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

IEC 60947-5-1:2016-05 RLV(en)

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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) udpate of EMC requirements;
e) clarification of requirements and update of 8.2;
f) addition of requirements for screwless-type clamping units;
g) udpate 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.

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

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- withdrawn,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

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

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LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

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

1 General

~~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.~~

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 ~~may~~ 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 ~~shall~~ also ~~meet~~ comply with the requirements and tests of IEC 60947-4-1 except for the utilization category which ~~shall~~ 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.

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The colour requirements of indicator lights, push-buttons, etc., are found in IEC 60073 and also in ~~publication 2 of the International~~ 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 60050(441):1984, *International Electrotechnical Vocabulary (IEV) – Chapter 441: Switchgear, controlgear and fuses*~~
~~Amendment 1 (2000)~~

~~IEC 60050(446):1983, *International Electrotechnical Vocabulary (IEV) – Chapter 446: Electrical relays*~~

IEC 60068-2-6:~~1995~~ 2007, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-14:~~1984~~ 2009, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*
~~Amendment 1 (1986)~~

IEC 60068-2-27:~~1987~~ 2008, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

IEC 60068-2-30:~~1980~~ 2005, *Environmental testing – Part 2-30: Tests – Test Db ~~and guidance~~: Damp heat, cyclic (12 h + 12 h cycle)*
~~Amendment 1 (1985)~~

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

~~IEC 60112:2003, *Method for the determination of the proof and the comparative tracking indices of solid insulating materials*~~

~~IEC 60255 (all parts), *Electrical relays*~~

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IEC 60417-DB:2002[1], *Graphical symbols for use on equipment*

IEC 60617 ~~(all parts)~~ DB:2012[2], *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:~~1999~~ 2007, *Low-voltage switchgear and controlgear – Part 1: General rules*
IEC 60947-1:2007/AMD1:~~2000~~ 2010
IEC 60947-1:2007/AMD2:~~2001~~ 2014

IEC 60947-4-1:~~2000~~ 2009, *Low-voltage switchgear and controlgear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters*
IEC 60947-4-1:2009/AMD1:2012

IEC 60947-5-5:1997, *Low-voltage switchgear and controlgear – Part 5-5: Control circuit devices and switching elements – Electrical emergency stop device with mechanical latching function*
IEC 60947-5-5:1997/AMD1:2005
IEC 60947-5-5:1997/AMD2:2016

IEC 60999-1:1999, *Connecting devices – Electrical copper conductors – Safety requirements for screw-type and screwless-type clamping units – Part 1: General requirements and particular requirements for clamping units for conductors from 0,2 mm^2 up to 35 mm^2 (included)*

IEC 61000-3-2, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current < 16 A per phase)*

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*

IEC 61000-4-2:~~1995~~ 2008, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*
~~Amendment 1 (1998)~~
~~Amendment 2 (2000)~~

IEC 61000-4-3:~~2002~~ 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

IEC 61000-4-4:~~1995~~ 2012, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – ~~Section 4:~~ Electrical fast transient/burst immunity test*
~~Amendment 1 (2000)~~
~~Amendment 2 (2001)~~

[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.

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IEC 61000-4-5:~~1995~~ 2014, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*
~~Amendment 1 (2000)~~

IEC 61000-4-6:~~1996~~ 2013, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*
~~Amendment 1 (2000)~~

IEC 61000-4-8:~~1993~~ 2009, *Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test*
~~Amendment 1 (2000)~~

IEC 61000-4-11:~~1994~~ 2004, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests*
~~Amendment 1 (2000)~~

IEC 61000-4-13:2002, *Electromagnetic compatibility (EMC) – Part 4-13: Testing and measurement techniques – Harmonics and interharmonics including mains signalling at a.c. power port, low frequency immunity tests*
IEC 61000-4-13:2002/AMD1:2009
IEC 61000-4-13:2002/AMD2:2015

IEC 61140:~~2001~~ 2015, *Protection against electric shock – Common aspects for installation and equipment*
IEC 61140:2015/AMD1:2004

CISPR 11:~~1997~~ 2015, *Industrial, scientific and medical ~~(ISM) radio-frequency~~ equipment – ~~Electromagnetic~~ Radio-frequency disturbance characteristics – Limits and methods of measurement*
~~Amendment 1 (1999)~~

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.

Alphabetical index of definitions ..... References

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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 ~~may~~ 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: ~~This definition differs from IEV 441-14-46 since~~ 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).

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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)

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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.

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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

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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 ~~(fleeting)~~ 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 ~~(snap)~~ 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

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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).

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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 ~~**(abbreviation: 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

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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

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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
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: ~~IEV 446-17-13~~ 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.

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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).
- ~~switching overvoltages (see 4.9).~~

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

~~The following shall be stated:~~

4.2.1 Kind of control circuit device

The kind of control circuit device shall be stated:

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- 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.

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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 ~~1~~ A switching elements ~~may~~ can be assigned a number of combinations of rated operational voltage and rated operational current.

~~NOTE 2~~ 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 ~~1~~ For a switching element to which a utilization category is assigned, it is not necessary to specify separately a making and breaking capacity.

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~~NOTE 2~~ A switching element ~~used~~ 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

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4.5 Vacant

4.6 Vacant

4.7 Vacant

4.8 Vacant

4.9 ~~Switching overvoltages~~ Vacant

~~Subclause 4.9 of IEC 60947-1 applies.~~

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) ~~Switching overvoltage, if applicable (see 4.9)~~ 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 ~~if less than 1 000 A~~.

m) Suitability for isolation, where applicable, with the symbol ~~07-13-06~~ S00288 of IEC 60617~~-7~~.

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;

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– "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 ~~n)~~ 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

~~Control switch actuators intended to be used as "stop" control for emergency use shall be coloured red and, in the case of a push-button, be of mushroom shape.~~ 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 60947-5-5:1997/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.

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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:

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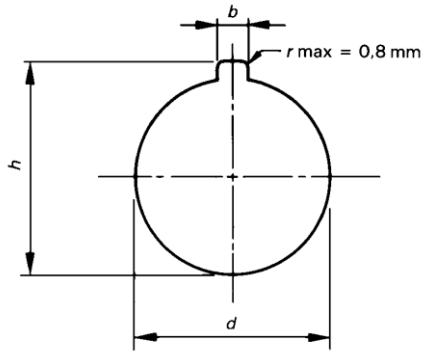
Table 2 – Mounting hole diameter and dimensions of the key recess (if any)



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 ~~may~~ 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

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devices. On the other hand, certain types of devices ~~may~~ 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

~~Materials shall be suitable for the particular application and shall enable the equipment to comply with the relevant test requirements.~~

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

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

~~NOTE Requirements are under consideration.~~

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:

a) making tests on the equipment; or

b) making tests on sections taken from the equipment; or

c) making tests on any parts of identical material having representative thickness; or

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.

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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

~~For control switches for which the manufacturer has declared a value of rated impulse withstand voltage (U_{imp}), minimum values are given in Tables 13 and 15 of IEC 60947-1.~~

~~Control switches for which the manufacturer has not declared a value of U_{imp}, shall have clearances and creepage distances in accordance with Annex D.~~

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.

~~The minimum starting force (or moment) shall be sufficiently large to prevent inadvertent operation; e.g. push-buttons and rotary switches to be used with enclosures complying with degrees of protection IPX5 or IPX6 shall not become actuated when hit by the jet of water applied during the test of the enclosed equipment.~~

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 ~~positive~~ direct opening ~~operation~~ 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.

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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.

~~During this test the overvoltages generated shall not exceed the impulse withstand voltage values stated by the manufacturer (see 7.2.6).~~

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.

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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 ~~Switching overvoltage~~ 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 ~~unless otherwise specified in this standard~~ 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.

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7.3.2.3 Acceptance criteria

Table7 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.

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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 1)

Table 4a

Utilization category	Make 2)			Break 2)			Minimum on-time		Sequence, number and rate of operations		
	I/I_e	U/U_e		I/I_e	U/U_e						
AC			cos φ			cos φ	Cycles (at 50 Hz or 60 Hz)		Order 7)	Number	Rate per minute
AC-12	1	1	0,9	1	1	0,9	2		1	50 4)	6
AC-13	2	1	0,65	1	1	0,65	2 3)		2	10	Rapidly 5)
AC-14	6	1	0,3	1	1	0,3	2 3)		3	990	60
AC-15	10	1	0,3	1	1	0,3	2 3)		4	5 000	6
DC			$T_{0,95}$ ms			$T_{0,95}$ ms	Time ms				
DC-12	1	1	1	1	1	1	25				
DC-13	1	1	$6 \times P$ 6)	1	1	$6 \times P$ 6)	$T_{0,95}$				
DC-14	10	1	15	1	1	15	25 3)				

Table 4b

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

1) See 8.3.3.5.2.

2) For tolerances on test quantities, see 8.3.2.2.

3) 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).

4) The first 50 operating cycles 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.

5) As rapidly as possible whilst ensuring complete closing and opening of contacts.

6) 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.

7) For all utilization categories the test sequence shall be in the order given.

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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 φ			cos φ	**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_e	Rated operational current	I	Current to be made or broken
U_e	Rated operational voltage	U	Voltage before make
$P = U_e \times I_e$	Steady-state power consumption, in W	$T_{0,95}$	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 × 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.

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Table 5 – Verification of making and breaking capacities of switching elements under abnormal conditions corresponding to the utilization categories~~1)~~

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 φ			cos φ	**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~~[c] [d]~~	~~1,1~~ –	~~1,1~~ –	~~$6 \times P$[5)]~~ –	~~1,1~~ –	~~1,1~~ –	~~$6 \times P$[5)]~~ –	~~$T_{0,95}$~~ –	~~10~~ –	~~6~~ –
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).

~~[5)] 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 consumption value.~~

~~For semiconductor switching devices the maximum time constant shall be 60 ms, i.e. $T_{0,95}$ = 180 (3 × time constant).~~

[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.

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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).

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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]		

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[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.

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In certain cases specified in ~~Annexes J and K~~ 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

~~Subclause 8.2 of IEC 60947-1 applies except for 8.2.5 and 8.2.6.~~

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.

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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

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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.

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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 ~~of IEC 60947-1~~)

– **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.

~~NOTE~~ 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).

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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.

~~During the whole part of the operating cycle where the contacts move from the open to closed position (or vice versa) or at least~~ 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:

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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 ~~Several temperature-rise tests may be necessary if the control circuit device has several positions in which switching elements are in their closed position.~~ 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.

8.3.3.4 Dielectric properties

Subclause 8.3.3.4 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.

8.3.3.4.1 Type tests

Subclause 8.3.3.4.1 of IEC 60947-1:2007/AMD1:2010/AMD2:2014 applies with the following addition.

Add, after the second paragraph of 3) c):

The control circuit device shall be capable of withstanding the test voltage applied as follows:

- between live parts of the switching element and parts of the control switch intended to be earthed;
- between live parts of the switching element and surfaces of the control switch likely to be touched in service, conductive or made conductive by a metal foil;
- between live parts belonging to electrically separated switching elements.

8.3.3.5 Making and breaking capacities

8.3.3.5.1 General

Tests for verification of making and breaking capacities shall be made according to the general test requirements stated in 8.3.2.1.

8.3.3.5.2 Test circuits and connections

Tests shall be carried out on a single-pole element or on one pole of a multi-pole device provided that all pole elements are identical in construction and operation.

Adjacent contact elements are considered to be of the opposite polarity unless otherwise stated by the manufacturer.

Change-over contacts of forms C and Za are of the same polarity and change-over contacts of form Zb are of the opposite polarity.

Single-pole elements or contact elements in a multi-pole device stated as the same polarity shall be connected in accordance with the circuit shown in Figure 5. Any adjacent contact elements not being tested shall not be connected.

Change-over contacts of forms C and Za shall be subject to separate tests in the normally open and normally closed positions connected in accordance with Figure 5.

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Contact elements of the opposite polarity shall be connected in accordance with the circuit shown in Figure 6. Adjacent contact elements of the opposite polarity not being tested shall be jointly connected to the supply, as shown.

Change-over contacts of form Zb shall be subject to separate tests in the normally open and normally closed positions but with both terminals of the opposite position being connected to the supply, as shown in Figure 6, for an adjacent contact of opposite polarity.

If the make and break operations require different values, the circuit shown in Figure 7 shall represent load L_d in Figures 5 and 6.

For a.c. tests:

The load shall be an air-cored inductor in series with a resistor, if needed, to obtain the specified power factor. The inductor shall be shunted by a resistor taking 3 % of the total power consumed (see Figure 7).

NOTE In the United States of America and in Canada both air-core loads and iron-core loads are used.

For d.c. tests:

To obtain the specified steady-state current the test current shall increase from zero to the steady-state value within the limits shown in Figure 9. For guidance, an example of an iron-cored load is shown in Annex B.

Test voltage and test current shall be in accordance with Tables 4 and 5. The test circuit applied shall be stated in the test report.

8.3.3.5.3 Making and breaking capacities of switching elements under normal conditions

The tests are intended to verify that the control circuit device is capable of performing its intended duty according to the utilization category.

With the load set in accordance with Table 4, the 6 050 operating cycles shall be carried out in the following sequence:

- 50 operations at 10 s intervals with the voltage set at 1,1 U_e;
- 10 operations as rapidly as possible whilst ensuring complete closing and opening of contacts;
- 990 operations at 1 s intervals;
- 5 000 operations at 10 s intervals (or at a shorter interval determined by the manufacturer).

When the construction of the device is such that rapid cycling is not possible, for example overload relay contacts, the operations shall be at 10 s intervals or as fast as the device will permit.

For auxiliary contacts of a switching device, for example contactor, circuit-breaker, the number of operating cycles shall be the same as that required for the verification of the conventional operational performance capability of the switching device (see appropriate product standard).

8.3.3.5.4 Making and breaking capacities of switching elements under abnormal conditions

The test is intended to verify that the control circuit device is capable of making and breaking currents associated with electromagnetic loads. Load values, together with the sequence of operations shall be in accordance with Table 5.

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8.3.3.5.5 Vacant

8.3.3.5.6 Results to be obtained

The following criteria shall be met entirely:

a) During the tests of 8.3.3.5.3 and 8.3.3.5.4 there shall be no electrical or mechanical failures, no contact welding or prolonged arcing, and the fuses shall not blow.

b) After the test of 8.3.3.5.3 and 8.3.3.5.4 the device shall withstand the power-frequency test voltage of 2 U_e, but not less than 1 000 V, applied as specified in 8.3.3.4.1.

8.3.4 Performance under conditional short-circuit current

8.3.4.1 General conditions for short-circuit tests

The switching element shall be in a new and clean condition, mounted as in service.

8.3.4.2 Test procedure

The switching element may be operated several times before the test, at no load or at any current not exceeding the rated current.

A contact element with two terminals shall be tested with the actuator in the position corresponding to the closed position of the switching element under test.

The contact element to be tested shall be in series with the short-circuit protective device (SCPD), the load impedance, and a separate switching device in a single-phase circuit as shown in Figure 8. The test quantities shall be in accordance with 8.3.4.3.

The test is performed by making the current with the separate making switch and the current shall be maintained until the SCPD operates.

The test shall be performed three times on the same contact element, the SCPD being reset or replaced after each test. The time interval between the tests shall be not less than 3 min. The actual time interval shall be stated in the test report.

For change-over contact elements, the above test shall be made separately on both the normally closed and normally open contacts.

NOTE For control switches with both two terminals and change-over contact elements, both types ~~should be~~ are tested.

A separate control circuit device may be used for each contact element.

8.3.4.3 Test circuit and test quantities

The switching element shall be connected in series with the short-circuit protective device of type and rating stated by the manufacturer; it shall also be in series with the switching device intended to close the circuit.

The test circuit load impedance shall be an air-cored inductor in series with a resistor, adjusted to a prospective current of 1 000 A, or ~~a higher~~ another value if stated by the manufacturer but not less than 100 A, at a power factor of between 0,5 and 0,7 and at the rated operational voltage. ~~No parallel damping load shall be added.~~ The open circuit voltage shall be 1,1 times the maximum rated operational voltage of the switching element.

The switching element shall be connected in the circuit using 1 m total length of cable corresponding to the operational current of the switching element.

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8.3.4.4 Condition of the switching element after the test

The following criteria shall be met entirely:

a) After the short-circuit test it shall be possible to open the switching elements by the normal actuating system.

b) After the test the device shall withstand the power-frequency voltage of 2 U_e but not less than 1 000 V applied as specified in 8.3.3.4.1.

8.4 Tests for EMC

8.4.1 General

Control circuit devices having only passive components are not required to be tested.

Subclauses 8.3.2.1 of IEC 60947-1:2007/AMD1:2010/AMD2:2014 and 8.3.2.4 of IEC 60947-1:2007/AMD1:2010 apply with the following additions:

– Control circuit devices intended to be mounted in a hole of a panel shall be mounted in a hole which is located in the center of a grounded square metal plate.

  Control circuit devices intended to be mounted on surfaces or on standard rails shall be mounted directly on the grounded square metal plate or on the standard rail which is fixed on the grounded square metal plate.

  Control circuit devices intended to be mounted in associated metal enclosures shall be mounted in the grounded metal enclosure with the smallest dimension available or on the grounded square metal plate, whichever configuration yields the worst results.

– The dimension of the square metal plate shall be (300 ± 50) mm and the thickness $1{,}5^{+0{,}5}_{0}$ mm.

– If not required otherwise by horizontal standard the connecting leads shall be $2^{+0{,}1}_{0}$ m. If the length of the connecting leads is other than 2 m, the length has to be stated in the test report.

– For control circuit devices not having integral cables, the type of cable or wire used shall be specified by the manufacturer and recorded in the test report.

– The test sample shall be in the ON-status or in the OFF-status, whichever is the worse. The tested state shall be recorded in the test report.

– Where a range of control circuit devices are made according to the same principle and design, and using the same type of components, tests may be performed on representative samples.

8.4.2 Immunity

8.4.2.1 Electrostatic discharges

The test shall be performed according to IEC 61000-4-2 and 7.3.2.4, and shall be repeated 10 times at each measuring point, with a minimum time interval of 1 s between pulses.

8.4.2.2 Radiated radio-frequency electromagnetic fields

The test shall be performed according to IEC 61000-4-3 and 7.3.2.5.

8.4.2.3 Electrical fast transients/bursts

The test shall be performed according to IEC 61000-4-4 and 7.3.2.6, with all the connecting leads placed in the capacitive coupling clamp.

NOTE The capacitive coupling is the preferred test method because it simulates the disturbances present during normal application as a result of parallel wires.

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8.4.2.4 Surges

The test shall be conducted using the methods of IEC 61000-4-5. Capacitive coupling shall be preferred.

The surges shall be applied:

a) between terminals intended to be connected to the power supply;

b) between each output terminal and each terminal intended to be connected to the power supply.

The test voltage values are those of Table 8 but shall not exceed the corresponding U_{imp} value(s) given by the manufacturer following 7.2.3 of IEC 60947-1:2007/AMD1:2010.

The repetition rate shall be one surge per minute, with the number of pulses being five positive and five negative.

8.4.2.5 Conducted disturbances induced by radio-frequency fields

The test shall be performed according to IEC 61000-4-6 and 7.3.2.8.

8.4.2.6 Power-frequency magnetic fields

The test shall be performed according to IEC 61000-4-8 and 7.3.2.9.

8.4.2.7 Voltage dips and interruptions

The test shall be performed according to IEC 61000-4-11 and 7.3.2.10.

8.4.2.8 Harmonics in the supply

Test levels are under consideration.

8.4.3 Emission

The test shall be performed according to CISPR 11, group 1, class A, and 7.3.3.

These limits are given for control circuit devices exclusively built for an industrial environment (environment A).

When they are intended to be used in an environment B (low-voltage public networks such as domestic, commercial and light industrial locations/installations), the devices shall comply with the test levels for environment B or the notice according to 5.3 of IEC 60947-1:2007/AMD2:2014 shall be included in the instructions for use.

8.4.4 Test results and test report

The test results shall be documented in a comprehensive test report. The test report shall present the objective, the results and all relevant information of the tests. The test report shall define the control circuit device under test, including the layout of the connecting leads and if applicable the necessary auxiliary equipment. Any deviation from the test plan shall be mentioned.

NOTE The contents of the test plan are given in the corresponding horizontal standard (see IEC 61000 series).

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Table 9 – Test values for electrical performance and ageing test of screwless-type clamping units

Conductor size mm²	Test current A	
	for minimum cross-section	for maximum cross-section
0,2	1	I_{th} or I_{the} declared for the product
0,34	2	
0,5	3	
0,75	6	
1,0	8	
1,5	12	
2,5	20	
4,0	25	

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Number of the example	Disposition of the contact element(s)	Actuator positions 1	2	3	4	5
1		×				
2			×		×	×
3			×			
					×	
4			×			
5		×		×	×	×
6					×	×
7		×				
			×			
8		×				
			×			
9 A		×		×		
B		×		×		

Contact element closed in actuator position No. 1 only.
Contact element closed in actuator positions No. 2, 4 and 5.
Two contact elements used as change-over contact elements with 3 terminals.
Contact element with pulse (fleeting) contact closed between actuator positions No. 2 and 3.
Contact element with pulse (fleeting) contact open between actuator positions No. 3 and 4.
Contact element with maintained contact between actuator positions No. 4 and 5.
Two contact elements with close-before-open contacts between actuator positions No. 1 and 2.
Two contact elements with open-before-close contacts between actuator positions No. 1 and 2 (*).
Operation in which contact element B is arranged to close before and open after contact element A.

