

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**



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

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

**Part 5-1: Control circuit devices and switching elements –
Electromechanical control circuit devices**

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International Standard 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.

This fourth edition cancels and replaces the third edition published in 2003 and its Amendment 1:2009. This edition constitutes a technical revision.

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

- a) update of normative references;
- b) update and restructuration of subclauses in 7.1;
- c) addition of material requirements and test;
- d) update of EMC requirements;

- e) clarification of requirements and update of 8.2;
- f) addition of requirements for screwless-type clamping units;
- g) update of existing Tables 4 and 5;
- h) addition of new Tables 6, 7, 8 and 9;
- i) addition of a new Figure 10 ;
- j) addition of a new Annex N.

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

FDIS	Report on voting
121A/62/FDIS	121A/76/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.

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 standard, 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 60947-1:2007.

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

- 7.2.4.1: Making and breaking capacities (United States of America and Canada)
- 8.3.3.5.2: 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 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,
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- replaced by a revised edition, or
- amended.

The contents of the corrigenda of July 2016 and April 2020 have been included in this copy.

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices

1 General

1.1 Scope and object

This part of IEC 60947 applies to control circuit devices and switching elements intended for controlling, signalling, interlocking, etc., of switchgear and controlgear.

It applies to control circuit devices having a rated voltage not exceeding 1 000 V a.c. (at a frequency not exceeding 1 000 Hz) or 600 V d.c.

However, for operational voltages below 100 V a.c. or d.c., see 4.3.2.2.

This standard applies to specific types of control circuit devices such as:

- manual control switches, for example push-buttons, rotary switches, foot switches, etc.;
- electromagnetically operated control switches, either time-delayed or instantaneous, for example contactor relays;
- pilot switches, for example pressure switches, temperature sensitive switches (thermostats), programmers, etc.;
- position switches, for example control switches operated by part of a machine or mechanism;
- associated control circuit equipment, for example indicator lights, etc.

NOTE 1 A control circuit device includes (a) control switch(es) and associated devices such as (an) indicator light(s).

NOTE 2 A control switch includes (a) switching element(s) and an actuating system.

NOTE 3 A switching element can be a contact element or a semiconductor element.

It also applies to specific types of switching elements associated with other devices (whose main circuits are covered by other standards) such as:

- auxiliary contacts of a switching device (e.g. contactor, circuit breaker, etc.) which are not dedicated exclusively for use with the coil of that device;
- interlocking contacts of enclosure doors;
- control circuit contacts of rotary switches;
- control circuit contacts of overload relays.

Contactor relays also comply with the requirements and tests of IEC 60947-4-1 except for the utilization category which comply with this standard.

This standard does not include the relays covered in IEC 60255 or in the IEC 61810 series, nor automatic electrical control devices for household and similar purposes.

The colour requirements of indicator lights, push-buttons, etc., are found in IEC 60073 and also in CIE S 0004/E-2001 from the Commission of Illumination (CIE).

The object of this standard is to state:

- a) the characteristics of control circuit devices;
- b) the electrical and mechanical requirements with respect to:
 - 1) the various duties to be performed;
 - 2) the significance of the rated characteristics and of the markings;
 - 3) the tests to verify the rated characteristics;
- c) the functional requirements to be satisfied by the control circuit devices with respect to:
 - 1) environmental conditions, including those of enclosed equipment;
 - 2) dielectric properties;
 - 3) terminals.

1.2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

IEC 60068-2-14:2009, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-27:2008, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

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

IEC 60073:2002, *Basic and safety principles for man-machine interface, marking and identification – Coding principles for indications and actuators*

IEC 60417-DB:2002¹, *Graphical symbols for use on equipment*

IEC 60617-DB:2012², *Graphical symbols for diagrams*

IEC 60695-2-10:2013, *Fire hazard testing – Part 2-10: Glowing/hot-wire based test methods – Glow-wire apparatus and common test procedure*

IEC 60695-2-11:2014, *Fire hazard testing – Part 2-11: Glowing/hot-wire based test methods – Glow-wire flammability test method for end-products (GWEPT)*

IEC 60695-2-12:2010, *Fire hazard testing – Part 2-12: Glowing/hot-wire based test methods – Glow-wire flammability index (GWFI) test method for materials*

IEC 60695-2-12:2010/AMD1:2014

IEC 60947-1:2007, *Low-voltage switchgear and controlgear – Part 1: General rules*

IEC 60947-1:2007/AMD1:2010

IEC 60947-1:2007/AMD2:2014

¹ “DB” refers here to the IEC on-line database, available at: <http://www.graphical-symbols.info/equipment>.

² “DB” refers there to the IEC on-line database, available at: <http://std.iec.ch/iec60617>.

IEC 60947-4-1:2009, *Low-voltage switchgear and controlgear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters*
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IEC 60947-5-5:1997/AMD1:2005
IEC 60947-5-5:1997/AMD2:2016

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IEC 61000-3-3, *Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current < 16 A per phase and not subject to conditional connection*

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IEC 61000-4-3:2006, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*
IEC 61000-4-3:2006/AMD1:2007
IEC 61000-4-3:2006/AMD2:2010

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IEC 61000-4-5:2014, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-6:2013, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

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IEC 61000-4-11:2004, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests*

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IEC 61000-4-13:2002/AMD2:2015

IEC 61140:2015, *Protection against electric shock – Common aspects for installation and equipment*
IEC 61140:2015/AMD1:2004

CISPR 11:2015, *Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement*

CIE S 004/E-2001, *Colours of Light Signals*

2 Terms and definitions

For the purposes of document, the terms and definitions given in IEC 60947-1, as well as the following apply.

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2.1 Basic terms and definitions

2.1.1

control circuit device

an electrical device intended for the controlling, signalling, interlocking, etc., of switchgear and controlgear

Note 1 to entry: Control circuit devices can include associated devices dealt with in other standards, such as instruments, potentiometers, relays, in so far as associated devices are used for the purposes specified above.

2.1.2

control switch (for control and auxiliary circuits)

a mechanical switching device which serves the purpose of controlling the operation of switchgear or controlgear, including signalling, electrical interlocking, etc.

Note 1 to entry: A control switch consists of one or more contact elements with a common actuating system.

Note 2 to entry: A control switch may include semiconductor elements or contact elements (see 2.3.2 and 2.3.3).

[SOURCE: IEC 60050-441:1984, 441-14-46, modified – Addition of a new Note 2 to entry.]

2.1.3

control switch suitable for isolation

a control switch which, in the open position, complies with the requirements specified for the isolating function (see 2.1.19 and 7.1.7 of IEC 60947-1:2007)

Note 1 to entry: Such control switches are intended to provide a higher degree of safety to personnel when working on the equipment controlled. For this reason, they have to be manually actuated relying on the intelligence of instructed persons to react in case they would fail to operate, e.g. in case of insufficiently opened contacts.

2.1.4

control station

an assembly of one or more control switches fixed on the same panel or located in the same enclosure

Note 1 to entry: A control station panel or enclosure may also contain related equipment, e.g. potentiometers, signal lamps, instruments, etc.

[SOURCE: IEC 60050-441:1984, 441-12-08]

2.2 Control switches

2.2.1

automatic control switches

Note 1 to entry: Automatic control switches are operated by automatic control (see 2.4.5 of IEC 60947-1:2007). They are also designated as *pilot switches* (see 2.2.18 of IEC 60947-1:2007).

2.2.1.1

instantaneous contactor relay

a contactor relay operating without any intentional time delay

Note 1 to entry: Unless otherwise stated, a contactor relay is an instantaneous contactor relay.

[SOURCE: IEC 60050-441:1984, 441-14-36]

2.2.1.2

time-delay contactor relay

a contactor relay with specified time-delay characteristics

Note 1 to entry: The time-delay may be associated with energization (*e*-delay) or with de-energization (*d*-delay) or both.

Note 2 to entry: A time-delay contactor relay may also incorporate instantaneous contact elements.

[SOURCE: IEC 60050-441:1984, 441-14-37, modified – addition of a new Note 2 to entry.]

2.2.1.3

position switch

a pilot switch the actuating system of which is operated by a moving part of the machine, when this part reaches a predetermined position

[SOURCE: IEC 60050-441:1984, 441-14-49]

2.2.1.4

programmer

a control switch having a multiplicity of switching elements which, after initiation, operates in a defined sequence

2.2.2 manually operated control switches

Note 1 to entry: Manually operated control switches are operated by manual control (see 2.4.4 of IEC 60947-1:2007).

