8.1.5	Actuator	49
8.1.6	Indication of the contact position	50
8.1.7	Conditions for control switches suitable for isolation	50
8.1.8	Terminals	50

8.1.9	Vacant	50
8.1.10	Provisions for protective earthing	50
8.1.11	Enclosures for equipment	50
8.1.12	Degrees of protection of enclosed equipment	50
8.1.13	Conduit pull-out, torque and bending with metallic conduits	50
8.1.14	Requirements for control circuit devices with artificial optical radiation	50
8.1.15	Biological and chemical effects	51
8.1.16	Hygienic design	51
8.1.17	Security aspects	51
8.1.18	Limited energy source	51
8.1.19	Fault and abnormal conditions	53
8.1.20	Stored charge energy circuit	54
8.1.21	Embedded software	54
8.2	Performance requirements	54
8.2.1	Operating conditions	54
8.2.2	Temperature-rise	54
8.2.3	Dielectric properties	54
8.2.4	Ability to make and break under normal and abnormal load conditions	54
8.2.5	Conditional short-circuit current	55
8.2.6	Vacant	55
8.2.7	Additional requirements for control switches suitable for isolation	55
8.3	Electromagnetic compatibility (EMC)	55
8.3.1	General	55
8.3.2	Immunity	56
8.3.3	Emission	56
8.4	Special requirements	56
8.4.1	Additional requirements for reed contact magnetic switches	56
8.4.2	Class II control circuit devices	57
8.4.3	Additional requirements for control circuit devices with integrally connected cables	57
8.4.4	Additional requirements for semiconductor switching elements for control circuit devices	57
8.4.5	Special requirements for indicator lights, indicating towers and their optional audible functions	57
8.4.6	Special requirements for control switches with direct opening action	57
8.4.7	Special requirements for mechanically linked contact elements	57
8.4.8	Additional requirements for control circuit devices incorporating a built-in communication interface (SDCI)	57
9	Tests	57
9.1	Kinds of test	57
9.1.1	General	57
9.1.2	Type tests	57
9.1.3	Routine tests	58
9.1.4	Sampling tests	58
9.1.5	Special tests	58
9.2	Compliance with constructional requirements	59
9.2.1	General	59
9.2.2	Test of materials to abnormal heat and fire	59
9.2.3	Equipment	59
9.2.4	Degrees of protection	59

9.2.5	Mechanical and electrical properties of terminals	60
9.2.6	Verification of actuating force (or torque)	62
9.2.7	Verification of limitation of rotation (of a rotary switch).....	62
9.2.8	Conduit pull-out test, torque test and bending test with metallic conduits	62
9.2.9	Test of earth continuity for protective earth	62
9.2.10	Limited energy source test.....	62
9.2.11	Breakdown of components.....	63
9.2.12	Artificial optical radiation test.....	63
9.2.13	Stored charge energy test.....	64
9.3	Performance	64
9.3.1	Test sequences	64
9.3.2	General test conditions	65
9.3.3	Performance under no-load, normal load and abnormal load conditions.....	66
9.3.4	Performance under conditional short-circuit current	70
9.4	Tests for EMC.....	72
9.4.1	General	72
9.4.2	Immunity.....	72
9.4.3	Emission.....	74
9.4.4	Test results and test report	75
Annex A (normative)	Electrical ratings based on utilization categories (see 4.1)	76
Annex B (informative)	Example of inductive test loads for DC contacts	78
B.1	General.....	78
B.2	Construction	78
Annex C (normative)	Special tests – Durability tests	80
C.1	General.....	80
C.1.1	Durability declaration	80
C.1.2	Test procedures.....	80
C.1.3	Failure criteria	80
C.2	Mechanical durability	81
C.2.1	General	81
C.2.2	Test procedures.....	81
C.3	Electrical durability	81
C.3.1	General	81
C.3.2	Test procedures.....	81
Annex D (normative)	Additional requirements for reed contact magnetic switches.....	84
Annex E (informative)	Items subject to agreement between manufacturer and user	87
Annex F (normative)	Class II control circuit devices – Requirements and tests	88
Annex G (normative)	Additional requirements for control circuit devices with integrally connected cables	93
Annex H (normative)	Additional requirements for semiconductor switching elements for control circuit devices	97
Annex I (informative)	103
Annex J (normative)	Special requirements for indicator lights, indicating towers and audible signalling devices	104
Annex K (normative)	Special requirements for control switches with direct opening action.....	110
Annex L (normative)	Special requirements for mechanically linked contact elements	115

Annex M (normative) Terminal marking, distinctive number and distinctive letter for control circuit devices	118
M.1 General.....	118
M.2 Terminal marking rule	118
M.2.1 General	118
M.2.2 Function digit.....	118
M.2.3 Sequence digit.....	118
M.2.4 Numbering method	119
M.3 Distinctive number and distinctive letter	119
M.3.1 General	119
M.3.2 Distinctive number	119
M.3.3 Distinctive letter.....	119
M.4 Terminal numbering sequence	120
M.5 Contactor relays designated by the distinctive letter E	120
M.6 Contactor relays designated by distinctive letters X, Y or Z	122
M.6.1 Contactor relays designated by the distinctive letter Z	122
M.6.2 Contactor relays designated by the distinctive letter X	122
M.6.3 Contactor relays designated by the distinctive letter Y	122
Annex N (normative) Procedure to determine reliability data for electromechanical devices in control circuits used in functional safety applications.....	123
N.1 General.....	123
N.1.1 Overview	123
N.1.2 Object.....	123
N.1.3 General requirements	123
N.2 Terms, definitions and symbols	123
N.3 Method based on durability test results	123
N.3.1 General method	123
N.3.2 Test requirements.....	123
N.3.3 Number of samples.....	124
N.3.4 Characterization of a failure mode	124
N.3.5 Weibull modelling	124
N.3.6 Useful life and upper limit of failure rate.....	124
N.3.7 Reliability data.....	124
N.4 Data information	124
N.5 Example.....	124
Annex O (normative) Additional requirements for control circuit devices incorporating a built-in communication interface complying with IEC 61131-9	125
Bibliography.....	127
 Figure 1 – Operation of push-buttons	23
Figure 2 – Difference e between the over-travel of the actuator and that of the contact element.....	23
Figure 3 – Examples of contact elements (schematic sketches)	34
Figure 4 – Examples of the recommended method for drawing an operating diagram of a rotary switch	44
Figure 5 – Mounting hole diameter and dimensions of the key recess (if any)	47
Figure 6 – Voltage drop measurement at contact point of the clamping unit or terminal.....	61
Figure 7 – Test circuits for multi-pole control switches – Contacts of same polarity, not electrically separated	68