(*) Open-before-close contact elements may be used to break the current in one circuit before making the current in the other circuit, provided the time interval be properly related to the circuit conditions.

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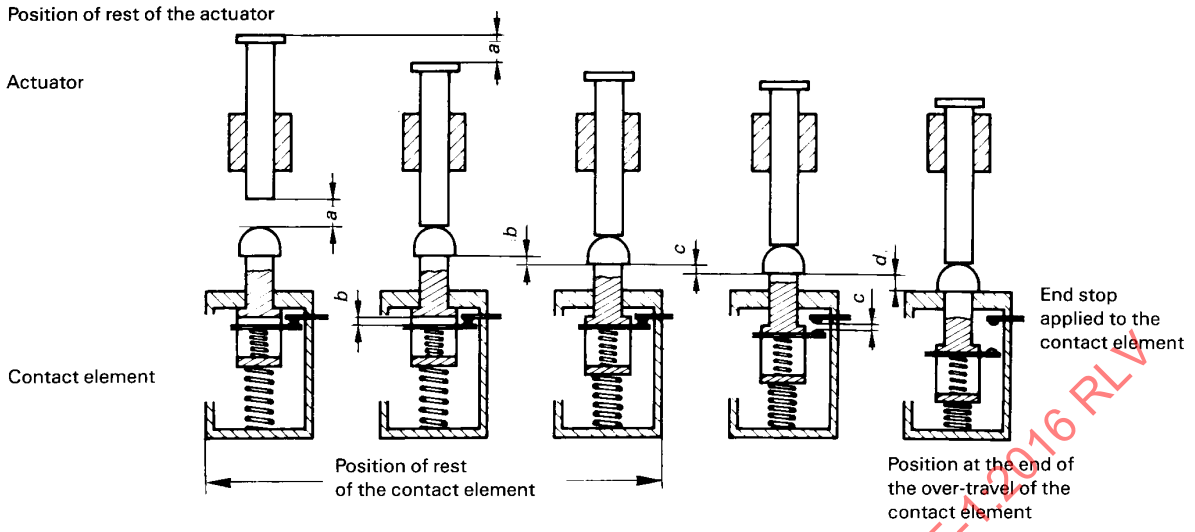
Figure 1 – Examples of the recommended method for drawing an operating diagram of a rotary switch



a Pre-travel of the actuator

b Pre-travel of the contact element

c Minimum value required to give adequate contact gap

d Over-travel of the contact element

b + *c* + *d* Total travel of the contact element

a + *b* + *c* + *d* + *e*)* Total travel of the actuator

* NOTE Because of a possible resilient connection between the actuator and the contact element (for example, see Figure 3), the over-travel of the actuator ~~may~~ can exceed the over-travel of the contact element by a length *e*.

Figure 2 – Operation of push-buttons

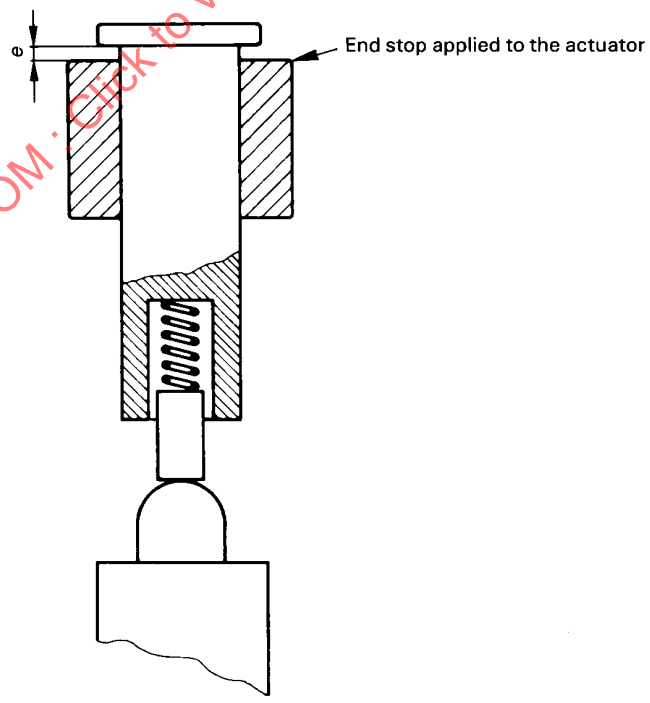


Figure 3 – Difference e between the over-travel of the actuator and that of the contact element

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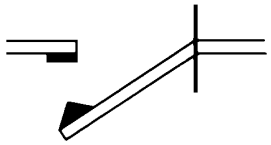
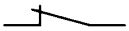
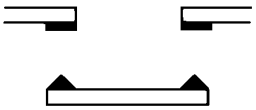
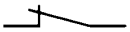
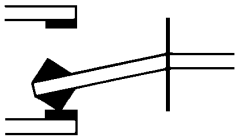
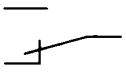
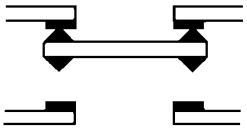
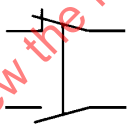
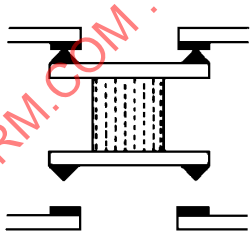
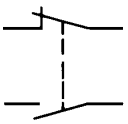
Figure No.	Figure	Symbols	Forms	Description
4a)		 Note 1	A	Single gap contact element with two terminals
		 Note 1	B	
4b)		 Note 1	X	Double gap contact element with two terminals
		 Note 1	Y	
4c)		 Note 1	C	Change-over, single gap, contact element with three terminals
4d)			Za	Change-over, double gap, contact element with four terminals Note – The contacts are of the same polarity
4e)			Zb	Change-over, double gap, contact element with four terminals (The two moving contacts are electrically separated) Note – Multiple electricaly separated contact configurations are also covered by Zb

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NOTE 1 Symbols according to IEC 60617.

Figure 4 – Examples of contact elements (schematic sketches)

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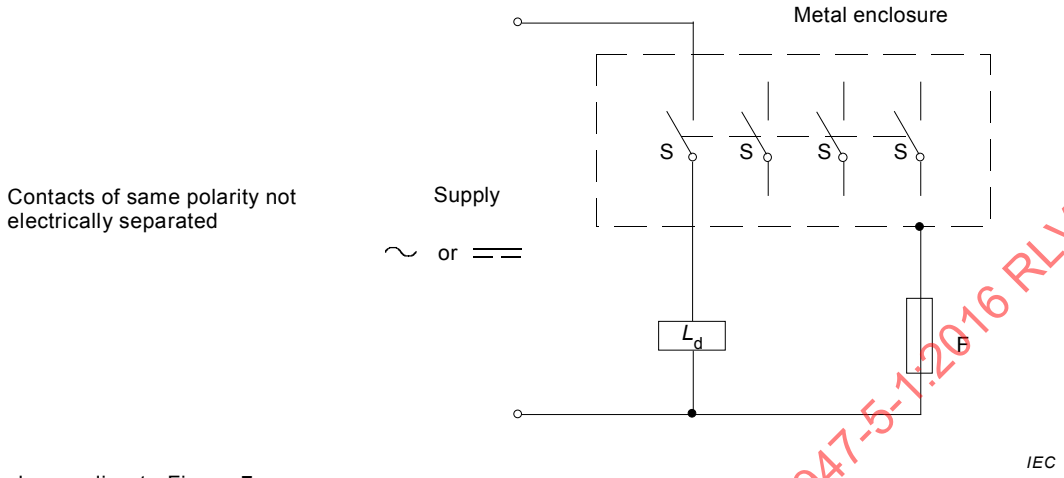
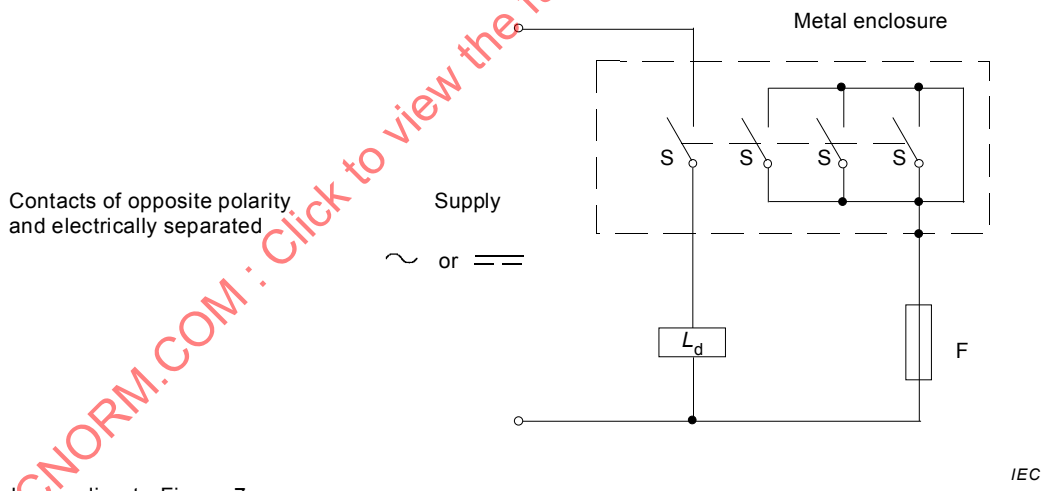
~~Test circuits~~
~~(see 8.3.3.5)~~
~~Multi-pole control switches~~



L_d: Load according to Figure 7
F: Fuse or isolation measurement device
S: Contact element (NO or NC)

Figure 5 – Test circuits for multi-pole control switches – Contacts of same polarity, not electrically separated



L_d: Load according to Figure 7
F: Fuse or isolation measurement device
S: Contact element (NO or NC)

Figure 6 – Test circuits for multi-pole control switches – Contacts of opposite polarity, and electrically separated

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~~Test circuit~~
~~(see 8.3.3.5)~~

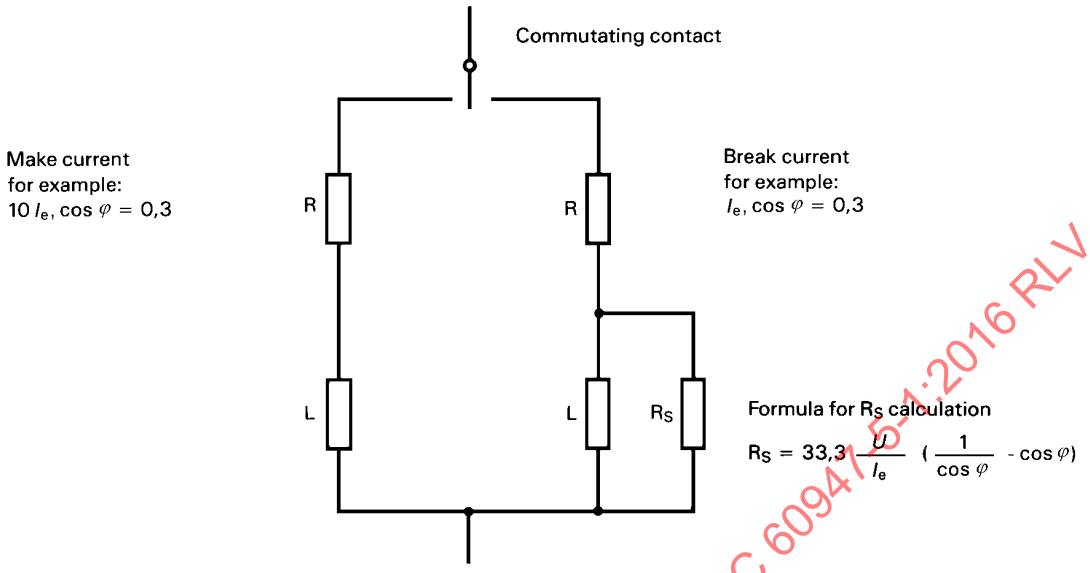
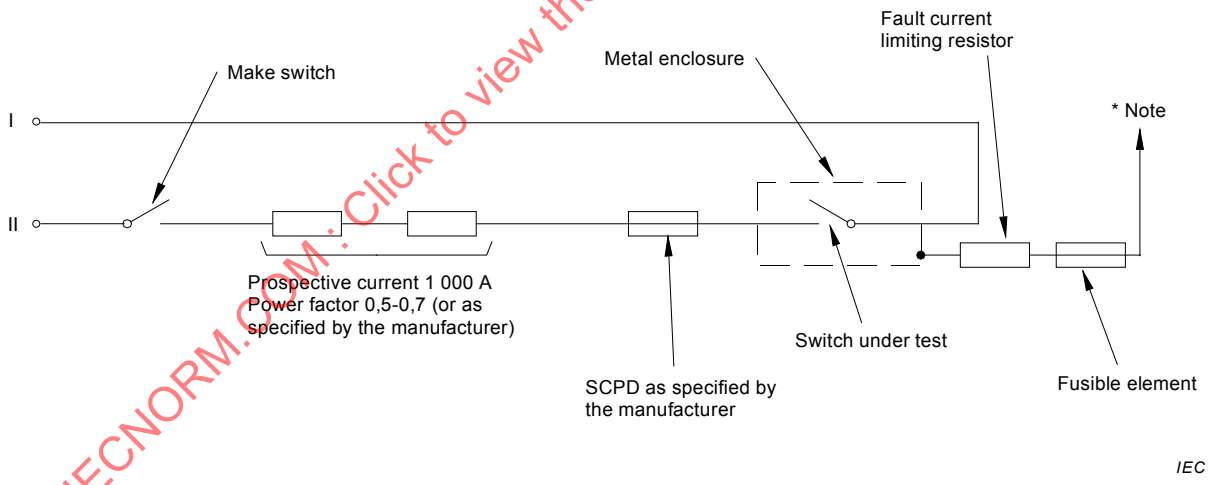


Figure 7 – Load L_d details for test conditions requiring different values of make and break current and/or power factor (time constant)



NOTE To be connected alternatively to I or II on successive tests.

Figure 8 – Test circuit, conditional short-circuit current (see 8.3.4.2)

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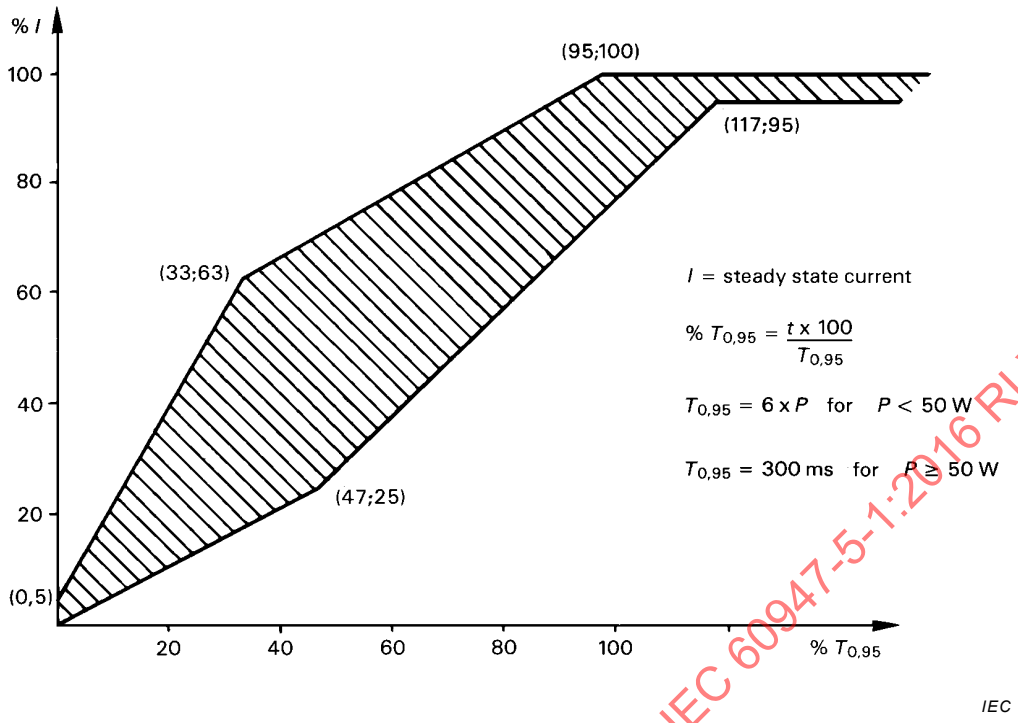

Figure 9 – Current/time limits for d.c. test loads (see 8.3.3.5.4)

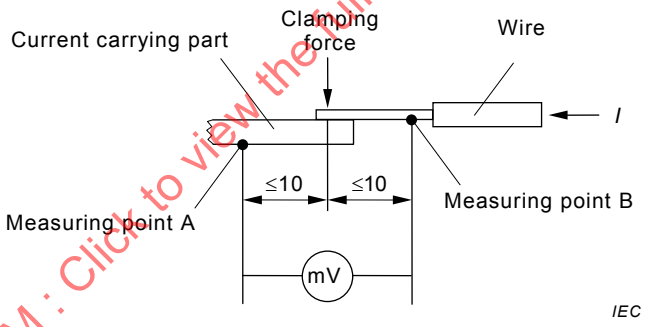

Figure 10 – Voltage drop measurement at contact point of the clamping unit or terminal

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Annex A
(normative)

Electrical ratings based on utilization categories (see 3.1)

Table A.1 – Examples of contact rating designation based on utilization categories

Désignation [1]	Utilization category	Conventional enclosed thermal current I_{the} A	Rated operational current I_e (A) at rated operational voltage U_e						VA rating [2] VA	
Alternative current			120 V	240 V	380 V	480 V	500 V	600 V	M	B
A150	AC-15	10	6	–	–	–	–	–	7 200	720
A300	AC-15	10	6	3	–	–	–	–	7 200	720
A600	AC-15	10	6	3	1,9	1,5	1,4	1,2	7 200	720
B150	AC-15	5	3	–	–	–	–	–	3 600	360
B300	AC-15	5	3	1,5					3 600	360
B600	AC-15	5	3	1,5	0,95	0,75	0,72	0,6	3 600	360
C150	AC-15	2,5	1,5	–	–	–	–	–	1 800	180
C300	AC-15	2,5	1,5	0,75	–	–	–	–	1 800	180
C600	AC-15	2,5	1,5	0,75	0,47	0,375	0,35	0,3	1 800	180
D150	AC-14	1,0	0,6	–	–	–	–	–	432	72
D300	AC-14	1,0	0,6	0,3	–	–	–	–	432	72
E150	AC-14	0,5	0,3	–	–	–	–	–	216	36
Direct current			125 V	250 V		400 V	500 V	600 V		
N150	DC-13	10	2,2	–		–	–	–	275	275
N300	DC-13	10	2,2	1,1		–	–	–	275	275
N600	DC-13	10	2,2	1,1		0,63	0,55	0,4	275	275
P150	DC-13	5	1,1	–		–	–	–	138	138
P300	DC-13	5	1,1	0,55		–	–	–	138	138
P600	DC-13	5	1,1	0,55		0,31	0,27	0,2	138	138
Q150	DC-13	2,5	0,55	–		–	–	–	69	69
Q300	DC-13	2,5	0,55	0,27		–	–	–	69	69
Q600	DC-13	2,5	0,55	0,27		0,15	0,13	0,1	69	69
R150	DC-13	1,0	0,22	–		–	–	–	28	28
R300	DC-13	1,0	0,22	0,11		–	–	–	28	28

M = make
B = break

~~NOTE~~ [1] The letter stands for the conventional enclosed thermal current and identifies (a.c. or d.c.): for example B means 5 A a.c. The rated insulation voltage U_i is at least equal to the number after the letter.

~~NOTE~~ [2] The rated operational current I_e (A), the rated operational voltage U_e (V) and the break apparent power B (VA) are correlated by the formula $B = U_e \cdot I_e$.

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Table A.2 – Examples of semiconductors switching element ratings for 50 Hz and/or 60 Hz [1)]

Switching element rating	Rated operational current I_e	Rated make current A				Minimum operational current	Maximum OFF-state current
Designation	A	AC15	AC14	AC13	AC12	A	mA
SA	10	100	60	20	10	0,1	15
SB	5	50	30	10	5	0,1	15
SC	2	20	12	4	2	0,05	10
SD	1	10	6	2	1	0,05	10
SE	0,5	5	3	1	0,5	0,01	10
SF	0,25	2,5	1,5	0,5	0,25	0,01	5
SG	0,1	1	0,6	0,2	0,1	0,01	3

1) The rated operational voltage shall be specified by the manufacturer.