2.2.2.1 push-button

a control switch having an actuator intended to be operated by force exerted by a part of the human body, usually the finger or palm of the hand, and having stored energy (spring) return

[SOURCE: IEC 60050-441:1984, 441-14-53]

2.2.2.2 pull-button

a control switch having an actuator intended to be operated by manual pull, and having stored energy (spring) return

2.2.2.3 push-pull button

a control switch having an actuator intended to be operated by manual push and returned to its initial position by manual pull, or vice versa

Note 1 to entry: There are also «push-push» or «push-turn» or other combinations of buttons.

2.2.2.4 rotary button

a combination of push-button type switching elements having an actuator operated by a manual rotation (see also 2.2.2.15 to 2.2.2.18 inclusive)

EXAMPLE A selector switch.

Note 1 to entry: A rotary push-button may have more than two positions; it may or may not have a spring return.

2.2.2.5 latched push-button

a push-button with spring return, but which remains in the actuated position until a latch is released by a separate action

Note 1 to entry: The latching may be released by subsequent actuation (such as pushing, turning, etc.) of the same or of an adjacent push-button or by the action of an electromagnet, etc.

2.2.2.6 locked push-button

a push-button which may be secured in one or more of its positions by a separate action

Note 1 to entry: The locking may be obtained by turning the button, by turning a key, by operating a lever, etc.

2.2.2.7 key-operated push-button

a push-button which can only be operated as long as a key remains inserted

Note 1 to entry: Key withdrawal may be provided at any position.

2.2.2.8 time-delay push-button

a push-button the contacts of which return to the initial position only after a pre-determined interval of time following the release of the actuating force

2.2.2.9**delayed action push-button**

a push-button in which the switching operation does not occur until after the force on the button has been maintained for a pre-determined interval of time

2.2.2.10**illuminated push-button**

a push-button incorporating a signalling lamp in the button

2.2.2.11**covered push-button**

a push-button in which the button is protected against inadvertent operation by a lid or a cover

2.2.2.12**shrouded push-button**

a push button in which the button is protected against inadvertent operation in certain directions

2.2.2.13**free push-button**

a push-button in which the rotation of the actuator around its axis is not limited

2.2.2.14**guided push-button**

a push-button in which the rotation of the actuator around its axis is prevented

Note 1 to entry: Examples of guided push-buttons: the actuators of which are keyed, square or rectangular, etc.

2.2.2.15**rotary control switch****rotary switch**

a control switch having an actuator intended to be operated by rotation

2.2.2.16**key-operated rotary switch**

a rotary switch where a key is used as the actuator

Note 1 to entry: Key withdrawal may be provided at any position.

2.2.2.17**limited movement rotary switch**

a rotary switch with a restricted angular movement of its actuator

2.2.2.18**unidirectional movement rotary switch**

a rotary switch in which the actuating system allows rotation in one direction only

2.2.2.19**joy stick**

a control switch having an actuator consisting of a pin or stick projecting essentially at a right angle from the panel or enclosure when in one of its positions and intended to be operated by angular displacement

Note 1 to entry: A joy stick may have more than two positions associated with different directions of the displacement of the stick and operating the contact elements differently: such a joy stick is referred to as a joy stick selector.

Note 2 to entry: The pin or stick may or may not have a spring return.

2.2.2.20

wobble stick

a joy stick which operates all contact elements alike, whatever be the direction of the displacement

2.2.2.21

foot switch

pedal

a control switch having an actuator intended to be operated by force exerted by a foot

[SOURCE: IEC 60050-441:1984, 441-14-52, modified – insertion of "force exerted by".]

2.3 Parts of control switches

2.3.1

switching element

a switching element may be a semiconductor element (see 2.3.2) or a contact element (see 2.3.3)

2.3.2

semiconductor element

an element designed to switch the current of an electric circuit by means of the controlled conductivity of a semiconductor

2.3.3

contact element

<control switch> the parts, fixed and movable, conducting and insulating, of a control switch necessary to close and open one single conducting path of a circuit

Note 1 to entry: The contact element and the actuating system may form an indivisible unit, but frequently one or more contact elements may be combined with one or more actuating system or systems. The actuating systems may be different.

Note 2 to entry: Terms and definitions relating to various kinds of contact elements are given in 2.3.3.1 to 2.3.3.10 inclusive.

Note 3 to entry: This definition does not include control coils and magnet systems.

The following definitions refer to a single contact element of a control switch:

2.3.3.1

single gap contact element

a contact element which opens or closes the conducting path of its circuit on one location only

Note 1 to entry: See Figures 4 a) and 4 c).

2.3.3.2

double gap contact element

a contact element which opens or closes the conducting path of its circuit in two locations in series

Note 1 to entry: See Figures 4 b), 4 d) and 4 e).

2.3.3.3

make-contact element

normally open

a contact element which closes a conducting path when the control switch is actuated

2.3.3.4**break-contact element****normally closed**

a contact element which opens a conducting path when the control switch is actuated

2.3.3.5**change-over contact elements**

a contact element combination which includes one make-contact element and one break-contact element

Note 1 to entry: See Figures 4 c), 4 d) and 4 e).

2.3.3.6**pulse contact element****fleeting contact element**

a contact element which opens or closes a circuit for a part of the travel during the transition of the actuator from one position to another

2.3.3.7**electrically separated contact elements**

contact elements belonging to the same control switch, but adequately insulated from each other so that they can be connected into electrically separated circuits, which can be either same polarity or opposite polarity

[SOURCE: IEC 60050-441:1984, 441-15-24, modified – supplemented by polarity statement]

2.3.3.8**independent action contact element****snap action contact element**

a contact element of a manual or automatic control device in which the velocity of contact motion is substantially independent of the velocity of motion of the actuator

2.3.3.9**dependent action contact element**

a contact element of a manual or automatic control device in which the velocity of contact motion depends on the velocity of motion of the actuator

2.3.3.10**contact unit**

a contact element or contact element combination which can be combined with similar units operated by a common actuating system

2.3.4**button**

the external end of the actuator of a push-button, to which the actuating force is applied

2.3.4.1**flush-button**

a button which is substantially level with the adjacent fixed surrounding surface when in its initial position and is below this surface when it is operated

2.3.4.2**recessed button**

a button which is below the adjacent fixed surrounding surface in both its initial and operated positions

2.3.4.3

extended button

a button which protrudes above the adjacent fixed surrounding surface both in its initial position and in its operated position

2.3.4.4

mushroom button

a button, the protruding end of which has an enlarged diameter

2.3.5

locating mechanism

<rotary switch> that part of the actuating system which retains the actuator and/or the contact elements in their positions

Note 1 to entry: Other devices (e.g. a push-button with two positions, or an emergency stop) can also have such a function.

2.3.6

end stop

a device that limits the travel of a moving part

Note 1 to entry: An end stop may relate either to the actuator or to the contact element.

2.4 Operation of control switches

2.4.1 Operation of contactor relays

2.4.1.1

e-delay

<contact element> a delay in the operation of a contact element of a contactor relay, following the energization of the coil of the electromagnet of this contactor relay

EXAMPLE: Delay to close make-contacts (ON delay).

Note 1 to entry: The terms 'e-delay' and 'd-delay' may be applied to any kind of contact elements (see 2.3.3).

2.4.1.2

d-delay

<contact element> a delay in the operation of a contact element of a contactor relay, following the de-energization of the coil of the electromagnet of this contactor relay

EXAMPLE: Delay to open make-contacts (OFF delay)

Note 1 to entry: The terms 'e-delay' and 'd-delay' may be applied to any kind of contact elements (see 2.3.3).

2.4.1.3

fixed delay

<contact element> a delay in the operation of a contact element of a contactor relay, which is not intended to be adjusted in value

2.4.1.4

adjustable delay

<contact element> a delay in the operation of a contact element of a contactor relay, which is intended to be adjusted to different values after the installation of the contactor relay

2.4.2 Operation of pilot switches

2.4.2.1

actuating quantity

the physical quantity, the value of which is decisive for the actuation or non-actuation of a pilot switch

2.4.2.2**operating value**

the value of the actuating quantity which is sufficient to cause a pilot switch to be actuated

2.4.2.3**return value**

the value of the actuating quantity which has to be re-established in order to cause an actuated pilot switch to return to its position of rest

2.4.2.4**differential value**

the difference between the operating value and the return value

2.4.3 Operation of rotary switches**2.4.3.1****definite position** (of a rotary switch)

a position into which the locating mechanism pulls the rotary switch and retains it as long as the actuating moment does not exceed a certain value

2.4.3.2**position of rest**

a stable (definite) position into which the locating mechanism tends to move back and retain the rotary switch by stored energy

2.4.3.3**transit position**

a (definite) position in which the locating mechanism produces an intended marked change in the operating moment, but in which the actuator cannot remain by itself

2.4.3.4**biased position**

a (definite) position of a rotary switch in which the actuator is pulled against a stop from which it will return to a position of rest by means of stored energy (for example, by means of a spring)

Note 1 to entry: During the transfer from a biased position to the adjacent position of rest, the rotary switch may pass through one or more transit positions.