Figure 8 – Test circuits for multi-pole control switches – Electrically separated	68
Figure 9 – Load L_d details for test conditions requiring different values of make and break current and/or power factor (time constant)	69
Figure 10 – Current/time limits for DC test loads	69
Figure 11 – Test circuit, conditional short-circuit current	71
Figure B.1 – Construction of load for DC contacts	79
Figure C.1 – Normal circuit (see C.3.2.2)	83
Figure C.2 – Simplified circuit (see C.3.2.2)	83
Figure F.1 – Device insulated by encapsulation	88
Figure F.2 – Device insulated by double and reinforced insulation	89
Figure F.3 – Test apparatus	91
Figure H.1 – Relationship between U_e and U_B	98
Figure H.2 – Example of test circuit for the verification of voltage drop, minimum operational current and OFF-state current	100
Figure H.3 – Short-circuit testing	101
Figure J.1 – Mounting dimensions for indicating tower socket	105
Figure J.2 – Mounting dimensions for temperature-rise tests	107
Figure K.1 – Verification of robustness of the actuating system	114
Figure L.1 – Example of representation of NO and NC contacts which are mechanically linked and NC non-linked contact	116
Figure L.2 – Symbol for device containing mechanically linked contacts	116
 Table 1 – Utilization categories for switching elements	36
Table 2 – Verification of making and breaking capacities of switching elements under normal load conditions corresponding to the utilization categories	39
Table 3 – Verification of making and breaking capacities of switching elements under abnormal conditions corresponding to the utilization categories	40
Table 4 – Mounting hole diameter and dimensions of the key recess (if any)	47
Table 5 – Preferred minimum distances between centres of mounting holes	47
Table 6 – Test conditions for glow-wire test	49
Table 7 – Limits for limited energy sources without an overcurrent protective device	52
Table 8 – Limits for limited energy sources with an overcurrent protective device	52
Table 9 – Limits for limited energy source with limited current impedance	53
Table 10 – Acceptance criteria	56
Table 11 – Test values for electrical performance and ageing test of screwless-type clamping units	61
Table 12 – Immunity tests	73
Table A.1 – Examples of contact rating designation based on utilization categories	76
Table A.2 – Examples of semiconductors switching element ratings for 50 Hz and/or 60 Hz	77
Table A.3 – Examples of semiconductors switching element ratings for direct current	77
Table B.1 – DC loads	79
Table C.1 – Making and breaking conditions for electrical durability	82
Table F.1 – Acceptance criteria for Annex F	90
Table G.1 – Material characteristics (informative)	94

Table G.2 – Examples of standard cable types (informative)	95
Table G.3 – Tensile forces.....	95
Table M.1 – Diagrams of control switches	120
Table M.2 – Diagrams of contactor relays designated by the distinctive letter E.....	121
Table M.3 – Diagrams of contactor relays designated by the distinctive letter Y.....	122

INTERNATIONAL ELECTROTECHNICAL COMMISSION

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –**Part 5-1: Control circuit devices and switching elements –
Electromechanical control circuit devices****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) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at <https://patents.iec.ch>. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 60947-5-1 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. It is an International Standard.

This fifth edition cancels and replaces the fourth edition published in 2016. This edition constitutes a technical revision.

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

- a) update of the scope structure and exclusions;
- b) requirements for control circuits;
- c) update of the normal service conditions (e.g. shock and vibration);
- d) update of information and marking requirements including environmental information requirements referencing IEC TS 63058:2021;

- e) update of the constructional requirements and the corresponding tests considering safety aspects (e.g. artificial optical radiation, security aspects, limited energy source, stored charge energy circuit);
- f) update of the EMC requirements according to the generic documents;
- g) new requirements for reed contact magnetic switches in Annex D;
- h) requirements for class II circuit devices achieved by double or reinforced insulation in Annex F;
- i) update of pull-out tests in Annex G;
- j) information requirements for audible signalling device in Annex J;
- k) insertion of new Annex O.

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

Draft	Report on voting
121A/585/FDIS	121A/598/RVD

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

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

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

This International Standard should be used in conjunction with IEC 60947-1.

The provisions of the general rules, IEC 60947-1, are applicable to this document, where specifically called for. General rules, clauses and subclauses thus applicable, as well as tables, figures and annexes are identified by a reference to IEC 60947-1, for example 1.2.3, Table 4 or Annex A of IEC 60947-1:2020.

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

- 8.2.4.1: Making and breaking capacities (United States of America and Canada).
- 9.3.3.5.2: Test circuits and connections (United States of America and Canada).

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

- reconfirmed,
- withdrawn, or
- revised.

IMPORTANT – The "colour inside" logo on the cover page of this document 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.