Table A.3 – Examples of semiconductors switching element ratings for d.c. [1)]

Switching element rating	Rated operational current I_e	Rated make current A			Maximum OFF-state current
Designation	A	DC14	DC13	DC12	mA
SN	10	100	10	10	5
SP	5	50	5	5	4
SQ	2	20	2	2	4
SR	1	10	1	1	2
SS	0,5	5	0,5	0,5	2
ST	0,25	2,5	0,25	0,25	1
SU	0,1	1	0,1	0,1	0,4
SV	0,05	0,5	0,05	0,05	0,2

1) The rated operational voltage shall be specified by the manufacturer.

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Annex B
(normative)

Example of inductive test loads for d.c. contacts

B.1 General

The direct current inductive loads found in control circuits are usually electromagnetically driven relays, contactors and solenoids with solid iron loads rated 50 W or less. The influence of these loads on the contacts of the control circuit device is determined by the stored energy of the inductor which, in turn, is related to the average rate of rise of the current in the inductor or to the charging time of the inductor.

It has been empirically determined that inductive loads up to 50 W almost always have a charging time ($T_{0,95}$) to 95 % of their full current value of 6 ms per watt or less.

B.2 Construction

The following inductive test loads may be used to approximate the loads imposed upon contacts used in d.c. control circuits:

The magnetic circuit consists of two solid steel cores, 44,5 mm in diameter and 158,7 mm long, which are fastened by screws at each end to solid steel yokes 25,4 mm × 63,5 mm × 152,4 mm on 101,6 mm centres (see Figure B.1). The steel has a resistance of between 13,3 and 19,9 μΩ/cm. (Cold-finished low carbon steels such as AISI 1010, 1015, 1018 or 116 equivalent meet this requirement.) At one end of each core, a non-magnetic spacer having a thickness adjustable to between 0,127 mm and 0,762 mm is interposed between the end of the core and the yoke. Non-magnetic screws shall be used to hold the yoke at the end having the non-magnetic spacer, and steel screws shall be used at the other end.

A coil having the winding characteristics shown in Figure B.1 surrounds one of the cores. The current in the coil, when energized at the test voltage, is adjusted to the value specified in the Table B.1 by means of a series resistor.

The thickness of the spacer is adjusted so that the coil current builds up from zero to 95 % of its full value within the limits shown in Figure 9. If the current curve falls below the minimum time limit, the cross section of the iron yoke is increased and if it falls above the maximum limit the cross section is reduced.

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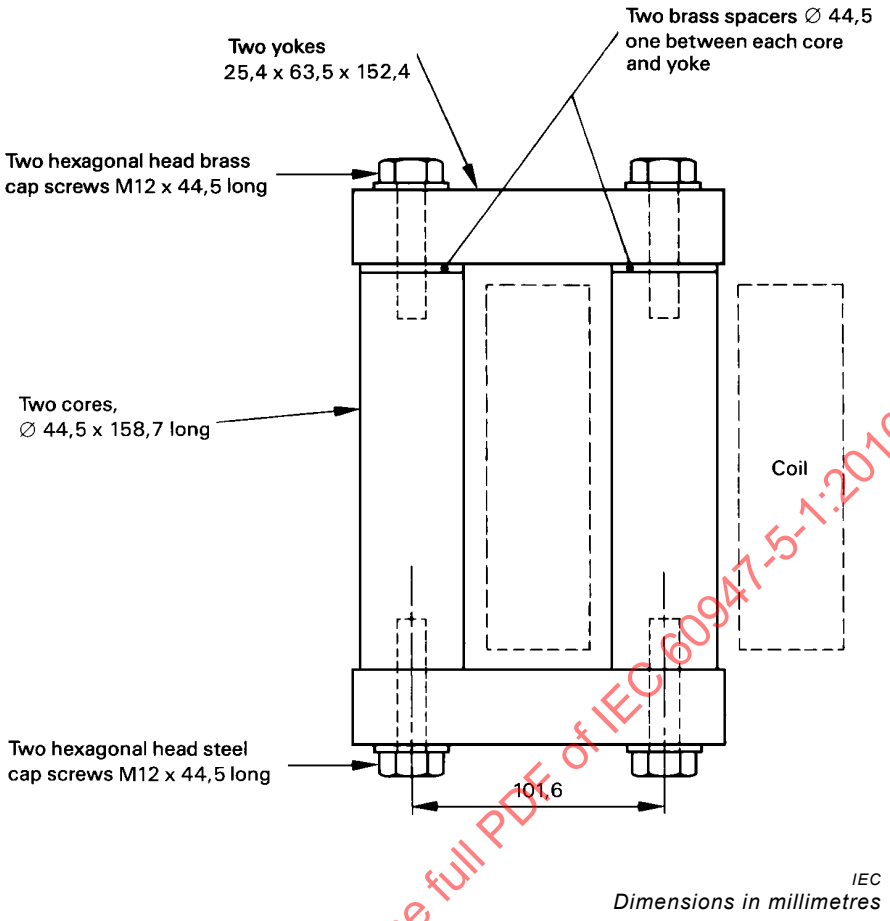

Figure B.1 – Construction of load for d.c. contacts

Table B.1 – DC loads

Coil construction					
Test voltage	**Number of turns**	**Wire size**	**Approximate coil resistance**	**Current limit with series resistor**	**Wattage at test voltage**
V		mm^2	Ω	A	W
125	7 000	0,52	74	1,1	138
250	14 000	0,26	295	0,55	138
600	33 400	0,10	1 680	0,20	120

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Annex C
(normative)

Special tests – Durability tests

C.1 General

C.1.1 Durability declaration

The special durability tests (see 7.2.4.3) described in this annex are conducted at the discretion of the manufacturer. If the manufacturer declares a mechanical and/or electrical durability, the value shall correspond to the special tests described respectively in C.2 and/or C.3.

NOTE Both durability types apply to the complete control circuit device.

Both durability types are expressed as a number of operating cycles (see C.2.1 and/or C.3.1).

The preferred numbers of operating cycles declared for any type of durability are the following: 0,01 – 0,03 – 0,1 – 0,3 – 1 – 3 – 10 – 30 or 100 millions.

C.1.2 Test procedures

C.1.2.1 General

Every test shall be performed under the general conditions stated in 8.3.2.1, and at a rate equal or higher than that declared by the manufacturer. The moving parts of the device shall reach their maximum operating positions in both directions, as recommended by the manufacturer.

The test results are verified by statistical analysis according to the *single 8* (see C.1.2.2) or *double 3* (see C.1.2.3) test methods.

The manufacturer may declare mechanical durability based on experience with similar design.

NOTE The *single 8* or *double 3* test methods are both given in IEC 60410 (see Tables X-C-2 and X-D-2). These two tests have been chosen with the objective of testing a limited number of control circuit devices on the same statistical characteristics (acceptance level: 10 %). Other methods providing the 10 % acceptance level ~~may~~ can be used.

C.1.2.2 Single 8 test

Eight control circuit devices shall be tested to the declared number of operating cycles.

If the number of failed devices does not exceed two, the test is considered passed.

C.1.2.3 Double 3 test

Three control circuit devices shall be tested to the declared number of operating cycles.

The test is considered passed if there is no failure, and failed if there is more than one failure. Should there be only one failure, then three additional control circuit devices are tested to the declared number of operating cycles and providing there is no additional failure, the test is considered passed.

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C.1.3 Failure criteria

During the tests described in C.2.2 and C.3.2, there shall be no electrical and/or mechanical failures. Following the tests, the switching element shall pass the dielectric test of 8.3.3.4 with a rated test voltage equal to 2 U_e with a minimum of 1 000 V.

C.2 Mechanical durability

C.2.1 General

The mechanical durability of a control circuit device is defined as the number of no-load operating cycles which will be attained or exceeded by 90 % of all devices tested without repair or replacement of any part.

C.2.2 Test procedures

Tests are carried out according to C.1.2.

During the test, periodically the contacts shall be checked at any voltage and current, selected by the manufacturer, and there shall be no failure (see C.1.3).

C.3 Electrical durability

C.3.1 General

The electrical durability of a control circuit device is defined as the number of on-load operating cycles which will be attained or exceeded by 90 % of all devices tested, without repair or replacement of any part.

C.3.2 Test procedures

C.3.2.1 General

Electrical durability tests are carried out by operating the device under the conditions defined in Table C.1, in accordance with C.3.2.2 for a.c. or with C.3.2.3 for d.c.

Each mechanical operating cycle shall include an interruption of test current.

The ON-duration of current shall be not more than 50 % and not less than 10 % of an operating cycle. If the test circuit shown in Figure C.1 is used, the ON-duration of current at ten times I_e shall not cause overheating.

Alternatively these tests may be performed on the actual load for which the control switch is intended.

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Table C.1 – Making and breaking conditions for electrical durability

Kind of current	Utilization category	Make			Break		
Alternating	AC-15	I	U	cos φ	I	U	cos φ
		10 I_e	U_e	0,7[1)]	I_e	U_e	0,4[1)]
Direct[2)]	DC-13	I	U	$T_{0,95}$	I	U	$T_{0,95}$
		I_e	U_e	6 × P[3)]	I_e	U_e	6 × P[3)]

I_e Rated operational current — I Current to be made or broken

U_e Rated operational voltage — U Voltage

$P = U_e \times I_e$ Steady-state power consumption, in W — $T_{0,95}$ Time to reach 95 % of the steady-state current, in milliseconds

1) The power-factors indicated are conventional values and apply only to the test circuits which simulate the electrical characteristics of coil circuits. It should be noted that, for circuits with power-factor 0,4, shunt resistors are used in the test circuit to simulate the damping effect on the eddy current losses of the actual electromagnet.

2) For d.c. electromagnetic loads provided with switching devices introducing an economy resistor, the rated operational current shall be at least equal to the maximum value of the inrush current.

3) The value "6 × 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 × 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.

C.3.2.2 AC tests

The circuit to be used shall be as shown in Figure C.1 below, comprising

- a making circuit, consisting of an air-cored inductor, in series with a resistor, having a power factor of 0,7 and drawing a current of 10 I_e;
- a breaking circuit, consisting of an air-cored inductor in series with a resistor, the whole being in parallel with a resistor in which flows about 3 % of the breaking current I_e, so that the total power factor be of 0,4.

If the contact element has a bounce time less than 3 ms, the test may be made with the simplified circuit shown in Figure C.2.

The test report shall record which test circuit has been used.

C.3.2.3 DC tests

Circuits to be used shall consist of:

a) an air-cored inductor in series with a resistor.

A resistor shall be connected across the complete test circuit to simulate the damping due to eddy currents; the resistance value shall be such that 1 % of the test current will pass through this resistor; or,

b) an iron-cored inductor, in series with a resistor, if required, to obtain a duration $T_{0,95}$ as indicated in Table C.1.

It shall be verified, by oscillograms, that the time to reach 95 % of the steady-state current is equal to the value given in Table C.1 ± 10 %, and the time to reach 63 % of the steady-state current is one-third of the value given in Table C.1 ± 20 %.

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~~AC test circuits (see C.3.2.1)~~

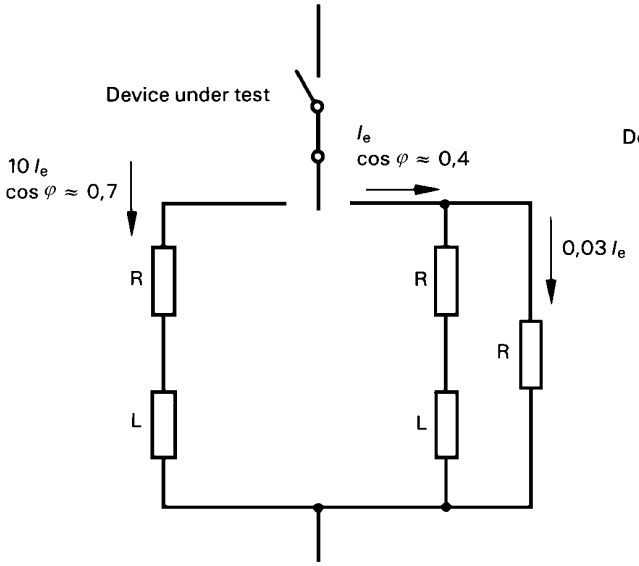

Figure C.1 – Normal circuit
(see C.3.2.2)

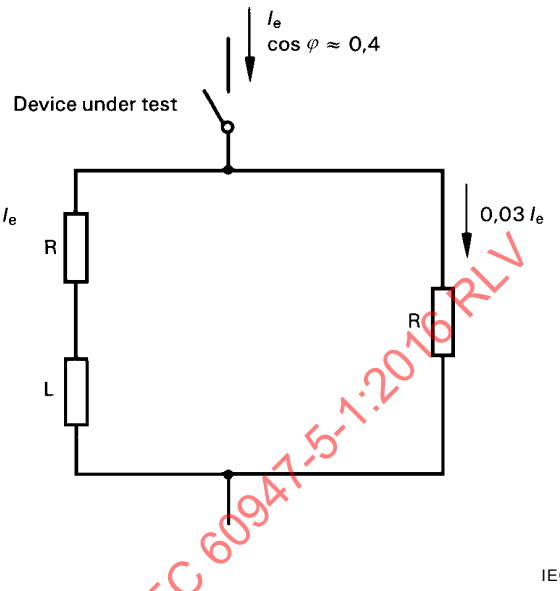

Figure C.2 – Simplified circuit
(see C.3.2.2)

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Annex D
(normative)

Clearances and creepage distances of control circuit devices

D.1 Scope

The recommendations of this annex apply to control circuit devices specified in this standard. They apply to equipment in air and to normal atmospheric conditions as defined in 6.1.3.2. When the atmospheric conditions differ from the normal, this should be recognized either by the choice of enclosures or by larger creepage distances. Observation of these recommendations does not imply that the devices will meet the test requirements of this standard.

They apply neither to devices for which a value of U_{imp} has been declared, nor to devices suitable for isolation which shall comply with the requirements of 7.1.3.

D.2 Definitions

D.3 General

D.3.1 It is recommended that the surface of the insulating parts should be designed with ridges so arranged as to break the continuity of conductive deposits which may form.

D.3.2 The recommended clearances and creepage distances apply to non-arcing parts. In the vicinity of arcs or in areas where ionized gases may be present, the normal atmospheric conditions defined in 6.1.3.2 do not exist and larger values may be necessary.

D.3.3 The recommended clearances do not apply to the gap between the separable contacts of the same pole when in the open position.

D.3.4 Conducting parts covered only with varnish or enamel, or protected only by oxidation or a similar process, should not be considered as being insulated.

D.3.5 The recommended clearances and creepage distances shall be maintained under the following circumstances:

a) on the one hand, without external electrical connections, on the other hand, when insulated or bare conductors of the type and of any dimensions specified for the contactor are installed according to the manufacturer's instructions, if any;

b) after interchangeable parts have been changed, taking into account maximum permissible manufacturing tolerances;

c) taking into consideration possible deformation due to the effect of temperature, ageing, shocks, vibration, or due to short-circuit conditions which the contactor is intended to endure.

D.4 Determination of clearances and creepage distances

In determining clearances and creepage distances, it is recommended that the following points should be considered:

D.4.1 If a clearance or a creepage distance is influenced by one or more metal parts, either one of the sections between these parts should have at least the prescribed minimum value, or the sum of the two largest sections should have at least 1,25 times the prescribed minimum

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~~value. Individual sections less than 2 mm in length should not be taken into consideration in the calculation of the total length of clearances and creepage distances.~~

~~**D.4.2** In determining a creepage distance, grooves at least 2 mm wide and 2 mm deep should be measured along their contour. Grooves having any dimension less than these dimensions and any groove liable to be clogged with dirt should be neglected and direct distance only measured.~~

~~**D.4.3** In determining a creepage distance, ridges less than 2 mm high should be neglected. Those at least 2 mm high:~~

- ~~are measured along their contour, if they are an integral part of a component in insulating material (for instance by moulding or welding);~~
- ~~are measured along the shorter of two paths: length of joint or profile of ridge, if they are not an integral part of a component in insulating material.~~

~~**D.4.4** The application of the foregoing recommendations is illustrated by examples 1 to 11 of Annex G of IEC 60947-1.~~

~~D.5 Minimum values of clearances and creepage distances~~

~~**D.5.1** The values of clearances and creepage distances are given in Table D.1 as a function of rated insulation voltage and of the conventional thermal current I_{th} of the control circuit device.~~

~~**D.5.2** The values of clearances are given between two live parts (L-L) and between a live part and an exposed conductive part (L-A). The distance between a live part and an earthed part (which is not an exposed conductive part) may be that specified for L-L for the corresponding voltage.~~

~~**D.5.3** The values of creepage distances also depend on the insulating material and the shape of the insulating piece.~~

~~*Column a:* 1) Ceramics (steatite, porcelain).~~

~~2) Other kinds of insulating materials designed with ridges or with approximately vertical surfaces, for which experience has shown that they are capable of giving satisfactory service with the creepage distances used for ceramics.~~

~~NOTE Such materials may be materials having a comparative tracking index of at least 140 V (see IEC 60112) for example phenolic mouldings.~~

~~*Column b:* All other cases.~~

~~The values in Table D.1 are given only as a guide to what may be regarded as minimum values.~~

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Table D.1 – Clearances and creepage distances

Rated insulation voltage U_i	Clearances mm		Creepage distances mm	
V	L-L	L-A	a	b
$U_i \leq$ 60	2	3	2	3
60 < $U_i \leq$ 250	3	5	3	4
250 < $U_i \leq$ 400	4	6	4	6
400 < $U_i \leq$ 500	6	8	6	10
500 < $U_i \leq$ 690	6	8	8	12
690 < $U_i \leq$ 750 c.a.	10	14	10	14
750 < $U_i \leq$ 1 000 c.a.	14	20	14	20

NOTE 1 The values in Table D.1 apply to the atmospheric conditions as specified in 6.1.3.2. For more severe conditions and for marine service, creepage distances should be at least those in column b.

NOTE 2 When the clearance L-A is greater than the corresponding creepage distance specified in column a or column b, then the creepage distance from the live part to the exposed conductive part shall be not less than the clearance.

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Annex D

Vacant

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Annex E
(normative)

Items subject to agreement between manufacturer and user

NOTE For the purpose of this annex:

- "agreement" is used in a very wide sense.
- "user" includes testing stations.

Annex J of IEC 60947-1:2007 applies, as far as covered by clauses and of this standard, with the following additions:

Clause or subclause number of this standard	Item
5.2.5	Relationship between the positions of the actuator of rotary switches and the associated contact element positions in the operating diagram (indication by the manufacturer)
5.2.6	Characteristics of the delay of time-delay contact elements with adjustable delay of contactors relays (indication by manufacturer)
K.6.1.1	Choice of connecting conductors for position switches with direct opening action
8.3.1	Test sequences made on one sample only (at the manufacturer's request)
8.3.4.3	Conditional short-circuit current test: – adjustment of the test circuit if the prospective current is different from 1 000 A (to be specified by the manufacturer) – power factor of the test circuit less than 0,5 (with the manufacturer's consent)

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Annex F
(normative)

Class II control circuit devices insulated by encapsulation Requirements and tests

NOTE The numbering of this annex is based on the numbering of the document.

F.1 General

This annex specifies constructional requirements and tests for class II control circuit devices or parts of devices in which insulation of class II according to IEC 61140 is achieved by encapsulation.

All non-encapsulated parts shall have clearances and creepage distances ~~double to~~ two times those specified in 7.1.4.

F.2 Terms and definitions

For the purposes of this annex, the following terms and definitions apply.

F.2.1
encapsulation
process by which all components, conductors and ends of integral cables are encased in an insulating compound by suitable means such as embedding or potting

F.2.1.1
embedding
process of completely encasing electrical device(s) by pouring a compound over it (them) in a mould, and removing the encased device(s) from the mould after solidification of the compound

F.2.1.2
potting
embedding process in which the mould remains attached to the encased electrical device(s)

F.2.2
compound
thermosetting, thermoplastic, catalytically cured and elastomeric materials with or without fillers and/or additives, after their solidification

F.2.3
temperature range of the compound
the ambient temperature range stated in 6.1.1 of IEC 60947-1:2007/AMD2:2014

F.5 Marking

Control devices according to this annex shall be marked with the following symbol

This symbol is 60417-5172.

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F.7 Instructional and functional requirements

F.7.1 Choice of compound

The compound shall be chosen so that the encapsulated control devices comply with the tests defined in F.8.

F.7.2 Adhesion of the compound

The adhesion of the compound shall be sufficient to prevent the ingress of moisture between the compound and all encapsulated parts and to prevent movement of the encapsulated portion of the cable if any.

Compliance shall be verified by tests of F.8.1.2.5 and F.8.1.2.2.