2.4.3.5**latched position**

a biased position in which the return mechanism is held by a latching arrangement

Note 1 to entry: The latching arrangement may be released manually or otherwise.

2.4.3.6**locked position**

a (definite) position in which a rotary switch is secured by separate action

Note 1 to entry: The locking may be obtained by turning a key, operating a lever, etc.

2.4.3.7**operating diagram**

the representation of the intended order in which the contact elements of a rotary switch operate as a result of actuation

2.4.4 Operation of mechanically operated control switches

2.4.4.1

pre-travel of the actuator

the maximum travel of the actuator which causes no travel of the contact elements

Note 1 to entry: See Dimension *a* on Figure 2.

2.4.4.2

over-travel of the actuator

the travel of the actuator after all the contacts have reached their closed (open) position

2.4.4.3

direct drive

a connection between actuator and contact element that excludes any pre-travel of the actuator

2.4.4.4

positive drive

a connection between actuator and contact element such that the force applied to the actuator is directly transmitted to the contact element

2.4.4.5

limited drive

a connection between actuator and contact element that limits the force transmitted to the contact element

2.4.4.6

minimum starting force

minimum starting moment

the smallest value of force (or moment) initiating the pre-travel of the actuator

2.4.4.7

minimum actuating force

minimum actuating moment

the minimum value of the force (or moment) to be applied to the actuator that will cause all contacts to reach their closed (open) position

2.4.4.8

pre-travel of the contact element

the relative movement which occurs within the contact element before the contacts make (break)

Note 1 to entry: See Dimension *b* on Figure 2.

2.4.4.9

over-travel of the contact element (dimension *d* on Figure 2)

the relative movement which occurs within the contact element after the contacts have reached the make (break) position

Note 1 to entry: See Dimension *d* on Figure 2.

2.4.4.10

bounce time

for a contact which is closing/opening its circuit, time interval between the instant when the contact circuit first closes/opens and the instant when the circuit is finally closed/opened

[SOURCE: IEC 60050-444:2002, 444-05-04, modified – Figure 1 deleted]

3 Classification

3.1 Contact elements

Contact elements may be classified as follows:

- a) Utilization categories (see 4.4).
- b) Electrical ratings based on utilization categories (see Annex A).
- c) One of the following form letters (see Figure 4):
 - 1) Form A – Single gap make-contact element;
 - 2) Form B – Single gap break-contact element;
 - 3) Form C – Single gap make-break three terminal change-over contact element;
 - 4) Form X – Double gap make-contact element;
 - 5) Form Y – Double gap break-contact element;
 - 6) Form Z – Double gap make-break four terminal change-over contact element.
- d) Other types not included in c).

NOTE 1 Regarding Figure 4e). the two moving contact elements are electrically separated (see 2.3.3.7).

NOTE 2 Distinction is made between make before break (overlap) change-over contact elements where the two circuits are both closed for a part of the travel of the moving contacts from one position to the other, and break before make (non-overlap) change-over contact elements where the two circuits are both open for a part of the travel of the moving contacts from one position to the other. Unless otherwise stated, change-over contact elements are break before make.

3.2 Control switches

Control switches may be classified according to the contact element and the nature of the actuating system, e.g. push-buttons, form X.

3.3 Control circuit devices

Control circuit devices may be classified according to the control switch and the associated control circuit equipment, e.g. push-buttons plus indicator lights.

3.4 Time delay switching elements

Distinction is made according to how the time delay of a switching element is achieved, e.g. electrical delay, magnetic delay, mechanical delay, or pneumatic delay.

3.5 Control switch mounting

The control switch mounting may be classified by the mounting hole size, e.g. D12, D16, D22, D30 (see 6.3.1).

4 Characteristics

4.1 Summary of characteristics

4.1.1 General

The characteristics of control circuit devices and switching elements should be stated in the following terms, where such terms are applicable:

- type of equipment (see 4.2);
- rated and limiting values for switching elements (see 4.3);
- utilization categories of switching elements (see 4.4);

- normal and abnormal load characteristics (see 4.3.6).

4.1.2 Operation of a control switch

The principal application of a control switch is the switching of loads as indicated for the various utilization categories in Table 1.

Other applications, e.g. the switching of tungsten filament lamps, small motors, etc., are not dealt with in detail in this standard, but are mentioned in 4.3.6.2.

4.1.2.1 Normal conditions of use

The normal use of a control switch is to close, maintain and open circuits in accordance with the utilization category shown in Table 1. Also refer to Table 4.

4.1.2.2 Abnormal conditions of use

Abnormal conditions may arise, for example, when an electromagnet, although energized, has failed to close. Refer to Table 5.

A control switch shall be able to break the current corresponding to such conditions of use.

4.2 Type of control circuit device or switching element

4.2.1 Kind of control circuit device

The kind of control circuit device shall be stated:

- manual control switches, e.g. push-buttons, rotary switches, foot switches, etc.;
- electromagnetically operated control switches, either time delayed or instantaneous, e.g. contactor relays;
- pilot switches, e.g. pressure switches, temperature sensitive switches (thermostats), programmers, etc.;
- position switches;
- associated control equipment, e.g. indicator lights, etc.

4.2.2 Kind of switching elements

The kind of switching elements shall be stated:

- auxiliary contacts of a switching device (e.g. contactor, circuit breaker, etc.) which are not dedicated exclusively for use with the coil of that device;
- interlocking contacts of enclosure doors;
- control circuit contacts of rotary switches;
- control circuit contacts of overload relays.

4.2.3 Number of poles

The number of poles shall be stated.

4.2.4 Kind of current

The kind of current shall be stated:

Alternating current or direct current.

4.2.5 Interrupting medium

The interrupting medium shall be stated:

Air, oil, gas, vacuum, etc.

4.2.6 Operating conditions

4.2.6.1 Method of operation

The method of operation shall be stated:

Manual, electromagnetic, pneumatic, electro-pneumatic.

4.2.6.2 Method of control

The method of control shall be stated:

- automatic;
- non-automatic;
- semi-automatic.

4.3 Rated and limiting values for switching elements

4.3.1 General

The rated values established for the switching elements of a control circuit device shall be stated in accordance with 4.3.2 to 4.3.6 inclusive but it is not necessary to specify all the values listed.

4.3.2 Rated voltages (of a switching element)

4.3.2.1 General

A switching element is defined by the rated voltages described in 4.3.2.2 to 4.3.2.4.

4.3.2.2 Rated operational voltage (U_e)

Subclause 4.3.1.1 of IEC 60947-1:2007 applies with the following additions:

For three-phase circuits, U_e is stated as r.m.s. voltage between phases.

NOTE A switching elements can be assigned a number of combinations of rated operational voltage and rated operational current.

Control switches dealt with in this standard are not normally intended to be used at very low voltages and they may not be suitable for such a service. It is therefore recommended to seek the advice of the manufacturer concerning any application with a low value of operational voltage, e.g. below 100 V a.c. or d.c.

4.3.2.3 Rated insulation voltage (U_i)

Subclause 4.3.1.2 of IEC 60947-1:2007 applies.

4.3.2.4 Rated impulse withstand voltage (U_{imp})

Subclause 4.3.1.3 of IEC 60947-1:2007 applies.

4.3.3 Currents

A switching element is characterized by the currents described in 4.3.3.1 to 4.3.3.3.

4.3.3.1 Conventional free air thermal current (I_{th})

Subclause 4.3.2.1 of IEC 60947-1:2007 applies.

4.3.3.2 Conventional enclosed thermal current (I_{the})

Subclause 4.3.2.2 of IEC 60947-1:2007 applies.

4.3.3.3 Rated operational current (I_e)

The first paragraph of 4.3.2.3 of IEC 60947-1:2007 applies.

4.3.4 Rated frequency

Subclause 4.3.3 of IEC 60947-1:2007 applies.