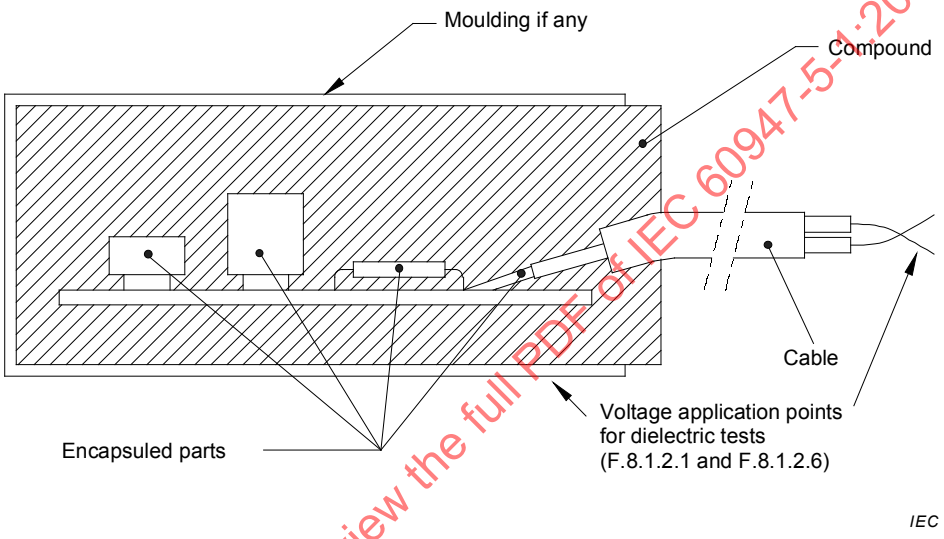

Figure F.1 – Insulation by encapsulation

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F.7.3 Dielectric properties

Subclause 7.2.3 applies with the following changes.

For the verification of the impulse withstand voltage, the test voltage U_{imp} shall be the next higher category of the maximum rated operational voltage in the first column of Table H.1 of IEC 60947-1:2007 for the stated overvoltage category.

For the verification of the power frequency withstand voltage, the test voltage shall be the sum of the voltage stated in Table 12A of IEC 60947-1:2007/AMD2:2014 plus 1 000 V.

F.8 Tests

F.8.1 Kind of tests

F.8.1.1 General

Subclause 8.1.1 of IEC 60947-1:2007 applies.

F.8.1.2 Type test

The following sequence of 6 tests shall be applied to each of 3 samples in the specified order.

F.8.1.2.1 Dielectric tests in new conditions

Subclause 8.3.3.4 of IEC 60947-1:2007/AMD1:2010/AMD2:2014 applies with the exception that the values of voltages shall be applied between the stripped joined ends of the cable or the shorted terminals and any point of the surface (or metallic foil on the surface) of the encapsulated device (see Figure F.1). No breakdown of the insulation shall occur.

F.8.1.2.2 Cable tests (if applicable)

Control circuit devices provided with integrally connected cables shall comply with requirements of Annex G.

F.8.1.2.3 Rapid change of temperature test

Test Na shall be performed in accordance with IEC 60068-2-14 with the following values:

T_A and T_B are the minimum and the maximum temperatures stated in F.2.3

Transition time t_2: 2 min to 3 min

Number of cycles: 5

Exposure time t_1: 3 h

After the test no visible damage shall be observed[3]

F.8.1.2.4 Impact test

The test is performed as follows (see Figure F.2). The sample is placed on a rigid support.

Three impacts of 0,5 J shall be applied near the centre of the largest surface or the longest axis (for cylindrical shape) of the encapsulated device.

The impacts are provided by dropping a steel ball of 0,25 kg from a height of 0,20 m.

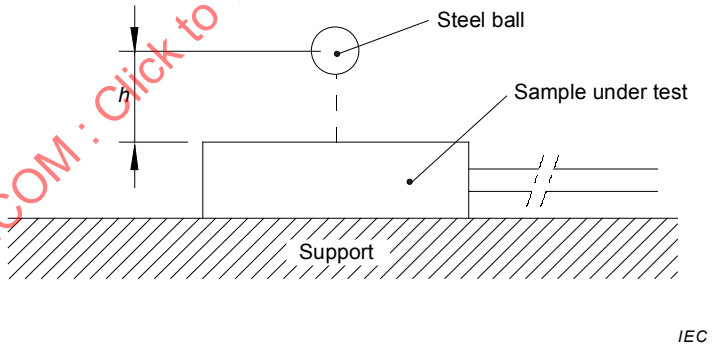

Figure F.2 – Test apparatus

The support is considered sufficiently rigid if its displacement under the impact energy is lower than 0,1 mm.

After test no visible damage shall be observed[4].

---

[3] Small cracks of the moulding compounds, if any (see Figure F.1) are acceptable after tests F.8.1.2.3, F.8.1.2.4 and F.8.1.2.5.
They shall not impair the results of the final test of F.8.1.2.6.

[4] Small cracks of the moulding compounds, if any (see Figure F.1) are acceptable after tests F.8.1.2.3, F.8.1.2.4 and F.8.1.2.5.
They shall not impair the results of the final test of F.8.1.2.6.

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F.8.1.2.5 Damp heat, cyclic

The test Db shall be performed according to IEC 60068-2-30 with the following values:

Upper temperature: 55 °C

Number of cycles: 6

The test report shall state which variant is applied: variant 1 or variant 2.

After the test no visible damage shall be observed[5].

F.8.1.2.6 Dielectric test after stresses

Following Test F.8.1.2.5, the dielectric properties shall be checked by repeating tests specified in 8.3.3.4 with the test voltage of power-frequency withstand voltage being applied for 5 s.

The results to be obtained shall be as stated in 8.3.3.4 with the addition that the leakage current shall not exceed 2 mA at 1,1 U_i.

F.8.1.3 Routine tests

Subclause 8.1.3 applies but the dielectric test is mandatory.

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5 Small cracks of the moulding compounds, if any (see Figure F.1) are acceptable after tests F.8.1.2.3, F.8.1.2.4 and F.8.1.2.5.
They shall not impair the results of the final test of F.8.1.2.6.

Annex G
(normative)

Additional requirements for control circuit devices with integrally connected cables

NOTE The numbering of this annex is based on the numbering of the document.

G.1 General

This annex gives additional requirements applying to control circuit devices with integrally connected cables for electrical connection to other equipment and/or to the power source.

The cable integrally connected to such control circuit devices is not considered replaceable by the user. This annex states the constructional and performance requirements for the cable, the cable anchorage and the cable entrance seal.

G.2 Terms and definitions

For the purposes of this annex, the following terms and definitions apply.

G.2.1
cable connected control circuit device
control circuit devices having integrally connected leads for electrical connection to other equipment and/or to the power source

G.2.2
cable entrance sealing means
sealing means between the cable and device enclosure providing the required protection from cable abrasion and which may provide required sealing of enclosure and cable anchorage

G.2.3
cable anchorage
means to relieve mechanical stress from the cable termination so as to prevent damage to the electrical connection between the device and the cable

G.7 Constructional and performance requirements

G.7.1 Constructional requirements

G.7.1.1 Cable material

The control circuit device shall be provided with flexible cable of appropriate voltage, current and temperature rating and environmental condition.

NOTE The length of cable provided ~~may~~ can be specified in the relevant product standard.

G.7.1.2 Cable anchorage

The cable anchorage shall be such that a force being applied to the cable is not transmitted to electrical connections integral to the device.

Movement of the cable into or out of the control circuit device shall not cause damage to the cable connection or internal parts of the device.

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G.7.1.3 Cable entrance sealing means

A sealing means shall be provided at the cable entrance to the control circuit device suitable for the degree of protection specified for the device (see Annex C of IEC 60947-1:2007/AMD1:2010/AMD2:2014).

NOTE The sealing means ~~may~~ can be inherent in the device encapsulation.

G.7.2 Performance requirements

The cable and the cable entrance sealing means shall be capable of withstanding the tests given in G.8.

G.8 Tests

G.8.1 General

The purpose of these tests is to ensure integrity of the cable anchorage during handling and installation. Once installed, the control circuit device and cable should be fixed relative to each other.

G.8.2 Type tests

G.8.2.1 General

The following sequence of four tests shall be performed on a representative sample in the specified order.

G.8.2.2 Pull-out test

The cable shall be subjected to a steady pull along the axis of the cable entry, applied to the insulating jacket of the cable for a duration of 1 min.

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

~~The pull force shall be 160 N for a cable diameter greater than or equal to 8 mm. The pull force for cable diameters of less than 8 mm shall be of the value (in N) of 20 times the external cable diameter (in mm).~~

In cases when cables consist of more than one conductor the pulling force is determined by multiplying the pulling force for a single conductor by the number of conductors in the cable. The maximum pulling force shall not exceed 160 N.

EXAMPLE A cable has three conductors, each with a cross section of 0,5 mm². From IEC 60947-1:2007/AMD1:2010 Table 5, the pulling force for one conductor is 20 N. Therefore the pulling force for the cable is 60 N.

G.8.2.3 Torque test

The cable shall be subjected to a torque of 0,1 N·m or limited to the value giving an angle of torque of 360°. The torque shall be applied clockwise for 1 min and then counter-clockwise for 1 min, to the cable at a distance of 100 mm from the control circuit device entrance.

G.8.2.4 Push test

The push force shall be applied along the axis of the cable as close as possible to the cable entrance.

The force is increased slowly to 20 N. The force shall be applied for 1 min for each time and with 1 min pause between applications.

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After the tests, no visible damage of the cable entrance sealing means and no displacement of the cable shall be observed.

G.8.2.5 Bend test

The cable shall be loaded and bent in the following manner:

a) suspend a 3 kg mass by attaching it to the cable, 1 m from the cable entrance and with the axis of the cable entrance vertical;

b) tilt the control circuit device 90° to cause a 90° bend in the cable, maintaining that position for 1 min;

c) tilt the control circuit device 90° in the opposite direction relative to vertical so as to cause an opposite 90° bend in the cable, maintaining the position for a duration of 1 min.

G.8.3 Results to be obtained

There shall be no damage to the cable, cable sealing means, cable entrance or the electrical connecting means of the control circuit device. This will be verified by visual examination and verification of compliance with the stated IP designation.

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Annex H
(normative)

Additional requirements for semiconductor switching elements for control circuit devices

NOTE The numbering of this annex is based on the numbering of the document.

H.1 General

~~H.1.1 Scope~~

This annex applies to control circuit devices with semiconductor switching elements for controlling, signalling, interlocking, etc. switchgear and controlgear. These devices shall also comply with the relevant requirements of this standard.

~~H.1.2 Object~~

The object of this annex is to state additional requirements for semiconductor switching elements which are not contained in this standard.

H.2 Terms and definitions

In addition to this standard, the following terms and definitions apply.

H.2.1
voltage drop
U_d
the voltage measured across the semiconductor switching element when carrying the operational current under specified conditions

H.2.2
minimum operational current
I_m
the current that is necessary to maintain ON-state conduction of the semiconductor switching element

H.2.3
OFF-state current
I_r
the current which flows through the load circuit when the switching element is in the OFF-state

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H.3 Classification

H.3.1 Semiconductor switching elements

Seminconductor switching elements may be classified as follows:

1) Utilization categories (see 4.4 and H.4.2).
2) Electrical ratings based on utilization categories (see Annex A).

H.4 Characteristics

H.4.1 Rated voltage

H.4.1.1 Rated operational voltage (U_e)

Subclause 4.3.2.2 applies.

H.4.1.2 Operational voltage

The operational voltage may be stated as a single value or as a range. When it is stated as a range it shall include all the tolerances of U_e and shall be designated U_B. The relationship between U_e and U_B is shown in Figure H.1.

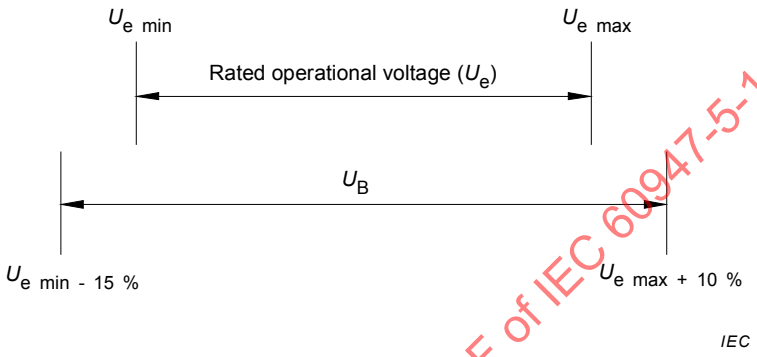

Figure H.1 – Relationship between U_e and U_B

H.4.2 Utilization categories

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

H.5 Product information

Nature of information

The following information shall be given by the manufacturer: 5.1 applies with the following additions:

Basic rated values and utilization

a) Voltage drop (see H.7.1.1)
b) Minimum operational current (see H.7.1.2)
c) OFF-state current (see H.7.1.3)
d) Making and breaking capacities (see H.7.2.1)
e) Conditional short-circuit current (see H.7.3)
f) Electromagnetic compatibility, EMC (see H.7.4)

H.7 Constructional and performance requirements

H.7.1 Performance requirements

Subclause 7.2 applies with the following additions:

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H.7.1.1 Voltage drop (U_d)

The voltage drop, measured across the switching element in the conductive mode, shall be stated by the manufacturer and verified according to H.8.2.

H.7.1.2 Minimum operational current (I_m)

This shall be stated by the manufacturer and verified according to H.8.3.

NOTE In Tables A.2 and A.3 the minimum operational currents are specified for the ratings shown.

H.7.1.3 OFF-state current (I_r)

The maximum current (I_r) which flows through the load in the OFF-state shall be in accordance with the values given in Tables A.2 and A.3, unless otherwise specified in the relevant product standard. The OFF-state current shall be verified according to H.8.4.

H.7.2 Ability to make under abnormal and normal conditions

H.7.2.1 Making and breaking capacities

See 4.3.6.

H.7.3 Conditional short-circuit current

The switching element shall withstand the stresses resulting from short-circuit currents under the conditions specified in H.8.6.

H.7.4 Electromagnetic compatibility (EMC)

Subclause 7.3 ~~of IEC 60947-1~~ applies.

H.8 Tests

H.8.1 Type tests

Subclause 8.1.2 applies with the following additions:

a) Voltage drop (see H.8.2)
b) OFF-state current (see H.8.4)
c) Making and breaking capacities (see H.8.5)
d) Performance under short-circuit current conditions (H.8.6)
e) Verification of electromagnetic compatibility (see H.8.7)
f) Impulse voltage withstand test (see 8.3.3.4)

H.8.2 Voltage drop (U_d)

The voltage drop is measured across the active output of the switching element in the ON state and carrying the current range of I_m and I_e at an ambient temperature of 23 °C ± 5 °C and at the rated frequency. The measurement is performed with the circuit in Figure H.2, with the switch S closed. The loads shall be resistive and R_2 is adjusted to obtain the test current with the supply voltage U_e.

The measured voltage drop shall not exceed the value specified in H.7.1.1.

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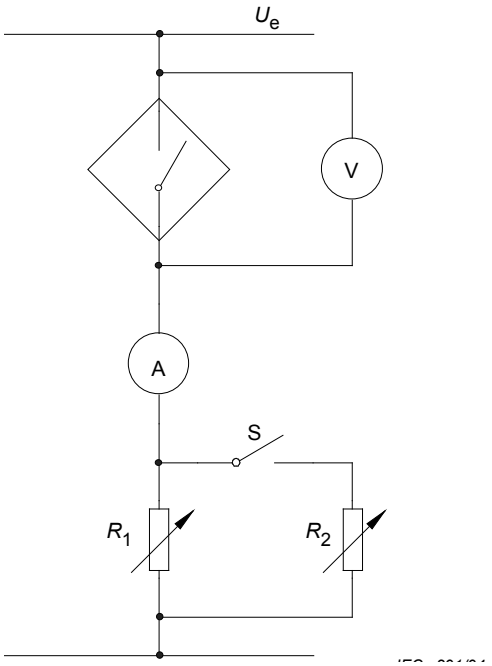

R_1 = Resistive load

R_2 = Resistive load

V = High impedance voltmeter, 0,2 MΩ/V

A = Ammeter

S = Switch

r.m.s. for a.c.
average for d.c.

Figure H.2 – Example of test circuit for the verification of voltage drop, minimum operational current and OFF-state current (see H.8.2, H.8.3 and H.8.4)

H.8.3 Minimum operational current (I_m)

The test is performed with the switching element connected to a test circuit shown in Figure H.2. With supply voltage (U_e), the switch open and the switching element in ON-state conduction, the resistive load R_1 is adjusted to obtain the current I_m. The measured value shall be according to H.7.1.2.

H.8.4 OFF-state current (I_r)

With the circuit in Figure H.2 and the S switch closed, the load R_2 is adjusted to obtain the rated operational current (I_e) when the highest supply voltage (U_e) is connected to the circuit. The switching element is then turned off and the OFF-state current is measured. The current shall be according to H.7.1.3.

H.8.5 Making and breaking capacities

Subclause 8.3.3.5 applies.

H.8.6 Performance under short-circuit current conditions

H.8.6.1 Test circuit and test procedure

A new switching element shall be mounted as in service, in free air, and connected to the test circuit using a 2 m total length cable suitable for the operational current of the switching element (see Figure H.3).

The short-circuit protective device (SCPD) shall be of the type and rating stated by the manufacturer. This SCPD shall be omitted if the switching element is integrally protected against short circuit.

The loads, R and L are so selected that the current flowing through the switching element is equal to its rated operational current at the rated operational voltage (U_e) and at the power factor or $T_{0,95}$ time constant stated in Table 5 or in Table H.3. The supply S shall be adjusted to a prospective short-circuit current of 1 000 A, ~~unless otherwise specified in the product~~

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~~standard~~ or another value if stated by the manufacturer but not less than 100 A (see 8.3.4.3), at the rated operational voltage (U_e). The supply circuit shall have air-cored reactors connected in series with resistors to provide a power factor of 0,5 to 0,7. No damping load shall be added parallel with the reactors. The open circuit voltage shall be 1,1 times the maximum rated operational voltage of the switching element.

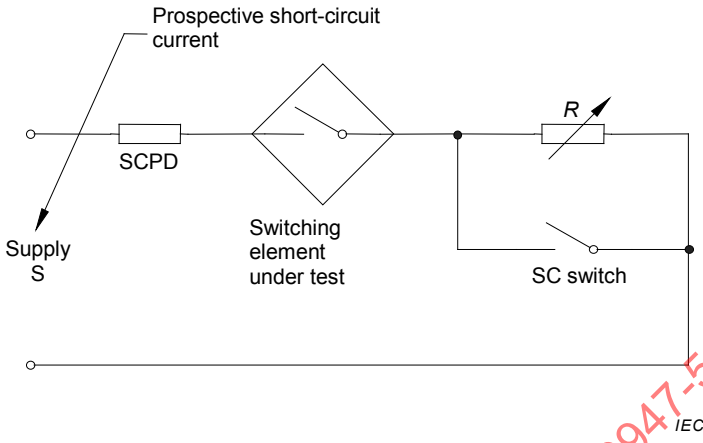

Figure H.3 – Short-circuit testing (see H.8.6.1)

The test shall be performed three times by randomly closing the "SC" switch. The test current is maintained until the SCPD operates or in the case of self-protecting elements, for 30 min. After each test the SCPD shall be replaced or reset. The interval between each of the three tests shall be not less than 3 min. The actual time between tests shall be stated in the test report.

H.8.6.2 Condition of the switching element after the test

Subclause 8.3.4.4 applies.

H.8.7 Verification of electromagnetic compatibility

H.8.7.1 General

~~Emission and immunity tests are type tests and shall be carried out under the following common conditions.~~

~~The switching element is mounted in free air connected to a load corresponding to the rated operational current (I_e) and is supplied with its rated operational voltage (U_e), or the maximum voltage of its voltage range.~~

~~The connecting leads shall be 2 m in length.~~

Subclause 8.4.1 applies with the following addition:

The tests shall be performed:

a) with the switching element in the ON-state;
b) with the switching element in the OFF-state.

H.8.7.2 Immunity

Subclause 8.4.2 applies with the following addition:

~~**H.8.7.2.1 General**~~

~~Performance criteria are based on the acceptance criteria in Table 24 of IEC 60947-1.~~

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Performance criterion A: During the tests, the output state of the switching element shall not change.

Performance criterion B: During the tests, the output state of the switching element shall not change for more than 1 ms for d.c. devices or one half wave of supply frequency for a.c. devices.

Performance criterion C: Temporary degradation or loss of performance which is self recoverable or requires system reset.

Table H.1 – Immunity tests

Type of test	Test level required	Acceptance criteria
Electrostatic discharges IEC 61000-4-2	8 kV / air discharge or 4 kV / contact discharge	B
Radiated radio-frequency electromagnetic fields (80 MHz to 1 GHz) IEC 61000-4-3	10 V/m	A
Electrical fast transients/bursts IEC 61000-4-4	2 kV on power ports [1] 1 kV on signal ports [2]	B
Surges (1,2/50 µs – 8/20 µs) IEC 61000-4-5 [3]	2 kV (line to earth) 1 kV (line to line)	B
Conducted disturbances induced by radio-frequency fields (150 kHz to 80 MHz) IEC 61000-4-6	10 V	A
Power frequency magnetic fields IEC 61000-4-8	30 A/m	A
Voltage dips and interruptions IEC 61000-4-11	Reduction to 30 % U_T for 0,5 cycle Reduction to 60 % U_T for 5 and 50 cycles	B
Harmonics in the supply IEC 61000-4-13	No requirements [4]	–

[1] Power port: the point at which a conductor or cable carrying the primary electrical power needed for the operation of the switching element or associated equipment is connected.

[2] Signal port: the point at which a conductor or cable carrying information for transferring data or signals is connected to the switching element.

[3] Not applicable for ports with a rated voltage of 24 V d.c. or less.

[4] Test levels are under study for the future.

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H.8.7.2.2 Electrostatic discharges

The test shall be performed according to IEC 61000-4-2 and Table H.1.

H.8.7.2.3 Radiated radio-frequency electromagnetic fields

The test shall be performed according to IEC 61000-4-3 and Table H.1.

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

H.8.7.2.4 Electrical fast transients/bursts

The test shall be performed according to IEC 61000-4-4 and Table H.1, with the connecting leads of the device placed in the capacitive coupling clamp.

~~NOTE The capacitive coupling is the preferred test method because it simulates the disturbances present during normal application as a result of parallel wires.~~

H.8.7.2.4 Surges

~~The test shall be performed according to IEC 61000-4-5 and Table H.1, with the following additional requirements in order to simplify the test procedure without impairing the validity of the verification of the EMC requirements:~~

~~The switching element is powered during the test.~~

~~– the impulse test shall be applied:~~

~~a) between terminals intended to be connected to the power supply;~~

~~b) between each output terminal and each terminal intended to be connected to the power supply.~~

~~– Three positive and three negative impulses shall be applied between each two points at intervals of not less than 5 s.~~

Subclause 8.4.2.4 applies with the following addition:

The switching element is powered during the test.

~~**H.8.7.2.6** Conducted disturbances induced by radio-frequency fields~~

~~The test shall be performed according to IEC 61000-4-6 and Table H.1.~~

~~**H.8.7.2.7** Power-frequency magnetic fields~~

~~The test shall be performed according to IEC 61000-4-8 and Table H.1.~~

~~Applicable only to equipment containing devices susceptible to power-frequency magnetic fields.~~

~~**H.8.7.2.8** Voltage dips and interruptions~~

~~The test shall be performed according to IEC 61000-4-11 and Table H.1.~~

~~Applicable only to a.c. switching elements.~~

H.8.7.3 Emission

The test shall be performed under worst case conditions according to CISPR 11 Group 1, Class A, and 7.3.3.2 of IEC 60947-1:2007/AMD2:2014.

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These limits are given for switching elements exclusively intended for use in industrial environment A. When they can be used in domestic environment B, the following notice shall be included in the instructions for use:

NOTICE

This is a Class A product. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

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Annex J
(normative)

Special requirements for indicator lights and indicating towers

J.1 General

~~J.1.1 Scope~~

This annex applies to indicator lights and indicating towers, which shall also comply with the relevant requirements of this standard.

~~J.1.2 Object~~

This annex gives additional requirements applicable to indicator lights, together with definitions and terms useful for stating the required characteristics of design and performance.

J.2 Terms and definitions

The following additional terms and definitions are applicable.

J.2.1
indicator light
light signal giving information either by lighting or extinguishing

J.2.2
lens of an indicator light
visible part, removable or not, constituting the surface intentionally made transparent or translucent

J.2.3
bezel
holder of a lens

J.2.4
indicator light with a built-in voltage-reducing device
indicator light, the body of which contains a device (transformer, resistor, etc.) intended to supply, at the terminals of a lamp, a voltage different from the rated operational voltage of the light

J.2.5
indicating tower
assembly including one or more signalling units giving information by visible or audible signals

NOTE Other elements, e.g. network interface elements ~~may~~ can be added.

J.3 Classification

Indicator lights may be classified by:

- the rated electrical power;
- the colour;
- the fixing hole diameter;

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- the means of connection;
- the nature of the current applied and its frequency, if any (for example lights with built-in transformers);
- the type of lamp socket;
- Nature of light source (for example: filament lamp, LED).

J.4 Characteristics

J.4.1 Rated operational voltage of an indicator light

A value of voltage, assigned by the manufacturer which determines the application of the indicator light.

J.4.2 Rated thermal power of an indicator light

The maximum lamp power which an indicator light is designed to tolerate under conditions specified for the temperature-rise test.

NOTE As the power of the light has an effect on the temperature rise, it ~~may~~ can be ~~necessary~~ useful to limit the power according to the mounting conditions; the manufacturer of the indicator light ~~may~~ can assign two values of rated power (see J.8.3.3.3):

- the rated power of the light for mounting on a steel plate;
- the rated power of the light for mounting in an insulating enclosure.

J.4.3 Rated values of the lamp

Rated value of the lamp(s) indicated by the manufacturer and with which the indicator light operates without attaining temperatures likely to damage its parts.

NOTE 1 Rated power and voltage ~~may~~ can be indicated by a type designation.

NOTE 2 It is assumed that a lamp does not dissipate a power higher than its rated power at its rated voltage.

J.5 Product information

The applicable requirements are:

Items a) and b) of 5.1;

c) the following markings shall appear on the indicator light:
   1) rated voltage of the indicator light;
   2) rated voltage of the lamp (if different from the rated voltage of the indicator light).
   3) rated power of the lamp or its type designation, or rated current for a LED.

J.6 Normal service, mounting and transport conditions

There are no supplementary requirements.

The following mounting dimensions for the indicating tower socket are recommended (see Figure J.1).

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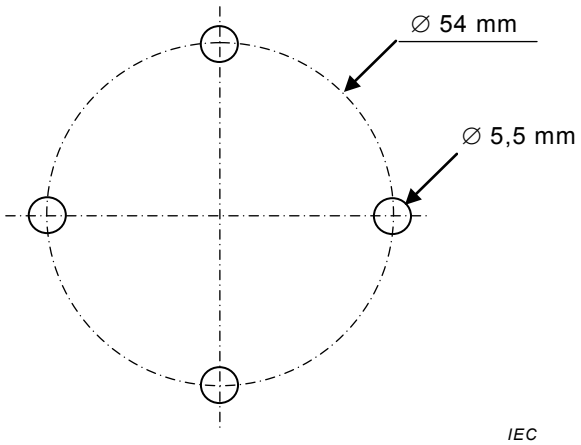

Figure J.1 – Mounting dimensions for indicating tower socket

J.7 Constructional and performance requirements

Clause 7 applies with the following additions:

J.7.1.12 Indicator lights with built-in transformers

The transformer shall have separate windings.

It is assumed that this condition is fulfilled if the indicator light passes the test described in 8.3.3.4.1.

~~**J.7.1.13 Colour of the lens**~~

~~It is recommended that the colour of the lens be chosen among those mentioned in IEC 60073 and also in Publication No. 2 of the International Commission of Illumination (CIE).~~

~~The colour shall remain essentially unchanged in spite of the adverse influence of the environment, including the effect of ultra-violet light.~~

~~Colours used for identification shall be bright and easily distinguishable.~~

~~NOTE For indicating towers on machines, the fifth edition of IEC 60204-1[1)] (under preparation) requires the following sequence of colours from top down: red, yellow, blue, green and white.~~

J.7.2.1.6 Limits of operation

The limiting value of the supply voltage at the terminals of the indicator light shall be 1,1 times the rated operational voltage. This requirement is verified only for indicator lights with built-in transformer according to J.8.3.4.

J.7.2.5.1 Short-circuit withstandability of built-in transformer

The transformer shall be able to withstand permanently the short circuit of its secondary winding. It is assumed that this condition is fulfilled if the indicator light passes the test described in J.8.3.3.3.

~~[1)] IEC 60204-1, *Safety of machinery – Electrical equipment of machines – Part 1: General requirements*~~

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J.8 Tests

J.8.3 Tests for indicator lights and indicating towers

The tests are type tests. No additional test (routine test or special test) is prescribed in this annex.

Each of the tests in J.8.3.3.3, J.8.3.3.4, J.8.3.4 and J.8.4 shall be made on new apparatus mounted in accordance with the test instructions.

J.8.3.3.3 Temperature-rise tests

The temperature-rise tests shall be conducted as follows:

a) If the indicator light has the same rated thermal power (see J.4.2) regardless of mounting conditions, a single test is made in an insulated enclosure.

b) If the rated thermal power (see J.4.2) is dependent on the mounting conditions, two tests are made:

   – on a steel plate, and

   – in an insulated enclosure.

c) Mounting on a steel plate

   Five indicator lights fitted with green lenses are fixed in accordance with the following diagram on a steel plate 2 mm thick, painted mat black (see Figure J.2).

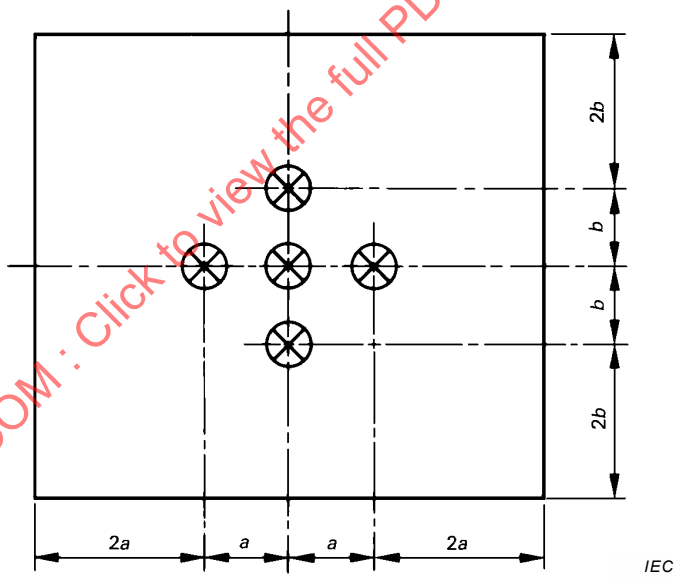

Figure J.2 – Mounting dimensions for temperature rise tests

Dimensions *a* and *b* are:

1) for indicator lights forming an integral part of a push-button range: in accordance with 6.3.1.3;

2) for other indicator lights: as stated by the manufacturer, but the values used shall be recorded in the test report.

The indicator lights are fitted with lamps as stated by the manufacturer and, if any, with built-in devices such as transformers, resistances, etc. The conductor sizes shall be as specified in 8.3.3.3.

The plate is located vertically on a table and the indicator lights are supplied at their rated voltage. The duration of the test shall be such that a steady-state temperature is reached.

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d) Mounting in an insulating enclosure

The test described in item c) is carried out again with the indicator lights mounted into an enclosure of insulating material, such as bakelite-coated paper 2 mm thick, the front face of which has the same dimensions as the steel plate and the depth of which is 110 mm. The indicator lights are fitted with lamps and mounted as stated by the manufacturer for this type of use; they are supplied at their rated operational voltage.

The duration of the test shall be such that a steady-state temperature is reached.

e) Results to be obtained

At the end of each of the tests described in items c) and d) the temperatures are measured:

– on the body of the indicator light;

– on the terminals;

– on the accessible part of the lens.

f) For indicating towers, an arrangement of five visual signalling units shall be mounted in a vertical position. The upper three signalling units, or the maximum number stated by the manufacturer if greater than three, shall be equipped with the maximum power lamp of signalling units as stated by the manufacturer and powered at the rated voltage. After the steady state temperature is reached, the temperature shall be measured on top of the tower and on the lens of the centre element of the complete tower.

None of the corresponding temperature-rises shall exceed the limits referred to in 7.2.2 of IEC 60947-1:2007.

J.8.3.3.4 Dielectric tests

8.3.3.4 applies.

J.8.3.3.4.3 Indicator lights with built-in transformers

Two additional dielectric tests shall be made, the duration of each being 1 min:

- between the primary and secondary windings of the transformer with the test voltage value specified in 8.3.3.4;
- between the secondary windings of the transformer and the frame of the indicator light with a test voltage value of 1 000 V.

J.8.3.4 Short-circuit test (on built-in transformers, if any)

The test shall be made under the following conditions:

- primary voltage: 1,1 × U_e;
- ambient air temperature: 20 °C ± 5 °C;
- duration of the test: 1 h.

The transformer shall be short-circuited by a conductor of negligible impedance.

After the test and after cooling to ambient temperature, the transformer shall withstand the dielectric test defined in J.8.3.3.4.3.

J.8.4 Shock and vibration

J.8.4.1 General

Tests for shock and vibration shall be carried out for indicating towers only. Indicator lights are not considered to be tested.

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J.8.4.2 Direct mounting

J.8.4.2.1 General

An indicating tower with five signalling units shall be mounted as stated by the manufacturer without extension poles and the upper three units powered at the rated voltage.

The tests shall be performed as follows.

J.8.4.2.2 Shock

In accordance with IEC 60068-2-27 with the following conditions.

Six shocks applied in each direction along three mutually perpendicular axes (a total of 36 shocks):

- pulse shape: half-sine;
- peak acceleration: 15 g_n;
- duration of the pulse: 11 ms.

J.8.4.2.3 Vibration

In accordance with IEC 60068-2-6 with the following conditions, along three mutually perpendicular axes:

- frequency range: 10 Hz to 55 Hz;
- amplitude: 0,5 mm;
- sweep cycle duration: 5 min;
- duration at resonant frequency or at 55 Hz: 30 min in each of the three axes (90 min in total).

J.8.4.3 Indirect support mounting

If the product literature includes other allowable mounting conditions (e.g. pole mounting), the manufacturer shall state the severity level for shock and vibration tests at which the requirements of J.8.4.4 are met.

J.8.4.4 Results to be obtained

After the tests, no visible damage shall be observed and the signalling shall not be impaired.

J.8.5 Degree of protection for indicating towers

If the manufacturer declares a degree of protection, the test shall be conducted according to Annex C of IEC 60947-1:2007/AMD1:2010 with all removable parts equipped as in normal service.

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Annex K
(normative)

Special requirements for control switches with direct opening action

K.1 General

~~K.1.1 Scope~~

This annex is applicable to control switches with direct opening action.

All control switches with direct opening action shall also comply with the relevant requirements of the standard and, where applicable, to those given in Annexes F, G, H and/or J.

~~K.1.2 Object~~

This annex gives additional requirements applicable to control switches with direct opening action, together with definitions and terms useful for stating the required characteristics of design and performance.

K.2 Terms and definitions

The following additional terms and definitions apply:

K.2.1
control switch with direct opening action
control switch having one or more break-contact elements coupled to the switch actuator via non-resilient members so that full contact opening of the break-contact element(s) is obtained when the actuator is moved through the direct opening travel by applying the force stated by the manufacturer

K.2.2
direct opening action
<contact element> achievement of contact separation as the direct result of a specified movement of the switch actuator through non-resilient members (for example not dependent upon springs)

K.2.3
direct opening travel
travel from the beginning of actuation of the actuator and the position when the direct opening action of the opening contacts is completed

K.2.4
direct opening force (or moment)
actuation force, or actuating moment for a rotary control switch, applied to the actuator for the direct opening action

K.3 Classification

There are two types of control switches with direct opening action:

Type 1: Having one contact element only, this contact element is a direct opening break-contact element.

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Type 2: Having one or more break-contact elements, and possibly, one or more make-contact elements and/or one or more change-over contact elements. All break-contact elements including the break part of change-over contact elements shall be direct opening break-contact elements.

K.4 Characteristics

The following additional characteristics apply:

K.4.3.1.2 Rated insulation voltage

The minimum value of the rated insulation voltage of the contact elements shall be 250 V.

K.4.3.2.1 Conventional free air thermal current

The minimum value of the conventional free air thermal current of the contact elements ~~is~~ shall be 2,5 A.

K.4.4 Utilization categories for switching elements

The utilization categories shall be AC-15 and/or DC-13.

~~NOTE~~ In addition to AC-15 and/or DC-13, other utilization categories according to Table 1 (e.g. AC-14 or DC-~~14~~ 12) are permitted.

K.5 Product information

Clause 5 is applicable with the following additions:

K.5.2 Marking

K.5.2.7 Direct opening action

Every contact element with direct opening action shall be indelibly and legibly marked on the outside by the symbol:  IEC 60617-S00226 (2001-07)

K.5.2.8 Electrical separation for change-over contact elements

Change-over contact elements with four terminals shall be indelibly and legibly marked with the relevant form Za or Zb as stated in Figure 4.

K.5.4 Additional information

K.5.4.1 Actuator travel and operating force

The manufacturer shall state the following:

a) the minimum direct opening travel;

b) the minimum force required to achieve direct opening action of all break contacts;

c) the maximum travel including travel beyond the minimum travel position (i.e. including overtravel);

d) for limit switches only the maximum speed of actuation;

e) for limit switches only the maximum frequency of actuation.

These statements shall appear in the marking or on the circuit diagram or other documents published by the manufacturers.

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NOTE 1 See also K.7.1.5.3.

NOTE 2 Type 2 control switches ~~may~~ can open with less travel than the direct opening travel stated by the manufacturer.

K.5.4.2 Short-circuit protection

The type of short-circuit protective device shall be stated either as marking on the switch or in the installation instructions.

K.6 Normal service, mounting and transport conditions

Clause 6 applies, with the following additions:

K.6.1.1 Ambient air temperature

Subclause 6.1.1 of IEC 60947-1:2007/AMD2:2014 applies, except for position switches with direct opening action, for which the upper and lower limits of temperature are respectively +70 °C and –25 °C, and the average temperature, measured over a period of 24 h, does not exceed +35 °C.

NOTE The choice of the connecting conductors ~~may~~ can, if ~~necessary~~ applicable, be subject to agreement between manufacturer and user (see footnote b of Table 2 of IEC 60947-1:2007).

K.7 Constructional and performance requirements

Clause 7 applies with the following additions:

K.7.1.4.3.1 Robustness of the actuating system

In order to have sufficient robustness, the actuating system shall pass the test described in K.8.3.7.

K.7.1.4.3.2 Directness of opening action

A control switch with direct opening action shall pass the tests described in K.8.3.4, K.8.3.5 (in the case of a position switch with a direct opening action), and K.8.3.7 without any deformation that would reduce the impulse voltage withstand across the contact gap.

K.7.1.4.5 Automatic opening of cable operated control switches

Cable operated control switches with direct opening action shall return automatically to the open position in case of failure of the cable or its anchorage.

K.7.1.4.6 Conditions for direct opening action (see 2.4.10 of IEC 60947-1:2007)

For parts of the travel that separates the contacts, there shall be a positive drive with no resilient member (for example springs) between the moving contacts and the point of the actuator to which the actuating force is applied.

K.7.1.4.6.1 Contact element types

Control switches with direct opening action may be provided with snap action or dependent action contact elements.

The break-contact elements shall be electrically separated from each other and from the operating make-contact elements.

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When the control switch has form C or form Za change-over contact elements (see Figures 4 c) and 4 d)), only one contact element (make or break) shall be used. In the case of form Zb change-over contact elements, both contacts may be used.

K.7.1.5.3 Actuator travel indication

In order to facilitate the setting up of the switch actuator in relation to the external operating means, for example a cam, the switch may include means for indicating the minimum travel of the actuator required to ensure direct opening action, for example by the provision of a mark on the actuator plunger (see Note 1, item a) of K.5.4.1).

K.8 Tests

In addition to Clause 8, and Annex C, the following applies:

K.8.3.1 Test sequences

Subclause 8.3.1 applies with the following additions:

- Test sequence VII (sample No. 7) – Mechanical operation of position switches with direct opening action.

  Test No. 1 – Mechanical operation at limits of temperature (see K.8.3.5).

  Test No. 2 – Verification of direct opening action (see K.8.3.6).
- Test sequence VIII (sample No. 8)
- Verification of robustness of the actuating system (see K.8.3.7).

K.8.3.4 Performance under conditional short-circuit current

Subclause 8.3.4 applies with the following additions:

K.8.3.4.2.1 Verification of conditional short-circuit current

The test shall be made as stated in 8.3.4.2, except that the current is made by a ~~positive~~ direct opening contact element and not by the additional switching device and the test is made on ~~each of~~ the ~~three~~ device~~s~~ by making the current three times by the same contact element in a single phase circuit.

For type 2 control switches, the contact element shall be chosen at random.

K.8.3.4.4.1 Operation ability after the test

After each test, the opening contact element shall open by the application of the force stated by the manufacturer through the ~~positive~~ direct opening travel (see items a) and b) of K.5.4.1).

The open position of the contact element shall be verified by the application of an impulse test voltage of 2 500 V across the contact gap.

K.8.3.5 Verification of mechanical operation of position switches at limits of temperature

This test applies only to position switches with direct opening action. The position switch shall be conditioned at +70 °C for 8 h.

At the end of the conditioning period and at the same temperature, the contacts shall be loaded with the maximum rated operational current for 10 min. The contacts shall then

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be operated 10 times by the application of the force stated by the manufacturer according to item b) of K.5.4.1.

The test shall be repeated after conditioning at –25 °C but without application of the current.

After completion of this test, the open position of the contacts shall be verified according to K.8.3.6.