4.3.5 Vacant

4.3.6 Normal and abnormal load characteristics

4.3.6.1 Rated making and breaking capacities and behaviour of switching elements under normal conditions

A switching element shall comply with both requirements given in Table 4 corresponding to the assigned utilization category and the requirements according to the rated operational voltage.

NOTE For a switching element to which a utilization category is assigned, it is not necessary to specify separately a making and breaking capacity.

A switching element designated for the switching of small motors and tungsten filament lamp loads shall be assigned a utilization category given in IEC 60947-4-1 and comply with the appropriate corresponding requirements in that publication.

4.3.6.2 Making and breaking capacities under abnormal conditions

A switching element shall comply with the requirements given in Table 5 corresponding to the assigned utilization category.

NOTE An example of an abnormal condition of use is one where the electromagnet does not operate and the switching elements have to interrupt the making current.

4.3.7 Short-circuit characteristics

4.3.7.1 Rated conditional short-circuit current

Subclause 4.3.6.4 of IEC 60947-1:2007 applies.

4.4 Utilization categories for switching elements

The utilization categories as given in Table 1 are considered standard. Any other types of application shall be based on agreement between manufacturer and user, but information given in the manufacturer's catalogue or tender may constitute such an agreement.

Table 1 – Utilization categories for switching elements

Kind of current	Category	Typical applications
Alternating current	AC-12	Control of resistive loads and solid state loads with isolation by optocouplers
	AC-13	Control of solid state loads with transformer isolation
	AC-14	Control of small electromagnetic loads (≤ 72 VA)
	AC-15	Control of electromagnetic loads (> 72 VA)
Direct current	DC-12	Control of resistive loads and solid state loads with isolation by optocouplers
	DC-13	Control of electromagnets
	DC-14	Control of electromagnetic loads having economy resistors in circuit

4.5 Vacant**4.6 Vacant****4.7 Vacant****4.8 Vacant****4.9 Vacant****4.10 Electrically separated contact elements**

The manufacturer shall state whether the contact elements of a control circuit device are electrically separated or not (see 2.3.3.7). Separated contact elements shall be assumed to be opposite polarity unless otherwise stated by the manufacturer.

4.11 Actuating quantities for pilot switches

The operating value and return value of the actuating quantity are to be determined on uniform rising values and normal falling values of the actuating quantity. Unless otherwise stated, the rate of change shall be regular and such that the operating (or return) value is reached in not less than 10 s.

The operating value and the return value may both be fixed values, or one of them or both may be adjustable (or the differential value may be adjustable).

Where appropriate, the manufacturer shall indicate a withstand value, either a maximum value higher than the highest setting of the operating value or a minimum value lower than the lowest setting of the return value. A withstand value implies no damage to the pilot switch or no change in its characteristics.

4.12 Pilot switches having two or more contact elements

Pilot switches having two or more contact elements which are not individually adjustable may have different operating and return values for each contact element.

A pilot switch having two or more contact elements which are individually adjusted is considered as a combination of pilot switches.

5 Product information**5.1 Nature of information**

The following information shall be given by the manufacturer:

Identification

- a) The manufacturer's name or trade mark.
- b) A type designation or serial number that makes it possible to get the relevant information concerning the switching element (or the entire control switch) from the manufacturer or from his catalogue or by selection from Annex A.
- c) IEC 60947-5-1 if the manufacturer claims compliance with this standard.

Basic rated values and utilization

- d) Rated operational voltages (see 4.3.2.2).
- e) Utilization category and rated operational currents at the rated operational voltages of the control circuit device.
- f) Rated insulation voltage (see 4.3.2.3).
- g) Rated impulse withstand voltage (see 4.3.2.4).
- h) Vacant.
- i) IP code, in case of an enclosed control circuit device (see 5.1 and Annex C of IEC 60947-1:2007/AMD1:2010).
- j) Pollution degree (see 6.1.3.2).
- k) Type and maximum ratings of short-circuit protective device (see 8.3.4.3).
- l) Conditional short-circuit current.
- m) Suitability for isolation, where applicable, with the symbol S00288 of IEC 60617.
- n) Indication of contact elements of same polarity.
- o) Length of insulation to be removed before insertion of the conductor into the terminal.
- p) For non-universal screwless terminals:
 - "s" or "sol" for terminals declared for rigid-solid conductors;
 - "r" for terminals declared for rigid (solid and stranded) conductors;
 - "f" for terminals declared for flexible conductors.

5.2 Marking

5.2.1 General

Marking of data under a) and b) of 5.1 is mandatory on the nameplate of the control circuit device in order to permit the complete information to be obtained from the manufacturer.

Marking of data under n) of 5.1 shall be included on the nameplate of the control circuit device in order to ensure proper wiring at installation.

Marking shall be indelible and easily legible, and shall not be placed on screws and removable washers.

Whenever space permits, data under c) to m) and o) of 5.1 shall be included on the nameplate, or on the control circuit device or otherwise in the manufacturer's published literature.

The indication "s", "sol", "r" or "f" for non-universal screwless terminals shall be marked on the device or, if the space available is not sufficient, on the smallest package unit or in technical information provided with the product.

5.2.2 Terminal identification and marking

Subclause 7.1.8.4 of IEC 60947-1:2007 applies, with the additional requirements stated in Annex M.

5.2.3 Functional markings

Actuators may be identified by symbols in the form of engravings. If a stop-button carries any symbol engraved or marked on the actuator, then this symbol shall be a circle or an oval (signifying the value zero). The symbols circle or oval shall be used for stop-buttons only.

Letters or words may be used where the space available is sufficient to ensure a clear identification. In all other cases, identification markings shall be placed on permanent labels surrounding each actuator or closely adjacent to it.

Symbols shall be in accordance with IEC 60417.

5.2.4 Emergency stop

Actuator shape and colour, background colour and direction of unlatching for emergency stop devices with mechanical latching function shall be in accordance with 4.2 of IEC 60947-5-1:1997/AMD2:2016.

5.2.5 Operating diagram

5.2.5.1 General

As rotary switches may have a multiplicity of contact elements and a multiplicity of actuator positions, it is necessary that the manufacturer indicates the relationship between the actuator positions and the associated contact element positions.

It is recommended that the relationship be given in the form of an operating diagram, examples of which are shown in Figure 1 together with explanatory notes.

5.2.5.2 Position indication and contact position

Subclause 7.1.6.1 of IEC 60947-1:2007/AMD1:2010 applies with the following addition:

The position indication shall be clear, and the associated text or symbols shall be indelible and easily legible.

5.2.5.3 Terminal markings for operating diagrams

Terminal markings shall be clearly identifiable with respect to the operating diagram. See also Annex M.

5.2.6 Time delay markings

For time-delay contactor relays, the markings shall include the value of the time delay in the case of a fixed delay and the range of time delay in the case of an adjustable delay.

In the case of more than one time-delay contact element, the relative delay between the operation of each contact element and the following one may be indicated for contact elements that follow the first delay.

If two or more contact elements have adjustable delays, it shall be indicated whether they are individually adjustable or not.

The manufacturer shall indicate, for each time-delay contact element, the characteristics of the delay, according to 2.4.1.1 or 2.4.1.2.

5.3 Instructions for installation, operation and maintenance

Subclause 5.3 of IEC 60947-1:2007/AMD1:2010/AMD2:2014 applies.

5.4 Additional information

Additional information necessary for certain types of control circuit devices shall appear according to the relevant rules of the appropriate Annexes J and K.

Such additional information shall be supplied by the manufacturer and may be in the form of a wiring diagram or in the instruction sheet supplied with the control circuit device.

6 Normal service, mounting and transport conditions

Clause 6 of IEC 60947-1:2007/AMD1:2010/AMD2:2014 applies with the following additions:

6.1.3.2 Pollution degree

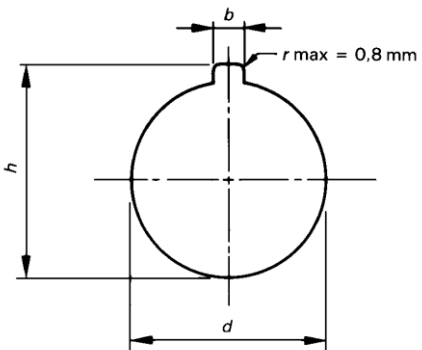
Unless otherwise stated by the manufacturer, a control circuit device is intended for installation under environmental conditions of pollution degree 3. However, other pollution degrees may apply, depending upon the micro-environment.