K.8.3.6 Verification of direct opening action

When the position switch is in the position corresponding to the direct opening travel stated in item a) of K.5.4.1, the contact gap shall withstand an impulse voltage of 2 500 V.

For position switches suitable for isolation, the value of the impulse withstand voltage shall be in accordance with Table 14 of IEC 60947-1:2007 corresponding to the rated impulse withstand voltage U_{imp} declared by the manufacturer.

K.8.3.7 Verification of robustness of the actuating system

The closed break contact(s) shall be loaded with a force F_1 of 10 N (see Figure K.1). A force (moment) F_2, higher than F_1, stated by the manufacturer, shall be applied to the actuator through the direct opening travel.

After this test, the actuating system and/or contacts shall remain functional and shall withstand an impulse test voltage in accordance with K.8.3.6.

For position switches suitable for isolation, the value of the impulse withstand voltage shall be in accordance with Table 14 of IEC 60947-1:2007 corresponding to the rated impulse withstand voltage U_{imp} declared by the manufacturer.

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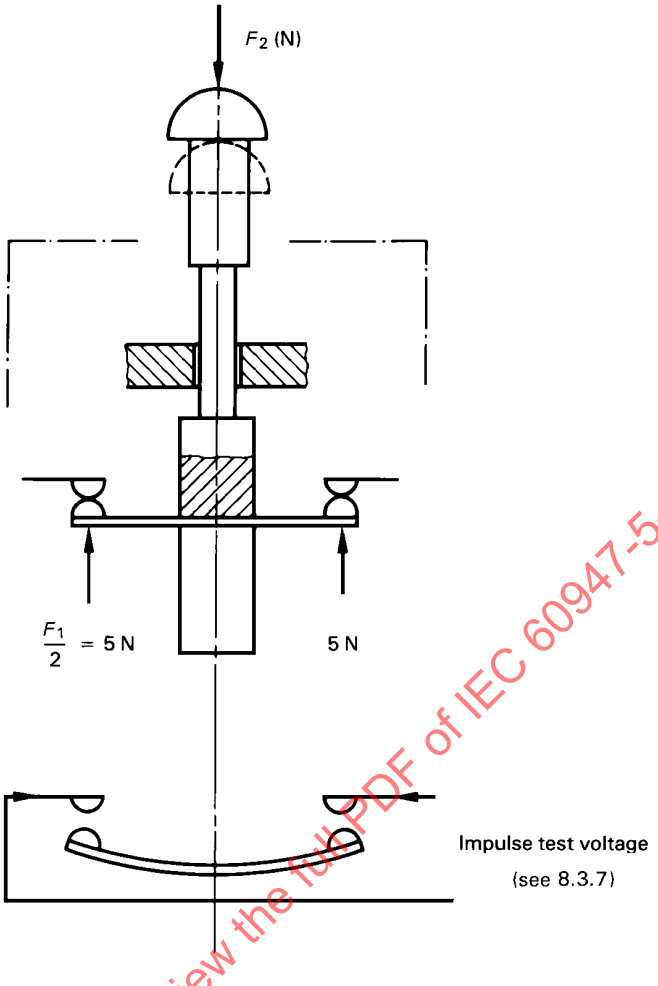

NOTE – F_1 = Required opening force = 10 N.
F_2 = Force (moment) stated by the manufacturer.

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Figure K.1 – Verification of robustness of the actuating system

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Annex L
(normative)

Special requirements for mechanically linked contact elements

L.1 General

~~L.1.1 Scope~~

This annex applies to mechanically linked auxiliary contact elements included in control circuit devices where actuating force is provided internally, such as contactor-relays.

Linkage between the auxiliary and main contacts is not covered by this annex.

NOTE 1 A typical application of mechanically linked contact elements is e.g. self-monitoring in machine control circuits.

NOTE 2 Mechanically linked contact elements have previously been referred to as forced contacts, positively activated contacts, or linked contacts, or, in French: "contacts forcés" or in German: "Zwangsgeführte Kontakte".

NOTE 3 Control circuit devices actuated externally (e.g. push-button or limit switches) do not have an actuating force limited to a maximum value (see L.8.4 a) 2)), so they cannot have mechanically linked contact elements. For such devices, safety applications generally use contacts with "direct opening action" (see Annex K).

~~L.1.2 Object~~

NOTE 4 The meaning of “mechanically linked” is also applicable to additional contact units which can be mounted by the user.

This annex provides additional specifications (definition, requirements and tests) which shall be used for stating the required design characteristics, marking and performance of mechanically linked contact elements.

L.2 Terms and definitions

The following additional terms and definitions apply.

L.2.1
mechanically linked contact elements
combination of *n* Make contact element(s) and m Break contact element(s) designed in such a way that they cannot be in closed position simultaneously under conditions defined in L.8.4

Note 1 to entry: One control circuit device may have more than one group of mechanically linked contact elements.

Note 2 to entry: See also L.7.1.9.

L.3 Classification

Clause 3 applies.

L.4 Characteristics

All mechanically linked contact elements shall also comply with the relevant requirements given in this standard.

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L.5 Product information

Clause 5 applies with the following addition:

L.5.2.7 Mechanically linked contact elements identification and marking

Mechanically linked contact elements shall be clearly identified:

- on the control circuit device itself;
- or in the manufacturer's documentation;
- or both.

The mechanical linkage shall be identified in circuit diagrams by a double parallel line connecting a filled circle on each of the mechanically linked contact symbols. An example is given in Figure L.1.

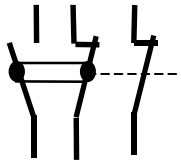

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Figure L.1 – Example of representation of NO and NC contacts which are mechanically linked and NC non-linked contact

If devices containing some or all mechanically linked contacts are marked, the symbol shown in Figure L.2 shall be used.

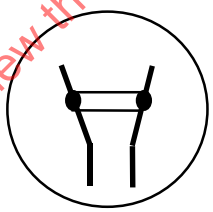

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Figure L.2 – Symbol for device containing mechanically linked contacts

L.6 Normal service, mounting and transport conditions

There are no supplementary requirements.

L.7 Constructional and performance requirements

Clause 7 applies with the following addition:

L.7.1.9 Requirements for mechanically linked contact elements

While any of the *n* Make contact element(s) is closed, none of the *m* Break contact element(s) shall be closed.

While any of the *m* Break contact element(s) is closed, none of the *n* Make contact element(s) shall be closed.

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L.8 Tests

Clause 8 applies with the following addition:

L.8.4 Special test for mechanically linked contact elements

This special test shall be carried out on a sample of (*m* + *n*) products where *m* is the number of break contact element(s) and *n* is the number of make contact element(s).

A different sample is used for each test.

The tests shall be carried out on products in new and clean condition. The test procedure shall be as follows:

a) Test of NC contact:

1) the NC contact element shall be maintained in the closed position ~~e.g. by welding or gluing each point of contact (e.g. for double breaking contact, welding is done at the two contacts points)~~ by any means at each point of contact (e.g. for a double breaking contact, the attaching shall be done at the two contact points). The thickness of ~~welding or gluing~~ the means of attachment shall be such that the distance between the NC contacts is not ~~modified~~ reduced and not increased by more than 0,02 mm;

2) an actuating force shall be applied by energising the operating coil at 110 % of its rated voltage;

3) while applying the force, an impulse test voltage of 2,5 kV (1,2/50 µs at sea level; correction should be made according to Table 12 of IEC 60947-1:2007) shall be applied across every NO contact. There shall be no disruptive discharge.

NOTE 1 This test ensures a minimum gap of ~~0,5~~ 0,6 mm in accordance with Table 13 of IEC 60947-1:2007.

b) Test of NO contact:

1) an actuating force shall be applied by energising the operating coil at its rated voltage;

2) the NO contact element shall be maintained in the closed position ~~e.g. by welding or gluing each point of contact (e.g. for double breaking contact, welding is done at the two contacts points)~~ by any means at each point of contact (e.g. for a double breaking contact, the attaching shall be done at the two contact points). The thickness of ~~welding or gluing~~ the means of attachment shall be such that the distance between the NO contacts is not ~~modified~~ reduced and not increased by more than 0,02 mm;

3) an actuating force shall be applied by de-energising the operating coil;

4) with the operating coil de-energised, an impulse test voltage of 2,5 kV (1,2/50 µs at sea level; correction should be made according to Table 12 of IEC 60947-1:2007) shall be applied across every NC contact. There shall be no disruptive discharge.

NOTE 2 This test ensures a minimum gap of ~~0,5~~ 0,6 mm in accordance with Table 13 of IEC 60947-1:2007.

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Annex M
(normative)

Terminal marking, distinctive number and distinctive letter for control circuit devices

M.1 Scope

This annex applies to control switches and contactor relays irrespective of their construction, having terminal marking.

The use of this annex is required where terminal marking is a requirement in this standard, or is usual practice.

M.2 Terminal marking rule

M.2.1 General

Terminal marking in accordance with this annex is based, in principle, on a two-digit number.

M.2.2 Function digit

Subclause L.3.2.1 of IEC 60947-1:2007 applies.

M.2.3 Sequence digit

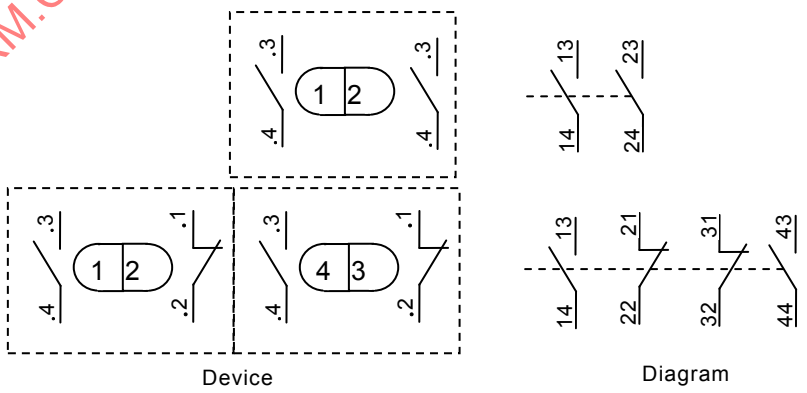
The tens digit is an ascending sequence number independent of the contact function.

Terminals belonging to the same contact are marked with the same sequence digit.

For contactor relays having 10 contact elements, the sequence digit 0 is used instead of 10.

The sequence digit may be omitted from the terminal marking only if additional information provided by the manufacturer or the user clearly gives such digit.

EXAMPLE For control switches



NOTE The dots before the function number shown in these examples are used merely to show the digit relationship, and do not need to be used in practice.

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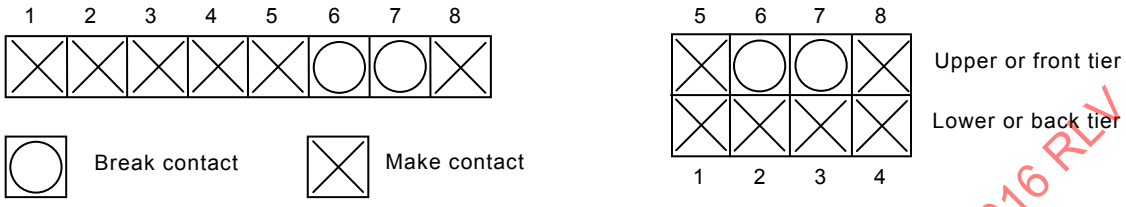
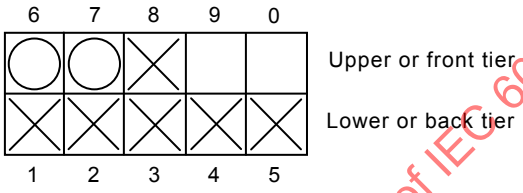
M.2.4 Numbering method

The contact terminals shall be numbered sequentially from left to right on the device; for devices with tiers of terminals, the numbering shall begin with the tier nearest to the mounting level.

EXAMPLE Contact numbering methods on contactor relays of various constructional types, but with the same distinctive number 62 E



The prescribed numbering method does not allow blank contact cells inside a contact series.



M.3 Distinctive number and distinctive letter

M.3.1 General

The quantity and type of the contact elements of a control switch according to this annex are indicated by a distinctive number. Contacts of contactor relays are indicated by a distinctive number followed by a distinctive letter.

M.3.2 Distinctive number

The first digit of the distinctive number gives the quantity of make contact elements and the second digit the quantity of break contact elements. The third digit, if any, shall give the quantity of change-over contact elements in control switches.

M.3.3 Distinctive letter

The distinctive letter indicates the location of the contact elements of a contactor relay in relation to each other and their terminal marking.

Clause M.5 defines the arrangement of contactor relays indicated by the distinctive letter E.

Clause M.6 gives information on permissible deviations, indicated by the distinctive letters X, Y or Z.

For new designs, the arrangement indicated by the distinctive letter E is preferred.

M.4 Terminal numbering sequence

For control switches having the same distinctive number, the preferred terminal marking is specified in Table M.1. Deviations from this numbering system are permitted.

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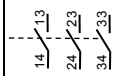
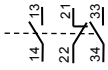
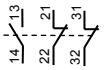
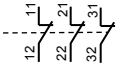
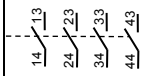
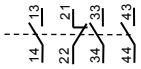
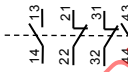
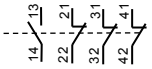
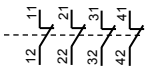
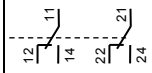
The position of the contact elements of the control switch need not correspond to that shown on diagrams of Table M.1.

Table M.1 – Diagrams of control switches

Distinctive number	Contact elements	Distinctive number	Contact elements	Distinctive number	Contact elements	Distinctive number	Contact elements	Distinctive number	Contact elements
10								01	
20		11						02	
30		21		12				03	
40		31		22		13		04	
001									
002									

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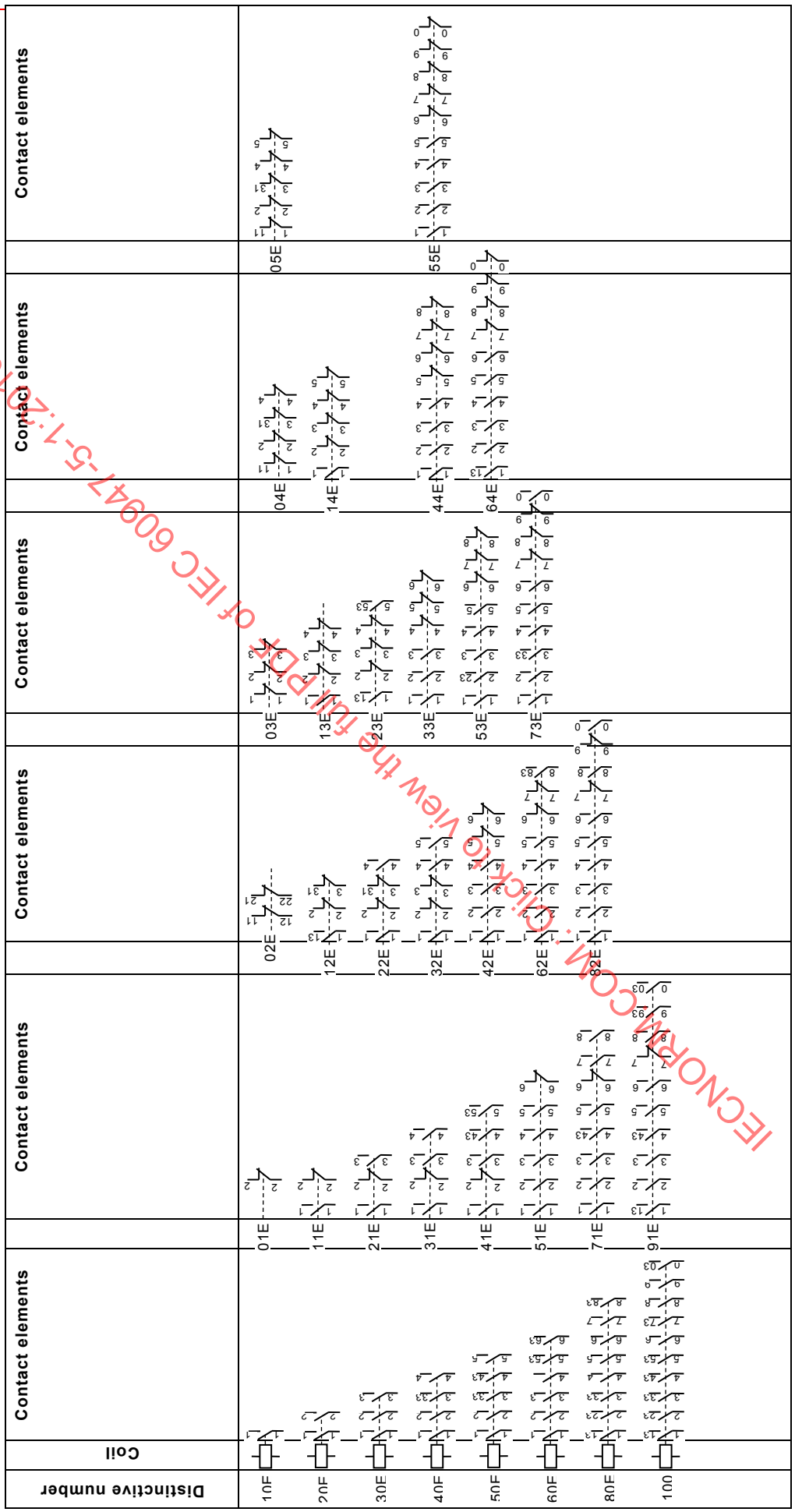
M.5 Contactor relays designated by the distinctive letter E

For contactor relays having the same distinctive number and the distinctive letter E, independently of their construction, the sequence of the contact elements within the device is specified in accordance with the diagrams of Table M.2.

As a result of this the sequence number becomes a location number and allows a given contact element terminal of a contactor relay in the equipment to be quickly found solely by counting the contacts.

Table M.2 – Diagrams of contactor relays designated by the distinctive letter E



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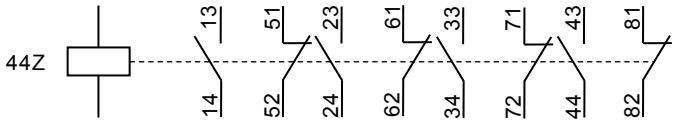
M.6 Contactor relays designated by distinctive letters X, Y or Z

M.6.1 Contactor relays designated by the distinctive letter Z

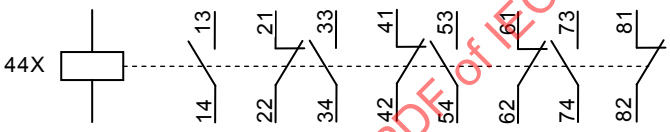
If the location of the contact elements within the device (but not the terminal marking) differs from the provisions of Clause M.5, the device shall be designated by the distinctive letter Z instead of the distinctive letter E.



M.6.2 Contactor relays designated by the distinctive letter X

If the location of the contact elements within the device and the terminal marking both differ from the requirements of Clause M.5, the device shall be designated by the distinctive letter X instead of the distinctive letter E.

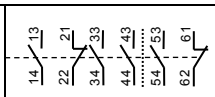
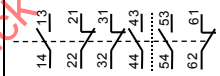
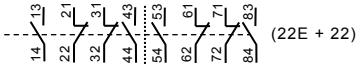
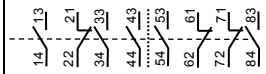
Such a device shall still comply with the requirements of Clauses M.2 and M.3.



M.6.3 Contactor relays designated by the distinctive letter Y

Devices consisting of combinations of contact elements and terminal marking in accordance with Table M.3 shall be designated by the distinctive letter Y instead of the distinctive letter E.

Table M.3 – Diagrams of contactor relays designated by the distinctive letter Y

42Y	 (31E + 11)	33Y	 (22E + 11)	44Y	 (22E + 22)
		53Y	 (31E + 22)		

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Annex N
(normative)

Procedure to determine reliability data for electromechanical devices in control circuits used in functional safety applications

N.1 General

N.1.1 Overview

Provision of these data is optional, at the discretion of the manufacturer.

N.1.2 Scope and object

K.1.2 of IEC 60947-1:2007/AMD2:2014 applies with the following addition:

This annex addresses only the intended use of electromechanical contacts in control circuit devices.

EXAMPLE: The intended use for normally closed contacts is to open the circuit.

N.1.3 General requirements

K.1.3 of IEC 60947-1:2007/AMD2:2014 applies.

N.2 Terms, definitions and symbols

K.2 of IEC 60947-1:2007/AMD2:2014 applies.

N.3 Method based on durability test results

N.3.1 General method

K.3.1 of IEC 60947-1:2007/AMD2:2014 applies.

N.3.2 Test requirements

N.3.2.1 General

The test environment shall be in accordance with Clause 6.

Every test shall be performed under the general conditions stated in 8.3.2.1 and at a rate equal or higher at the discretion of the manufacturer. The moving parts of the device shall reach their maximum operating positions in both directions, as recommended by the manufacturer. Reliability data to be published are described in Clause N.4.

N.3.2.2 Mechanical durability

The mechanical durability of a control circuit device is defined as the number of no-load operating cycles. For the no-make current or no-break current utilization the mechanical durability is applicable.

During the test, periodically the contacts shall be checked at any voltage and current, selected by the manufacturer, and there shall be no failure.

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N.3.2.3 Electrical durability

The electrical durability of a control circuit device is defined as the number of on-load operating cycles.

Electrical durability shall be determined in accordance with C.3.2 using utilization category AC-15 and / or DC-13 unless otherwise stated by the manufacturer.

N.3.3 Number of samples

K.3.3 of IEC 60947-1:2007/AMD2:2014 applies with the following addition:

The selection of samples to be tested for a series of devices with same fundamental design and without significant difference in construction shall be based on engineering judgment.

EXAMPLE If an auxiliary contact is in use for a range of devices (e.g. contactors), only one set can be tested with one contactor representative for the whole frame size.

N.3.4 Characterization of a failure mode

K.3.4 of IEC 60947-1:2007/AMD2:2014 applies.

N.3.5 Weibull modelling

K.3.5 of IEC 60947-1:2007/AMD2:2014 applies.

N.3.6 Useful life and upper limit of failure rate

K.3.6 of IEC 60947-1:2007/AMD2:2014 applies.

N.3.7 Reliability data

K.3.7 of IEC 60947-1:2007/AMD2:2014 applies.

N.4 Data information

K.4 of IEC 60947-1:2007/AMD2:2014 applies.

N.5 Example

K.5 of IEC 60947-1:2007/AMD2:2014 applies.

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Bibliography

IEC 60050-441:1984: *International Electrotechnical Vocabulary – Part 441: Switchgear, controlgear and fuses*
IEC 60050-441:1984/AMD1:2000

IEC 60050-444:2002, *International Electrotechnical Vocabulary – Part 444: Elementary relays*

IEC 60255 (all parts), *Electrical relays*

IEC 60410, *Sampling plans and procedures for inspection by attributes*

IEC 61000 (all parts), *Electromagnetic compatibility (EMC)*

IEC 61810 (all parts), *Electromechanical elementary relays*

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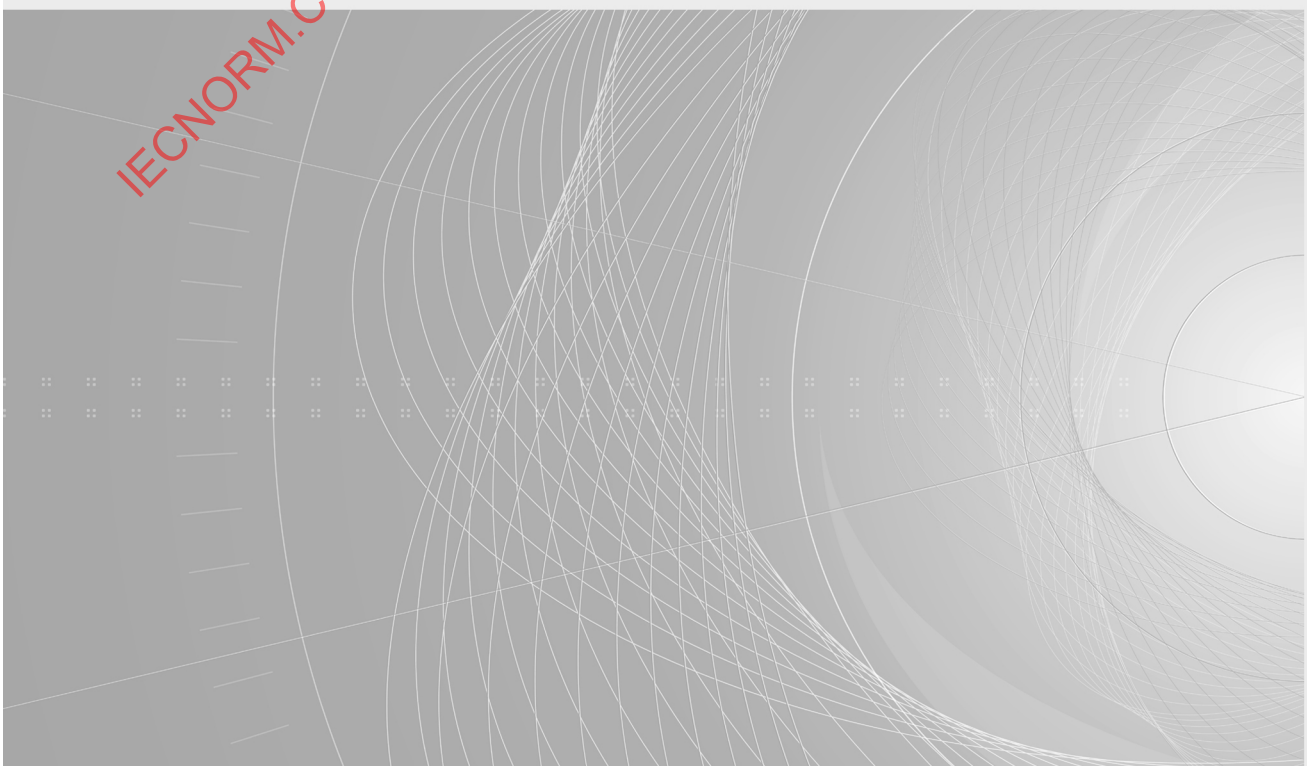
Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices

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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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.
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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) udpate of EMC requirements;

e) clarification of requirements and update of 8.2;

f) addition of requirements for screwless-type clamping units;

g) udpate 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,
- withdrawn,
- replaced by a revised edition, or
- amended.

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

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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).

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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:2002[1], *Graphical symbols for use on equipment*

IEC 60617-DB:2012[2], *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

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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.

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IEC 60947-4-1:2009, *Low-voltage switchgear and controlgear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters*
IEC 60947-4-1:2009/AMD1:2012

IEC 60947-5-5:1997, *Low-voltage switchgear and controlgear – Part 5-5: Control circuit devices and switching elements – Electrical emergency stop device with mechanical latching function*
IEC 60947-5-5:1997/AMD1:2005
IEC 60947-5-5:1997/AMD2:2016

IEC 60999-1:1999, *Connecting devices – Electrical copper conductors – Safety requirements for screw-type and screwless-type clamping units – Part 1: General requirements and particular requirements for clamping units for conductors from 0,2 mm^2 up to 35 mm^2 (included)*

IEC 61000-3-2, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current < 16 A per phase)*

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*

IEC 61000-4-2:2008, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

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

IEC 61000-4-4:2012, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

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*

IEC 61000-4-8:2009, *Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test*

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

IEC 61000-4-13:2002, *Electromagnetic compatibility (EMC) – Part 4-13: Testing and measurement techniques – Harmonics and interharmonics including mains signalling at a.c. power port, low frequency immunity tests*
IEC 61000-4-13:2002/AMD1:2009
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

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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.

Alphabetical index of definitions ..... References

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B

C

D

E

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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

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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

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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.

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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

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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

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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

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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

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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]

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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);

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- 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.

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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.

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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.

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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:

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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.

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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 60947-5-5:1997/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.

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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

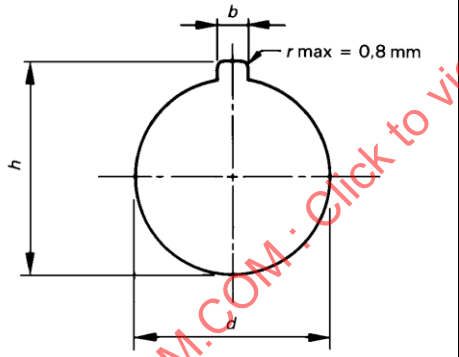
Unless otherwise stated by the manufacturer, a control circuit device is intended for installation under environmental conditions of pollution degree 3. However, other pollution degrees may apply, depending upon the micro-environment.

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	$12{,}1\,^{+0{,}2}_{0}$	$13{,}8\,^{+0{,}2}_{0}$	$1{,}7\,^{+0{,}2}_{0}$

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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:

a) making tests on the equipment; or

b) making tests on sections taken from the equipment; or

c) making tests on any parts of identical material having representative thickness; or

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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.

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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*

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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.

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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.

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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.

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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 φ			cos φ	**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_e Rated operational current — I Current to be made or broken

U_e Rated operational voltage — U Voltage before make

$P = U_e \times I_e$ Steady-state power consumption, in W — $T_{0,95}$ 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 × 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.

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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 φ			cos φ	**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 — I Current to be made or broken

U_e Rated operational voltage — U Voltage before make

$P = U_e \times I_e$ Steady-state power consumption, in W — $T_{0,95}$ 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.

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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).

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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]		

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[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.

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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.

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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.

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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)

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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);

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– 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.

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8.3.3.4 Dielectric properties

Subclause 8.3.3.4 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.

8.3.3.4.1 Type tests

Subclause 8.3.3.4.1 of IEC 60947-1:2007/AMD1:2010/AMD2:2014 applies with the following addition.

Add, after the second paragraph of 3) c):

The control circuit device shall be capable of withstanding the test voltage applied as follows:

- between live parts of the switching element and parts of the control switch intended to be earthed;
- between live parts of the switching element and surfaces of the control switch likely to be touched in service, conductive or made conductive by a metal foil;
- between live parts belonging to electrically separated switching elements.

8.3.3.5 Making and breaking capacities

8.3.3.5.1 General

Tests for verification of making and breaking capacities shall be made according to the general test requirements stated in 8.3.2.1.

8.3.3.5.2 Test circuits and connections

Tests shall be carried out on a single-pole element or on one pole of a multi-pole device provided that all pole elements are identical in construction and operation.

Adjacent contact elements are considered to be of the opposite polarity unless otherwise stated by the manufacturer.

Change-over contacts of forms C and Za are of the same polarity and change-over contacts of form Zb are of the opposite polarity.

Single-pole elements or contact elements in a multi-pole device stated as the same polarity shall be connected in accordance with the circuit shown in Figure 5. Any adjacent contact elements not being tested shall not be connected.

Change-over contacts of forms C and Za shall be subject to separate tests in the normally open and normally closed positions connected in accordance with Figure 5.

Contact elements of the opposite polarity shall be connected in accordance with the circuit shown in Figure 6. Adjacent contact elements of the opposite polarity not being tested shall be jointly connected to the supply, as shown.

Change-over contacts of form Zb shall be subject to separate tests in the normally open and normally closed positions but with both terminals of the opposite position being connected to the supply, as shown in Figure 6, for an adjacent contact of opposite polarity.

If the make and break operations require different values, the circuit shown in Figure 7 shall represent load L_d in Figures 5 and 6.

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For a.c. tests:

The load shall be an air-cored inductor in series with a resistor, if needed, to obtain the specified power factor. The inductor shall be shunted by a resistor taking 3 % of the total power consumed (see Figure 7).

NOTE In the United States of America and in Canada both air-core loads and iron-core loads are used.

For d.c. tests:

To obtain the specified steady-state current the test current shall increase from zero to the steady-state value within the limits shown in Figure 9. For guidance, an example of an iron-cored load is shown in Annex B.

Test voltage and test current shall be in accordance with Tables 4 and 5. The test circuit applied shall be stated in the test report.

8.3.3.5.3 Making and breaking capacities of switching elements under normal conditions

The tests are intended to verify that the control circuit device is capable of performing its intended duty according to the utilization category.

With the load set in accordance with Table 4, the 6 050 operating cycles shall be carried out in the following sequence:

- 50 operations at 10 s intervals with the voltage set at 1,1 U_e;
- 10 operations as rapidly as possible whilst ensuring complete closing and opening of contacts;
- 990 operations at 1 s intervals;
- 5 000 operations at 10 s intervals (or at a shorter interval determined by the manufacturer).

When the construction of the device is such that rapid cycling is not possible, for example overload relay contacts, the operations shall be at 10 s intervals or as fast as the device will permit.

For auxiliary contacts of a switching device, for example contactor, circuit-breaker, the number of operating cycles shall be the same as that required for the verification of the conventional operational performance capability of the switching device (see appropriate product standard).

8.3.3.5.4 Making and breaking capacities of switching elements under abnormal conditions

The test is intended to verify that the control circuit device is capable of making and breaking currents associated with electromagnetic loads. Load values, together with the sequence of operations shall be in accordance with Table 5.

8.3.3.5.5 Vacant

8.3.3.5.6 Results to be obtained

The following criteria shall be met entirely:

a) During the tests of 8.3.3.5.3 and 8.3.3.5.4 there shall be no electrical or mechanical failures, no contact welding or prolonged arcing, and the fuses shall not blow.

b) After the test of 8.3.3.5.3 and 8.3.3.5.4 the device shall withstand the power-frequency test voltage of 2 U_e, but not less than 1 000 V, applied as specified in 8.3.3.4.1.

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8.3.4 Performance under conditional short-circuit current

8.3.4.1 General conditions for short-circuit tests

The switching element shall be in a new and clean condition, mounted as in service.

8.3.4.2 Test procedure

The switching element may be operated several times before the test, at no load or at any current not exceeding the rated current.

A contact element with two terminals shall be tested with the actuator in the position corresponding to the closed position of the switching element under test.

The contact element to be tested shall be in series with the short-circuit protective device (SCPD), the load impedance, and a separate switching device in a single-phase circuit as shown in Figure 8. The test quantities shall be in accordance with 8.3.4.3.

The test is performed by making the current with the separate making switch and the current shall be maintained until the SCPD operates.

The test shall be performed three times on the same contact element, the SCPD being reset or replaced after each test. The time interval between the tests shall be not less than 3 min. The actual time interval shall be stated in the test report.

For change-over contact elements, the above test shall be made separately on both the normally closed and normally open contacts.

NOTE For control switches with both two terminals and change-over contact elements, both types are tested.

A separate control circuit device may be used for each contact element.

8.3.4.3 Test circuit and test quantities

The switching element shall be connected in series with the short-circuit protective device of type and rating stated by the manufacturer; it shall also be in series with the switching device intended to close the circuit.

The test circuit load impedance shall be an air-cored inductor in series with a resistor, adjusted to a prospective current of 1 000 A, or another value if stated by the manufacturer but not less than 100 A, at a power factor of between 0,5 and 0,7 and at the rated operational voltage. The open circuit voltage shall be 1,1 times the maximum rated operational voltage of the switching element.

The switching element shall be connected in the circuit using 1 m total length of cable corresponding to the operational current of the switching element.

8.3.4.4 Condition of the switching element after the test

The following criteria shall be met entirely:

a) After the short-circuit test it shall be possible to open the switching elements by the normal actuating system.

b) After the test the device shall withstand the power-frequency voltage of 2 U_e but not less than 1 000 V applied as specified in 8.3.3.4.1.

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8.4 Tests for EMC

8.4.1 General

Control circuit devices having only passive components are not required to be tested.

Subclauses 8.3.2.1 of IEC 60947-1:2007/AMD1:2010/AMD2:2014 and 8.3.2.4 of IEC 60947-1:2007/AMD1:2010 apply with the following additions:

– Control circuit devices intended to be mounted in a hole of a panel shall be mounted in a hole which is located in the center of a grounded square metal plate.

  Control circuit devices intended to be mounted on surfaces or on standard rails shall be mounted directly on the grounded square metal plate or on the standard rail which is fixed on the grounded square metal plate.

  Control circuit devices intended to be mounted in associated metal enclosures shall be mounted in the grounded metal enclosure with the smallest dimension available or on the grounded square metal plate, whichever configuration yields the worst results.

– The dimension of the square metal plate shall be (300 ± 50) mm and the thickness $1{,}5^{+0{,}5}_{0}$ mm.

– If not required otherwise by horizontal standard the connecting leads shall be $2^{+0{,}1}_{0}$ m. If the length of the connecting leads is other than 2 m, the length has to be stated in the test report.

– For control circuit devices not having integral cables, the type of cable or wire used shall be specified by the manufacturer and recorded in the test report.

– The test sample shall be in the ON-status or in the OFF-status, whichever is the worse. The tested state shall be recorded in the test report.

– Where a range of control circuit devices are made according to the same principle and design, and using the same type of components, tests may be performed on representative samples.

8.4.2 Immunity

8.4.2.1 Electrostatic discharges

The test shall be performed according to IEC 61000-4-2 and 7.3.2.4, and shall be repeated 10 times at each measuring point, with a minimum time interval of 1 s between pulses.

8.4.2.2 Radiated radio-frequency electromagnetic fields

The test shall be performed according to IEC 61000-4-3 and 7.3.2.5.

8.4.2.3 Electrical fast transients/bursts

The test shall be performed according to IEC 61000-4-4 and 7.3.2.6, with all the connecting leads placed in the capacitive coupling clamp.

NOTE The capacitive coupling is the preferred test method because it simulates the disturbances present during normal application as a result of parallel wires.

8.4.2.4 Surges

The test shall be conducted using the methods of IEC 61000-4-5. Capacitive coupling shall be preferred.

The surges shall be applied:

a) between terminals intended to be connected to the power supply;

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b) between each output terminal and each terminal intended to be connected to the power supply.

The test voltage values are those of Table 8 but shall not exceed the corresponding U_{imp} value(s) given by the manufacturer following 7.2.3 of IEC 60947-1:2007/AMD1:2010.

The repetition rate shall be one surge per minute, with the number of pulses being five positive and five negative.

8.4.2.5 Conducted disturbances induced by radio-frequency fields

The test shall be performed according to IEC 61000-4-6 and 7.3.2.8.

8.4.2.6 Power-frequency magnetic fields

The test shall be performed according to IEC 61000-4-8 and 7.3.2.9.

8.4.2.7 Voltage dips and interruptions

The test shall be performed according to IEC 61000-4-11 and 7.3.2.10.

8.4.2.8 Harmonics in the supply

Test levels are under consideration.

8.4.3 Emission

The test shall be performed according to CISPR 11, group 1, class A, and 7.3.3.

These limits are given for control circuit devices exclusively built for an industrial environment (environment A).

When they are intended to be used in an environment B (low-voltage public networks such as domestic, commercial and light industrial locations/installations), the devices shall comply with the test levels for environment B or the notice according to 5.3 of IEC 60947-1:2007/AMD2:2014 shall be included in the instructions for use.

8.4.4 Test results and test report

The test results shall be documented in a comprehensive test report. The test report shall present the objective, the results and all relevant information of the tests. The test report shall define the control circuit device under test, including the layout of the connecting leads and if applicable the necessary auxiliary equipment. Any deviation from the test plan shall be mentioned.

NOTE The contents of the test plan are given in the corresponding horizontal standard (see IEC 61000 series).

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Table 9 – Test values for electrical performance and ageing test of screwless-type clamping units

Conductor size mm²	**Test current** A	
	for minimum cross-section	for maximum cross-section
0,2	1	I_{th} or I_{the} declared for the product
0,34	2	
0,5	3	
0,75	6	
1,0	8	
1,5	12	
2,5	20	
4,0	25	

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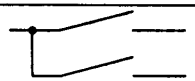
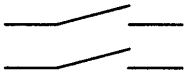
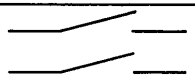
Number of the example	Disposition of the contact element(s)	Actuator positions 1	2	3	4	5	
1		×					Contact element closed in actuator position No. 1 only.
2			×		×	×	Contact element closed in actuator positions No. 2, 4 and 5.
3			×				Two contact elements used as change-over contact elements with 3 terminals.
					×		
4			×				Contact element with pulse (fleeting) contact closed between actuator positions No. 2 and 3.
5		×		×	×	×	Contact element with pulse (fleeting) contact open between actuator positions No. 3 and 4.
6					×	×	Contact element with maintained contact between actuator positions No. 4 and 5.
7		×					Two contact elements with close-before-open contacts between actuator positions No. 1 and 2.
			×				
8		×					Two contact elements with open-before-close contacts between actuator positions No. 1 and 2 (*).
			×				
9 A		×		×			Operation in which contact element B is arranged to close before and open after contact element A.
B		×		×			

(*) Open-before-close contact elements may be used to break the current in one circuit before making the current in the other circuit, provided the time interval be properly related to the circuit conditions.