6.3.1 Mounting of single hole mounted devices

The single hole mounted push-buttons and indicator lights are located in a circular hole of the panel, which may have a rectangular recess for a key.

The dimensions are indicated in Table 2:

Table 2 – Mounting hole diameter and dimensions of the key recess (if any)

	Size	Mounting hole diameter, d mm	Key recess (if any)	
			Height, h mm	Width, b mm
	D30	$30,5^{+0,5}_0$	$33,0^{+0,5}_0$	$4,8^{+0,2}_0$
	D22	$22,3^{+0,4}_0$	$24,1^{+0,4}_0$	$3,2^{+0,2}_0$
	D16	$16,2^{+0,2}_0$	$17,9^{+0,2}_0$	$1,7^{+0,2}_0$
	D12	$12,1^{+0,2}_0$	$13,8^{+0,2}_0$	$1,7^{+0,2}_0$

6.3.1.1 Location of the key recess (if any)

The standardized position of the key is in the up position (12 o'clock) and associated with the b dimension in Table 3.

6.3.1.2 Range of panel thickness

The device, with or without the sealing gasket indicated by the manufacturer, shall be capable of being mounted on any thickness of panel between 1 mm and 6 mm, if necessary by the use of packing piece(s) supplied for the purpose.

NOTE The sealing gasket is not standardized.

6.3.1.3 Grouping of devices

When a number of devices of the sizes given in 6.3.1 are mounted in rows on a panel, the distances a between the mounting centres in the same row and b between the centre lines of the rows shall be not less than those given in Table 3, unless otherwise stated by the manufacturer.

**Table 3 – Preferred minimum distances
between centres of mounting holes**

Size	a mm	b mm
D30	50	65
D22	30	50
D16	25	25
D12	20	20

Distances a and b may be interchanged.

These values are intended to guide development; however, when it is intended to mount devices of different manufacture, the user shall establish the compatibility of the devices and ensure the clearances and creepage distances are maintained when the devices are installed and connected.

NOTE Depending on design details, connections, labels, etc., some devices can be capable of being mounted at distances less than those given in Table 3 in accordance with the indication of the manufacturer of the devices. On the other hand, certain types of devices can require distances greater than those given in Table 3.

7 Constructional and performance requirements

7.1 Constructional requirements

7.1.1 General

Subclause 7.1 of IEC 60947-1:2007/AMD1:2010/AMD2:2014 applies except for 7.1.2, 7.1.3, 7.1.7, 7.1.9 and 7.1.13, and with the following additions:

7.1.2 Materials

7.1.2.1 General materials requirements

Subclause 7.1.2.1 of IEC 60947-1:2007/AMD1:2010 applies with the following addition:

Special attention shall be called to humidity resisting qualities, and to the necessity to protect certain insulating materials against humidity.

7.1.2.2 of this standard applies instead of 7.1.2.2 of IEC 60947-1:2007/AMD1:2010/AMD2:2014.

7.1.2.2 Glow-wire testing

The suitability of materials used is verified by:

- making tests on the equipment; or
- making tests on sections taken from the equipment; or
- making tests on any parts of identical material having representative thickness;

- d) providing data from the insulating material supplier fulfilling the requirements according to IEC 60695-2-12.

The suitability shall be determined with respect to resistance to abnormal heat and fire. The manufacturer shall indicate which methods, amongst a), b), c) and d) shall be used.

If an identical material having representative cross-sections has already satisfied the requirements of any of the tests of 8.2.1 of IEC 60947-1:2007/AMD1:2010, then those tests need not be repeated.

Tests on equipment shall be made by the glow-wire end-product test of IEC 60695-2-10 and IEC 60695-2-11.

Tests shall be made according to 8.2.1.1.1 of IEC 60947-1:2007/AMD1:2010 with the conditions given in Table 6.

NOTE For parts with a mass lower than 2 g and for small parts, as specified in IEC 60695-2-11, no other test is required.

7.1.2.3 Test based on flammability category

Subclause 7.1.2.3 of IEC 60947-1:2007/AMD1:2010 applies.

7.1.3 Current-carrying parts and their connections

Current-carrying parts shall have the necessary mechanical strength and current-carrying capacity for their intended use.

For electrical connections, no contact pressure shall be transmitted through insulating material other than ceramic or other material with characteristics not less suitable, unless there is sufficient resiliency in the metallic parts to compensate for any possible shrinkage or yielding of the insulation material.

7.1.4 Clearances and creepage distances

Subclause 7.1.4 of IEC 60947-1:2007/AMD2:2014 applies.

7.1.5.3 Actuating force (or moment)

The force (or moment) required to operate the actuator shall be compatible with the intended application, taking into account the size of the actuator, the type of enclosure or panel, the environment of the installation and the use for which it is intended.

7.1.5.4 Limitation of rotation (of a rotary switch)

When actuators with limited or unidirectional movement are used, they shall be fitted with robust means of limitation, capable of withstanding five times the actual maximum actuating moment.

7.1.5.5 Emergency stop

The actuator shall preferably latch in the actuated position with the control contact open. This latching shall be released by a separate action, e.g. by pulling, rotation, or by means of a key.

NOTE Additional requirements for emergency stop devices with a latching function are given in IEC 60947-5-5.

7.1.7 Conditions for control switches suitable for isolation

A control switch suitable for isolation shall be manually operated with a direct opening action (see Annex K) and shall comply with the isolating function in the open position (see 2.1.19 and 7.1.7 of IEC 60947-1:2007/AMD1:2010/AMD2:2014).

The open position of a control switch suitable for isolation shall be a position in which the switch can remain when no actuating force is applied.

In order to avoid unintentional reclosing, it shall be possible to prevent the operation of the control switches suitable for isolation when the contact elements are in the open position. This may be obtained by padlocking or by a latch which shall only be releasable by a special tool or key.

7.1.8 Terminals

The requirements of this subclause shall be verified by the tests of 8.2.4 of this standard.

7.1.14 Class II control circuit devices

These devices shall not be provided with means for protective earthing (see IEC 61140).

For class II control circuit devices insulated by encapsulation, see Annex F.

7.1.15 Requirements for control devices with integrally connected cables

See Annex G.

7.2 Performance requirements

Subclauses 7.2.1.1 and 7.2.2 of IEC 60947-1:2007/AMD1:2010/AMD2:2014 apply with the following additions:

7.2.1.2 Limits of operation of contactor relays

The limits of operation for contactor relays shall be in accordance with IEC 60947-4-1.

7.2.3 Dielectric properties

Subclause 7.2.3 of IEC 60947-1:2007/AMD1:2010/AMD2:2014 applies with the following addition.

For Class II control circuit devices insulated by encapsulation, see Annex F.

7.2.4 Ability to make and break under normal and abnormal load conditions

7.2.4.1 Making and breaking capacities

a) *Making and breaking capacities under normal conditions*

The switching elements shall be capable of making and breaking currents without failure under the conditions stated in Table 4, for the required utilization categories and the number of operating cycles indicated, under the conditions specified in 8.3.3.5.3.

NOTE In the United States of America and in Canada it is established that the switching elements are capable of making and breaking currents without failure under the conditions stated for the electrical ratings based on utilization categories (e.g. A600) stated in Table A.1 in Annex A. See Federal regulations and product standards.

b) *Making and breaking capacities under abnormal conditions*

The switching elements shall be capable of making and breaking currents without failure under the conditions according to 8.3.3.5.4 and stated in Table 5, for the required utilization categories and the number of operating cycles specified in Table 5.

7.2.4.2 Vacant

7.2.4.3 Durability

Subclause 7.2.4.3 of IEC 60947-1:2007/AMD1:2010 applies with the following additions:

a) Mechanical durability

The mechanical durability of a control circuit device is verified, when needed, by a special test conducted at the discretion of the manufacturer. Instructions for conducting this test are given in Annex C.

b) Electrical durability

The electrical durability of a control circuit device is verified, when needed, by a special test conducted at the discretion of the manufacturer. Instructions for conducting this test are given in Annex C.

7.2.5 Conditional short-circuit current

The switching element shall withstand the stresses resulting from short-circuit currents under the conditions specified in 8.3.4.

7.2.6 Vacant

7.2.7 Additional requirements for control switches suitable for isolation

Control switches suitable for isolation shall be tested according to 8.3.3.4 of IEC 60947-1:2007/AMD1:2010/AMD2:2014 with a value of test voltage as specified in Table 14 of IEC 60947-1:2007 corresponding to the rated impulse withstand voltage U_{imp} declared by the manufacturer.

Other additional requirements applicable to such control switches are under consideration.

7.2.8 Maximum recovery time

For equipment incorporating electronic circuits the maximum recovery time and the measuring method shall be stated by the manufacturer.

7.3 Electromagnetic compatibility (EMC)

7.3.1 General

Subclause 7.3.1 of IEC 60947-1:2007/AMD1:2010 applies with the following additions:

The control circuit device to be tested shall have all the essential design details of the type which it represents and shall be in a clean and new condition.

The EMC tests shall be conducted at rated operational voltage U_e , or if the rated operational voltage is given as a range, then the test shall be conducted at a voltage which represents the worst case condition.

Maintenance or replacement of parts during or after a testing cycle is not permitted.

Generally two environments A and B are defined. The products covered by this standard are intended for use in environment A.

Contactor relays incorporating electronic circuits shall follow the requirements of 8.3.2.2 of IEC 60947-4-1:2009.

7.3.2 Immunity

7.3.2.1 Equipment not incorporating electronic circuits

Subclause 7.3.2.1 of IEC 60947-1:2007 applies.

7.3.2.2 Equipment incorporating electronic circuits

Subclause 7.3.2.2 of IEC 60947-1:2007/AMD1:2010 applies.

Tests shall be made according to 8.4.

7.3.2.3 Acceptance criteria

Table 7 gives acceptance criteria.

7.3.2.4 Electrostatic discharges

Requirements are stated in IEC 61000-4-2 and Table 8.

7.3.2.5 Radiated radio-frequency electromagnetic fields

Requirements are stated in IEC 61000-4-3 and Table 8.

If the worst case direction is known, then the test need only be performed in that direction. Otherwise, the electromagnetic field shall be facing to the device under test in three mutually perpendicular directions.

7.3.2.6 Electrical fast transients/bursts

Requirements are stated in IEC 61000-4-4 and Table 8.

7.3.2.7 Surges

Requirements are stated in IEC 61000-4-5 and Table 8.

7.3.2.8 Conducted disturbances induced by radio-frequency fields

Requirements are stated in IEC 61000-4-6 and Table 8.

7.3.2.9 Power-frequency magnetic fields

Requirements are stated in IEC 61000-4-8 and Table 8.

7.3.2.10 Voltage dips and interruptions

Requirements are stated in IEC 61000-4-11 and Table 8.

7.3.2.11 Harmonics in the supply

Requirements are stated in IEC 61000-4-13 and Table 8.

7.3.3 Emission

7.3.3.1 Equipment not incorporating electronic circuits

Subclause 7.3.3.1 of IEC 60947-1:2007/AMD1:2010/AMD2:2014 applies.

7.3.3.2 Equipment incorporating electronic circuits

7.3.3.2.1 Limits for high-frequency emissions

Control circuit devices including electronic circuits can generate continuous electromagnetic disturbances.

Such emissions shall not exceed the limits given in CISPR 11 for environment A. These tests are only required when the control and/or auxiliary circuits contain components with fundamental switching frequencies greater than 9 kHz.

7.3.3.2.2 Limits for low-frequency emissions

Subclause 7.3.3.2.2 of IEC 60947-1:2007/AMD1:2010 applies.

NOTE These requirements are not applicable for devices that will not be connected to public mains.

7.3.3.2.3 Conditions during measurement

Each measurement shall be performed in defined and reproducible conditions.

Descriptions of the tests, test methods and set-ups are given in CISPR 11. Nevertheless, some modifications or additional information needed for the practical application of the tests are given in this standard.

Control circuit devices which are intended to be powered by public mains supply, therefore within the scope of IEC 61000-3-2 and IEC 61000-3-3, regarding low-frequency emission shall also comply with the requirements of these standards.

Table 4 – Verification of making and breaking capacities of switching elements under normal conditions corresponding to the utilization categories

Utilization category	Make ^a			Break ^a			Minimum on-time	Sequence, number and rate of operations			
	I/I_e	U/U_e		I/I_e	U/U_e						
AC			$\cos \varphi$			$\cos \varphi$	Cycles (at 50 Hz or 60 Hz)	Order No. ^{d, e}			
								1	2	3	4
AC-12	1	1	0,9	1	1	0,9	2	50	10	990	5 000
AC-13	2	1	0,65	1	1	0,65	2 ^b				
AC-14	6	1	0,3	1	1	0,3	2 ^b				
AC-15	10	1	0,3	1	1	0,3	2 ^b				
DC			$T_{0,95}$ ms			$T_{0,95}$ ms	Time ms				
DC-12	1	1	1	1	1	1	25	50	10	990	5 000
DC-13	1	1	$6 \times P^c$	1	1	$6 \times P^c$	$T_{0,95}$				
DC-14	10	1	15	1	1	15	25 ^b				
I_eRated operational current U_eRated operational voltage $P = U_e \times I_e$Steady-state power consumption, in W ICurrent to be made or broken UVoltage before make $T_{0,95}$Time to reach 95 % of the steady-state current											
NOTE For the objective of the test see 8.3.3.5.3.											
a For tolerances on test quantities, see 8.3.2.2. b Both on-time values (for I_{make} and for I_{break}) shall be at least equal to 2 cycles (or 25 ms for DC-14). c The value "$6 \times P$" results from an empirical relationship which is found to represent most d.c. magnetic loads to an upper limit of $P = 50$ W, i.e. $6 \times P = 300$ ms. Loads having power consumption greater than 50 W are assumed to consist of smaller loads in parallel. Therefore, 300 ms is to be an upper value, irrespective of the power. For semiconductor switching devices the maximum time constant shall be 60 ms, i.e. $T_{0,95} = 180$ ms ($3 \times$ time constant). d For all utilization categories the test sequence shall be in the order given. e The rate for the test shall be: For Order No.1: 6 operating cycles per minute, which shall be made with the test voltage raised to $U_e \times 1,1$, the test current I_e having been first set with the voltage at U_e. For Order No.2: as rapidly as possible whilst ensuring complete closing and opening of contacts. For Order No.3: 60 operating cycles per minute. For Order No.4: 6 operating cycles per minute.											

Table 5 – Verification of making and breaking capacities of switching elements under abnormal conditions corresponding to the utilization categories

Utilization category	Make ^a			Break ^a			Minimum on-time	Making and breaking operation	
	I/I_e	U/U_e		I/I_e	U/U_e			Number	Rate per minute
AC			$\cos \varphi$			$\cos \varphi$	Cycles (at 50 Hz or 60 Hz)		
AC-12	–	–	–	–	–	–	–	–	–
AC-13 ^b	10	1,1	0,65	1,1	1,1	0,65	2 ^c	10	6
AC-14	6	1,1	0,7	6	1,1	0,7	2	10	6
AC-15	10	1,1	0,3	10	1,1	0,3	2	10	6
DC			$T_{0,95}$ ms			$T_{0,95}$ ms	Time ms		
DC-12	–	–	–	–	–	–	–	–	–
DC-13 ^d	–	–	–	–	–	–	–	–	–
DC-14	10	1,1	15	10	1,1	15	25 ^c	10	6
I_e Rated operational current U_e Rated operational voltage $P = U_e \times I_e$ Steady-state power consumption, in W									
I Current to be made or broken U Voltage before make $T_{0,95}$ Time to reach 95 % of the steady-state current									
NOTE The abnormal condition is to simulate a blocked open electromagnet. See 8.3.3.5.4.									
^a For tolerances on test quantities, see 8.3.2.2. ^b For semiconductor switching devices an overload protective device specified by the manufacturer should be used to verify the abnormal conditions. ^c Both on-time values (for I_{make} and for I_{break}) shall be at least equal to 2 cycles (or 25 ms for DC-14). ^d The test for DC-13 under abnormal conditions is covered by the test under normal conditions.									

Table 6 – Test conditions for glow-wire test

Part under test	Test condition
Part with a mass lower than 2 g (see 3.14 of IEC 60695-2-11:2014)	Test is not required ^a
Part which is a small part according to 3.15 of IEC 60695-2-11:2014	Test is not required ^a
Part which retains current-carrying parts in position	Glow-wire test at a temperature of 750 °C
All other parts	Glow-wire test at a temperature of 650 °C ^b
^a Alternative tests do not have to be conducted. ^b Glow wire temperature can be reduced to 550 °C if it can be demonstrated that the residual risk of fire is acceptable.	

Table 7 – Acceptance criteria

Item	Acceptance criteria (performance criteria during tests)		
	A	B	C
Overall performance	No noticeable changes of the operating characteristic. Operating as intended ^a	Temporary degradation or loss of performance which is self-recoverable ^b	Temporary degradation or loss of performance which requires operator intervention or system reset.
Operation of displays and signalling components	No changes to visible display information. Only slight light or sound intensity fluctuation of the optical or audible signal source, or slight movement of characters or slight change of frequency of the audible signal source.	Temporary visible changes or loss of information. Undesired optical or audible signal.	Shut down, permanent loss of display or wrong information. Unpermitted operating mode. Not self-recoverable.
Information processing and sensing functions	Undisturbed communication and data interchange to external devices remains within the specification.	Temporarily disturbed communication, which is detected and is self-recoverable.	Erroneous processing of information. Undetected loss of data and/or information. Errors in communication. Not self-recoverable.
^a The manufacturer shall state in his literature the operating frequency and bandwidth where conducted radio frequencies may cause malfunction. ^b The recovery time shall not exceed the maximum time which can be measured when the device is started by power-on at the power supply terminals (maximum recovery time, see 7.2.8).			

Table 8 – Immunity tests

Type of test	Basic standard	Test level required		Acceptance criteria
Electrostatic discharge immunity test	IEC 61000-4-2	8 kV / air discharge or 4 kV / contact discharge		B ^k
Radiated radio-frequency electromagnetic field immunity test 80 MHz to 1 GHz	IEC 61000-4-3	10 V/m		A
Radiated radio-frequency electromagnetic field immunity test 1,4 GHz to 2 GHz	IEC 61000-4-3	3 V/m		A
Radiated radio-frequency electromagnetic field immunity test 2 GHz to 2,7 GHz	IEC 61000-4-3	1 V/m		A
Electrical fast transient/burst immunity test (with capacitive coupling clamp)	IEC 61000-4-4	2 kV / 5 kHz on power ports ^a 1 kV / 5 kHz on signal ports ^b		B ^k
Surge immunity test (1,2/50 µs - 8/20 µs) ^c	IEC 61000-4-5	2 kV (line to earth) 1 kV (line to line)		B
Conducted disturbances induced by radiofrequency fields immunity test (150 kHz to 80 MHz)	IEC 61000-4-6	10 V		A
Power frequency magnetic field immunity test ^d	IEC 61000-4-8	30 A/m		A
Voltage dips immunity test ^h	IEC 61000-4-11	Class 2 ^{e, f} 0 % during 0,5 cycle	Class 3 ^{e, f} 0 % during 0,5 cycle	B ^{k, l}
		Class 2 ^{e, f} 0 % during 1 cycle	Class 3 ^{e, f} 0 % during 1 cycle	B
		Class 2 ^{e, f, g} 70 % during 25/30 cycles	Class 3 ^{e, f, g} 40 % during 10/12 cycles 70 % during 25/30 cycles 80 % during 250/300 cycles	C
Voltage interruptions immunity test ^h	IEC 61000-4-11	Class 2 ^{e, f, g} 0 % during 250/300 cycles	Class 3 ^{e, f, g} 0 % during 250/300 cycles	C
Immunity to harmonics in the supply	IEC 61000-4-13	No requirements ⁱ		

- ^a Power port: the point at which a conductor or cable carrying the primary electrical power needed for the operation of the electronic circuit or the switching element or associated equipment is connected.
- ^b Signal port: the point at which a conductor or cable carrying information for transferring data or signals is connected to the electronic circuit or the switching element.
- ^c Not applicable for extra-low voltage a.c. ports (≤ 30 V) and extra-low voltage d.c. input/output ports (≤ 60 V), when the secondary circuits (isolated from the a.c. mains) are not subject to transient overvoltages.
- ^d Applicable only to equipment containing devices susceptible to power frequency magnetic fields.
- ^e Class 2 applies to points of common coupling and in-plant points of common coupling in the industrial environment in general.

Class 3 applies to in-plant couplings in industrial environment only. This class should be considered when a major part of the load is fed through converters; welding machines are present; large motors are frequently started or loads vary rapidly.

The manufacturer shall state the applicable class.
- ^f The given percentage means percentage of the rated operational voltage, e.g. 0 % means 0 V.
- ^g The value before the solidus (/) is for 50 Hz and the value behind is for 60 Hz tests.
- ^h Applicable for a.c. equipment only.
- ⁱ Requirements are under study for the future.
- ^k For keeping the functionality at the system level (e.g. automation or process) the state of the switching element shall not change for more than 1 ms for d.c. devices or one half-cycle of supply frequency for a.c. devices.
- ^l For devices with power consumption of more than 750 mW, the recovery time of the switching element may be longer than one half-cycle but shall be less than the maximum recovery time.

8 Tests

8.1 Kinds of test

8.1.1 General

Subclause 8.1.1 of IEC 60947-1:2007 applies.

8.1.2 Type tests

Type tests are intended to verify compliance of the designs of the control circuit devices with this standard.

They comprise the verification of:

- a) temperature-rise (8.3.3.3);
- b) dielectric properties (8.3.3.4);
- c) making and breaking capacities of switching elements under normal conditions (8.3.3.5.3);
- d) making and breaking capacities of switching elements under abnormal conditions (8.3.3.5.4);
- e) performance under conditional short-circuit current (8.3.4);
- f) constructional requirements (8.2);
- g) degree of protection of enclosed control circuit devices (8.3.1).
- h) EMC tests, where applicable (see 8.4).

8.1.3 Routine tests

Routine tests are the responsibility of the manufacturer and are usually limited to a mechanical inspection and a verification of the mechanical operation.

In certain cases specified in Annex F, the inspection is supplemented by a dielectric test.

When performed, the dielectric test is carried out according to 8.3.3.4 with the following amendments: the required minimum duration of voltage application is reduced to about 1 s and the metal foil and external terminal connections are unnecessary.

Additional routine tests for the control switch or the control circuit device may be specified as appropriate. A sampling plan may be accepted.

8.1.4 Sampling tests

Sampling tests shall be performed on time delay devices to verify the time delay or range of time delay as stated by the manufacturer.

NOTE Sampling tests for clearance verification, according to 8.3.3.4.3 of IEC 60947-1:2007 are under consideration.

8.1.5 Special tests

These tests are subject to agreement between manufacturer and user.

They comprise the verification of the durability (see Annex C). In cases where it is necessary to obtain data needed for functional safety applications, tests shall be made according to Annex N.

The mechanical and electrical durability tests shall be performed with the actuator operated by a machine that complies with the requirements of 8.3.2.1.

In cases where it is necessary to verify environmental conditions of damp heat, salt mist, vibration and shock, the tests shall be conducted according to Annex Q of IEC 60947-1:2007/AMD1:2010/AMD2:2014.

The conditioning procedures and the tests shall be conducted in the open position or in the unpowered state where power supply terminals are provided. After the test the device shall comply with the requirements given in 7.2.1.2 or 7.1.5.3.

When auxiliary devices are assembled to a main device their performance shall be tested in conjunction with the main device.

8.2 Compliance with constructional requirements

8.2.1 Materials

8.2.1.1 Test of resistance to abnormal heat and fire

8.2.1.1.1 Glow-wire test (on equipment)

Subclause 8.2.1.1.1 of IEC 60947-1:2007 applies with the following addition:

The conditions specified in 7.1.2.2 of this document and Table 6 applies.

8.2.1.1.2 Flammability, hot wire ignition and arc ignition tests (on materials)

Subclause 8.2.1.1.2 of IEC 60947-1:2007 applies.

8.2.2 Equipment

Subclause 8.2.2 of IEC 60947-1:2007 applies.

8.2.3 Enclosures for equipment

Subclause 8.2.3 of IEC 60947-1:2007 applies.

8.2.4 Mechanical and electrical properties of terminals

8.2.4.1 General conditions for tests

Subclause 8.2.4.1 of IEC 60947-1:2007/AMD2:2014 applies.

8.2.4.2 Tests of mechanical strength of terminals

Subclause 8.2.4.2 of IEC 60947-1:2007/ AMD1:2010 applies.

8.2.4.3 Testing for damage to and accidental loosening of conductors (flexion test)

Subclause 8.2.4.3 of IEC 60947-1:2007/AMD1:2010 applies.

8.2.4.4 Pull-out test

Subclause 8.2.4.4 of IEC 60947-1:2007/AMD1:2010 applies.

8.2.4.5 Test for insertability of unprepared round copper conductors having the maximum cross-section

Subclause 8.2.4.5 of IEC 60947-1:2007/AMD1:2010 applies.

8.2.4.7 Electrical performance of screwless-type clamping units

If terminals are used which are qualified according to IEC 60999-1 and the operating conditions of the terminals in the device are according to the operating conditions specified by the manufacturer of the terminals, then the test does not need to be performed.

NOTE 1 See Figure D.8 of IEC 60947-1:2007/AMD1:2010 for an explanation of the parts of a connecting device.

Subclause 8.2.4.7 of IEC 60947-1:2007/AMD1:2010/AMD2:2014 applies with the following changes:

- The test shall be done on the connecting device equipped with the clamping units;
- The number of specimens shall be at least 8;
- The test shall be done as a single 8 test:
 - Eight clamping units shall be tested to the declared voltage drop;
 - If the number of failed clamping units does not exceed two, the test is considered passed.

NOTE 2 See C.1.2.2 for a description of the single 8 test.

The insertion and disconnection of the conductors shall be made in accordance with the manufacturer's instructions.

A suitable test arrangement is shown in Figure 10. If the measurement points cannot be positioned within 10 mm of the point of contact, the voltage difference between the ideal and the actual measuring points shall be deducted from the voltage drop measured. This voltage difference within the part of the conductor shall be determined with a suitable measurement method on one specimen at a stabilised temperature. The measurement methods and the results shall be documented in the test report.

The test current applied shall be according to Table 9.

The voltage drop shall not exceed 15 mV.

The device sample may be provided with holes or equivalent arrangements which provide measurement access points for the voltage drop on the terminal.

NOTE 3 Usually it is possible to equip products covered by this standard with many different types of wires (stranded, solid, flexible...) which results in a sufficient number of tests for the same terminal.

8.2.4.8 Ageing test for screwless-type clamping units

If terminals are used which are qualified according to IEC 60999-1 and the operating conditions of the terminals in the device are according to the operating conditions specified by the manufacturer of the terminals, then the test does not need to be performed.

Subclause 8.2.4.8 of IEC 60947-1:2007/AMD1:2010/AMD2:2014 applies with the following changes:

The test shall be done on the connecting device equipped with the clamping units.

The test current shall be according to Table 9.

The maximum temperature for the temperature cycles shall be 40°C.

The maximum voltage drop shall not exceed the smaller one of the following two values:

- 22,5 mV, or;
- 1,5 times the value measured after the 24th cycle.

The device sample may be provided with holes or equivalent arrangements which provide measurement access points for the voltage drop on the terminal.

8.2.5 Verification of actuating force (or moment)

When required in 7.1.5.3, the minimum actuating force or moment shall be tested during sequence V of 8.3.1. The performance shall be as stated in 7.1.5.3.

8.2.6 Verification of limitation of rotation (of a rotary switch)

When this test is required in 7.1.5.4, it shall be tested during sequence VI of 8.3.1. The test sample shall be mounted according to the manufacturer's instructions.

The operation moment shall be measured five times and the maximum value recorded. The maximum moment value, multiplied by five, shall be applied to the actuator by forcing it against the means of limitation. The moment shall be applied for 10 s.

The test is passed if the means of limitation has not moved, become loose or prevented the actuator's normal operation.

8.2.7 Conduit pull-out test, torque test and bending test with metallic conduits

Subclause 8.2.7 of IEC 60947-1:2007 applies.

8.3 Performance

8.3.1 Test sequences

The type and sequence of tests to be performed on representative samples are as follows.

- **Test sequence I** (sample No. 1)

- Test No. 1 – Operating limits of contactor relays (8.3.3.2), if applicable
- Test No. 2 – Temperature rise (8.3.3.3)
- Test No. 3 – Dielectric properties (8.3.3.4)
- Test No. 4 – Mechanical and electrical properties of terminals (8.2.4)
- **Test sequence II** (sample No. 2)
 - Test No. 1 – Making and breaking capacities of switching elements under normal conditions (8.3.3.5.3)
 - Test No. 2 – Dielectric verification (8.3.3.5.6 b))
- **Test sequence III** (sample No. 3)
 - Test No. 1 – Making and breaking capacities of switching elements under abnormal conditions (8.3.3.5.4)
 - Test No. 2 – Dielectric verification (8.3.3.5.6 b))
- **Test sequence IV** (sample No. 4)
 - Test No. 1 – Performance under conditional short-circuit current (8.3.4)
 - Test No. 2 – Dielectric verification (8.3.3.5.6 b))
- **Test sequence V** (sample No. 5)
 - Test No. 1 – Degree of protection of enclosed control circuit devices (Annex C of IEC 60947-1:2007/AMD2:2014)
 - Test No. 2 – Verification of actuation force or moment (8.2.5)
- **Test sequence VI** (sample No. 6)
 - Test No. 1 – Measurement of clearances and creepage distances, if applicable (7.1.4 of IEC 60947-1:2007/AMD2:2014)
 - Test No. 2 – Verification of limitation of rotation of a rotary switch (8.2.6).

There shall be no failure in any of the above tests.

More than one test sequence or all test sequences may be conducted on one sample at the request of the manufacturer. However, the tests shall be conducted in the sequence given for each sample above.

For class II control circuit devices insulated by encapsulation, additional samples are required (see Annex F).

For control circuit devices with integrally connected cables, one additional sample is required (see Annex G).

8.3.2 General test conditions

8.3.2.1 General requirements

Subclause 8.3.2.1 of IEC 60947-1:2007/AMD2:2014 applies with the following addition:

The tests shall be performed with the actuator operated by a machine complying with the requirements of 8.3.2.1 a) for linear movement or, for a rotary switch, in accordance with 8.3.2.1 b) or 8.3.2.1 c).

- a) For push-buttons and/or related control switches the operating machine shall apply the actuating force (or moment) to the actuator in the direction of its motion.

The force (or moment) or the travel of the operating machine shall comply with one of the following conditions according to the manufacturer's instructions:

- the maximum force (or moment) exerted on the actuator shall not exceed 1,5 times the force (or moment) required for maximum over-travel of the contact element(s),

- the cover-travel of the contact elements shall be between 50 % and 80 % of the over-travel inherent in the design of the contact elements.

At the moment in time when the switching operation occurs, the velocity of the operating machine, measured where it touches the actuator, shall be between 0,05 m/s and 0,15 m/s unless otherwise declared by the manufacturer in the test report.

The mechanical connection between the operating machine and the actuator shall have a sufficient free play (lost motion) to avoid the operating machine impeding the free motion of the actuator away from it.

- b) For switches fully rotary in both directions, one operating cycle comprises either one fully clockwise operation of the actuator or one fully anticlockwise operation of the actuator. However, in this case approximately three-quarters of the total number of operating cycles shall be made in the clockwise direction, followed by the remainder in the anticlockwise direction. The angular velocity shall be between 0,5 to 1 revolution per second unless otherwise declared by the manufacturer in the test report.
- c) For limited movement rotary switches, operation shall be at a speed of 1 to 4 revolutions per second unless otherwise declared by the manufacturer in the test report.

8.3.2.2 Test quantities

Subclause 8.3.2.2 of IEC 60947-1:2007/AMD2:2014 applies except for 8.3.2.2.3.

8.3.2.3 Evaluation of test results

The condition of the control circuit device after each test shall be checked by the verifications applicable to each test.

A control circuit device is deemed to have met the requirements of this standard if it meets the requirements of each test and/or test sequence as applicable.

8.3.2.4 Test reports

Subclause 8.3.2.4 of IEC 60947-1:2007 applies.

8.3.3 Performance under no-load, normal load and abnormal load conditions

8.3.3.1 Operation

Subclause 8.3.3.1 of IEC 60947-1:2007 applies.

8.3.3.2 Operating limits of contactor relays

The operating limits of contactor relays shall be in accordance with the standard applicable to contactors (see IEC 60947-4-1).

8.3.3.3 Temperature rise

Subclause 8.3.3.3 of IEC 60947-1:2007/AMD1:2010/AMD2:2014 applies with the following addition:

All switching elements of the control circuit device shall be tested. All switching elements that may be simultaneously closed shall be tested together. However, switching elements forming an integral part of an actuating system in such a manner that the elements cannot remain in the closed position are exempt from this test.

NOTE The fact that a control circuit device can have several positions in which switching elements are in their closed position can lead to the execution of several tests.

The minimum length of each temporary connection, from terminal to terminal, shall be 1 m.