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Figure 1 – Examples of the recommended method for drawing an operating diagram of a rotary switch

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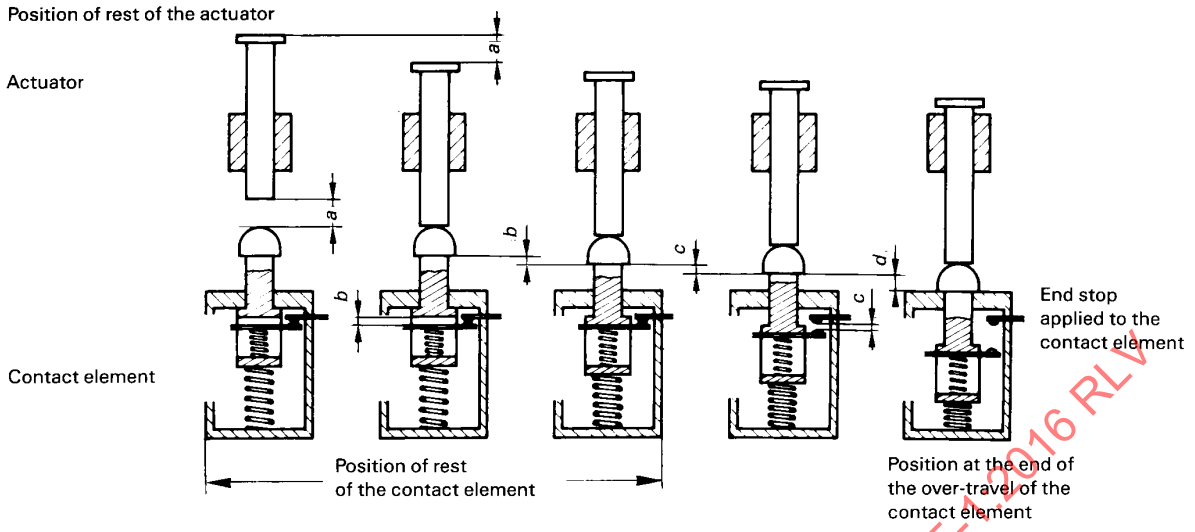

a Pre-travel of the actuator

b Pre-travel of the contact element

c Minimum value required to give adequate contact gap

d Over-travel of the contact element

b + *c* + *d* Total travel of the contact element

a + *b* + *c* + *d* + *e*)* Total travel of the actuator

* NOTE Because of a possible resilient connection between the actuator and the contact element (for example, see Figure 3), the over-travel of the actuator can exceed the over-travel of the contact element by a length *e*.

Figure 2 – Operation of push-buttons

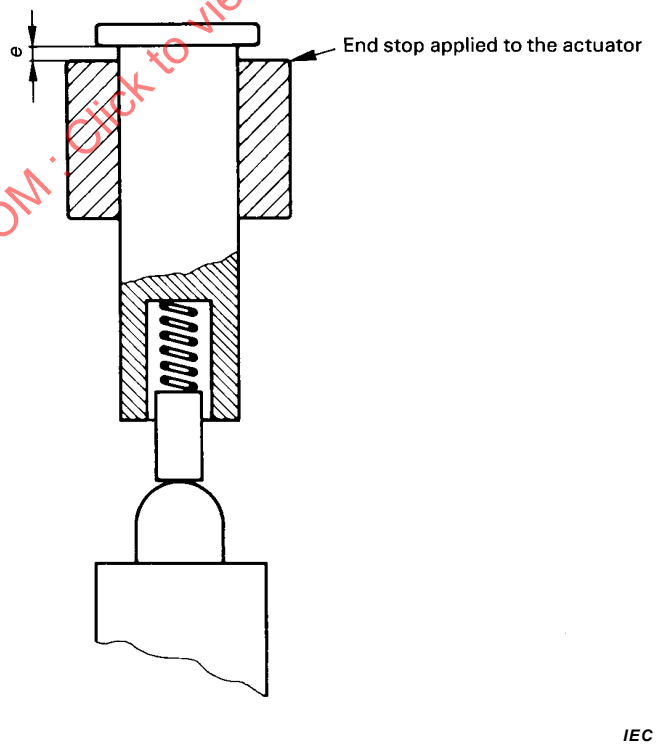

Figure 3 – Difference e between the over-travel of the actuator and that of the contact element

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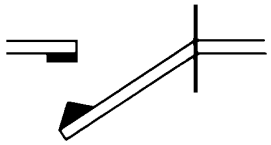
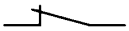
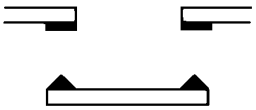
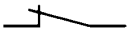
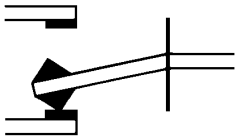
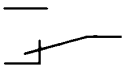
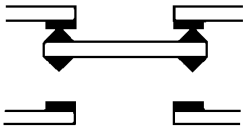
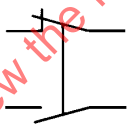
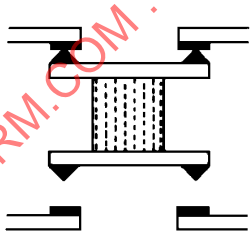
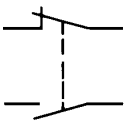
Figure No.	Figure	Symbols	Forms	Description
4a)		 Note 1	A	Single gap contact element with two terminals
		 Note 1	B	
4b)		 Note 1	X	Double gap contact element with two terminals
		 Note 1	Y	
4c)		 Note 1	C	Change-over, single gap, contact element with three terminals
4d)			Za	Change-over, double gap, contact element with four terminals Note – The contacts are of the same polarity
4e)			Zb	Change-over, double gap, contact element with four terminals (The two moving contacts are electrically separated) Note – Multiple electricaly separated contact configurations are also covered by Zb

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NOTE 1 Symbols according to IEC 60617.

Figure 4 – Examples of contact elements (schematic sketches)

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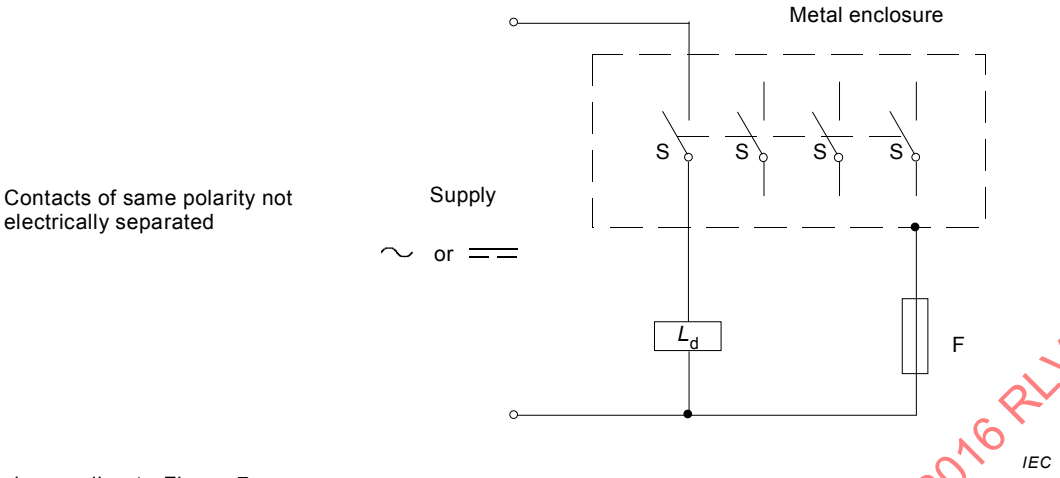
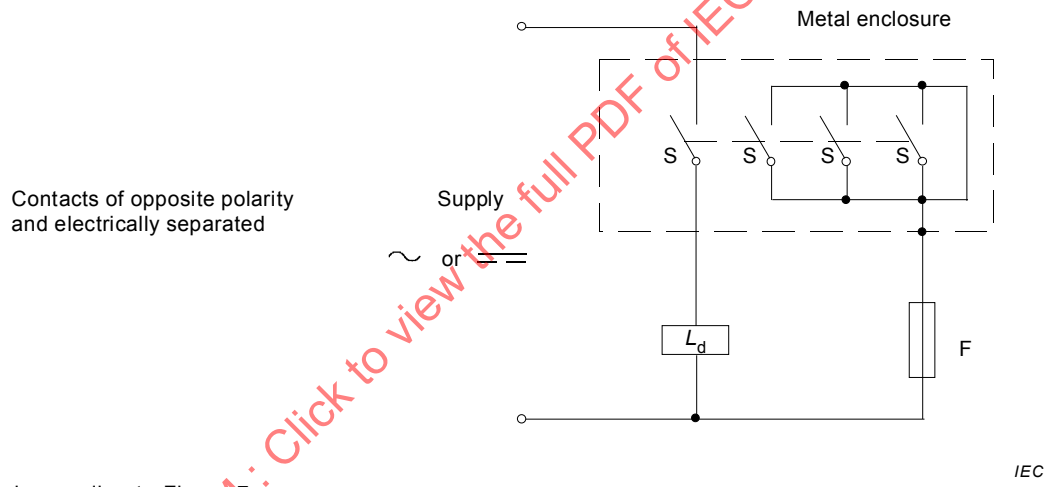


L_d: Load according to Figure 7

F: Fuse or isolation measurement device

S: Contact element (NO or NC)

Figure 5 – Test circuits for multi-pole control switches – Contacts of same polarity, not electrically separated



L_d: Load according to Figure 7

F: Fuse or isolation measurement device

S: Contact element (NO or NC)

Figure 6 – Test circuits for multi-pole control switches – Contacts of opposite polarity, and electrically separated

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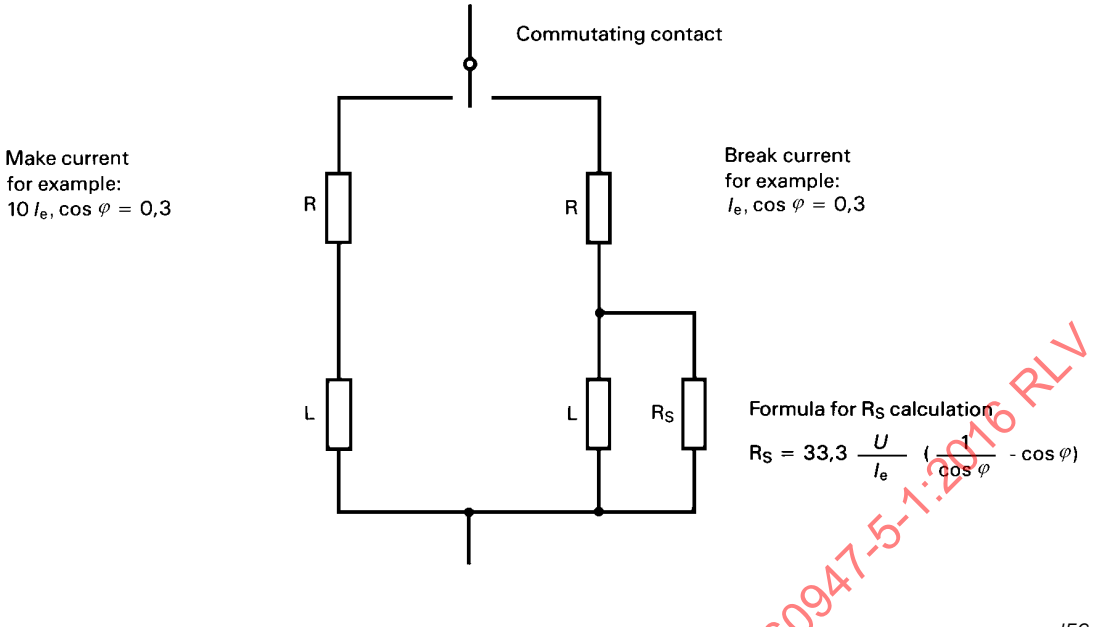
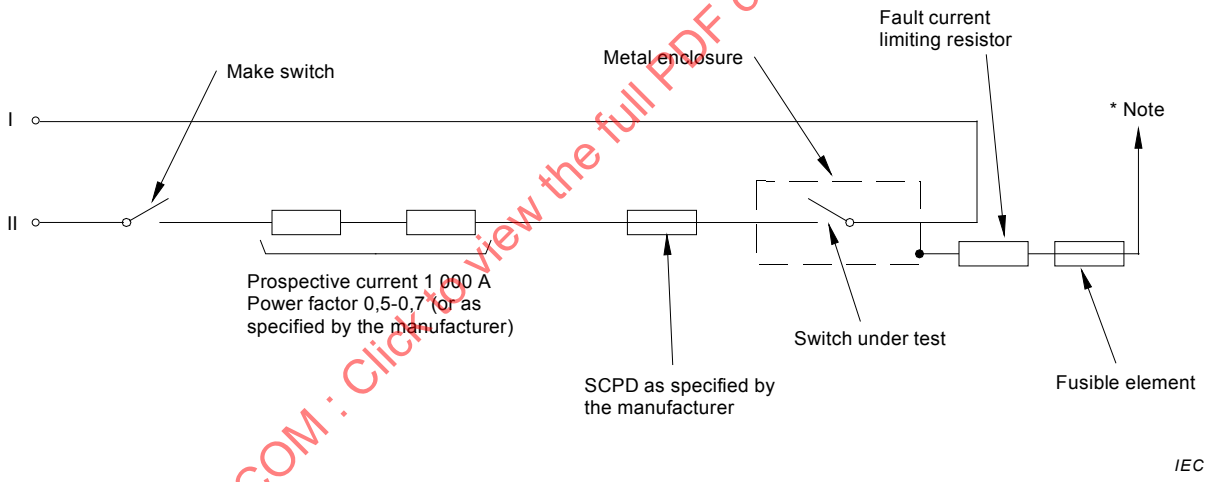


Figure 7 – Load L_d details for test conditions requiring different values of make and break current and/or power factor (time constant)



NOTE To be connected alternatively to I or II on successive tests.

Figure 8 – Test circuit, conditional short-circuit current (see 8.3.4.2)

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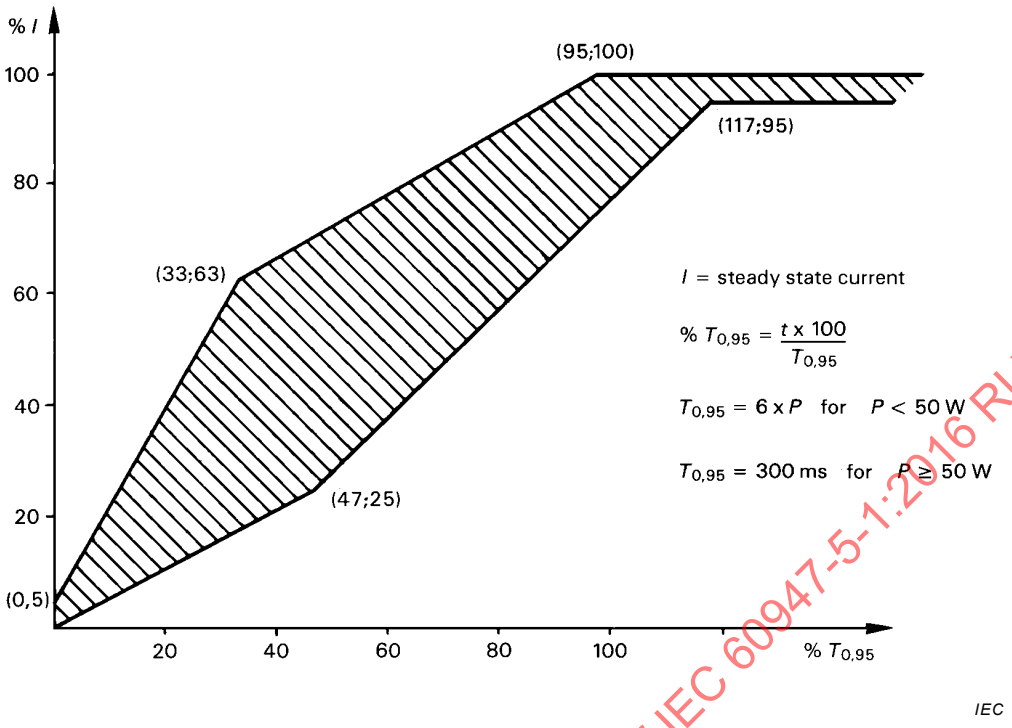

Figure 9 – Current/time limits for d.c. test loads (see 8.3.3.5.4)

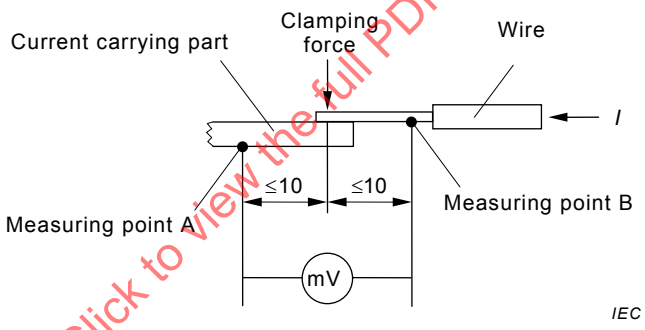

Figure 10 – Voltage drop measurement at contact point of the clamping unit or terminal

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Annex A
(normative)

Electrical ratings based on utilization categories
(see 3.1)

Table A.1 – Examples of contact rating designation based on utilization categories

Désignation [1]	Utilization category	Conventional enclosed thermal current I_{the} A	Rated operational current I_e (A) at rated operational voltage U_e						VA rating [2] VA	
Alternative current			120 V	240 V	380 V	480 V	500 V	600 V	M	B
A150	AC-15	10	6	–	–	–	–	–	7 200	720
A300	AC-15	10	6	3	–	–	–	–	7 200	720
A600	AC-15	10	6	3	1,9	1,5	1,4	1,2	7 200	720
B150	AC-15	5	3	–	–	–	–	–	3 600	360
B300	AC-15	5	3	1,5					3 600	360
B600	AC-15	5	3	1,5	0,95	0,75	0,72	0,6	3 600	360
C150	AC-15	2,5	1,5	–	–	–	–	–	1 800	180
C300	AC-15	2,5	1,5	0,75	–	–	–	–	1 800	180
C600	AC-15	2,5	1,5	0,75	0,47	0,375	0,35	0,3	1 800	180
D150	AC-14	1,0	0,6	–	–	–	–	–	432	72
D300	AC-14	1,0	0,6	0,3	–	–	–	–	432	72
E150	AC-14	0,5	0,3	–	–	–	–	–	216	36
Direct current			125 V	250 V		400 V	500 V	600 V		
N150	DC-13	10	2,2	–		–	–	–	275	275
N300	DC-13	10	2,2	1,1		–	–	–	275	275
N600	DC-13	10	2,2	1,1		0,63	0,55	0,4	275	275
P150	DC-13	5	1,1	–		–	–	–	138	138
P300	DC-13	5	1,1	0,55		–	–	–	138	138
P600	DC-13	5	1,1	0,55		0,31	0,27	0,2	138	138
Q150	DC-13	2,5	0,55	–		–	–	–	69	69
Q300	DC-13	2,5	0,55	0,27		–	–	–	69	69
Q600	DC-13	2,5	0,55	0,27		0,15	0,13	0,1	69	69
R150	DC-13	1,0	0,22	–		–	–	–	28	28
R300	DC-13	1,0	0,22	0,11		–	–	–	28	28

M = make
B = break

[1] The letter stands for the conventional enclosed thermal current and identifies (a.c. or d.c.): for example B means 5 A a.c. The rated insulation voltage U_i is at least equal to the number after the letter.

[2] The rated operational current I_e (A), the rated operational voltage U_e (V) and the break apparent power B (VA) are correlated by the formula $B = U_e \cdot I_e$.

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Table A.2 – Examples of semiconductors switching element ratings for 50 Hz and/or 60 Hz [1)]

Switching element rating	Rated operational current I_e	Rated make current A				Minimum operational current	Maximum OFF-state current
Designation	A	AC15	AC14	AC13	AC12	A	mA
SA	10	100	60	20	10	0,1	15
SB	5	50	30	10	5	0,1	15
SC	2	20	12	4	2	0,05	10
SD	1	10	6	2	1	0,05	10
SE	0,5	5	3	1	0,5	0,01	10
SF	0,25	2,5	1,5	0,5	0,25	0,01	5
SG	0,1	1	0,6	0,2	0,1	0,01	3

1) The rated operational voltage shall be specified by the manufacturer.

Table A.3 – Examples of semiconductors switching element ratings for d.c. [1)]

Switching element rating	Rated operational current I_e	Rated make current A			Maximum OFF-state current
Designation	A	DC14	DC13	DC12	mA
SN	10	100	10	10	5
SP	5	50	5	5	4
SQ	2	20	2	2	4
SR	1	10	1	1	2
SS	0,5	5	0,5	0,5	2
ST	0,25	2,5	0,25	0,25	1
SU	0,1	1	0,1	0,1	0,4
SV	0,05	0,5	0,05	0,05	0,2

1) The rated operational voltage shall be specified by the manufacturer.

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Annex B
(normative)

Example of inductive test loads for d.c. contacts

B.1 General

The direct current inductive loads found in control circuits are usually electromagnetically driven relays, contactors and solenoids with solid iron loads rated 50 W or less. The influence of these loads on the contacts of the control circuit device is determined by the stored energy of the inductor which, in turn, is related to the average rate of rise of the current in the inductor or to the charging time of the inductor.

It has been empirically determined that inductive loads up to 50 W almost always have a charging time ($T_{0,95}$) to 95 % of their full current value of 6 ms per watt or less.

B.2 Construction

The following inductive test loads may be used to approximate the loads imposed upon contacts used in d.c. control circuits:

The magnetic circuit consists of two solid steel cores, 44,5 mm in diameter and 158,7 mm long, which are fastened by screws at each end to solid steel yokes 25,4 mm × 63,5 mm × 152,4 mm on 101,6 mm centres (see Figure B.1). The steel has a resistance of between 13,3 and 19,9 μΩ/cm. (Cold-finished low carbon steels such as AISI 1010, 1015, 1018 or 116 equivalent meet this requirement.) At one end of each core, a non-magnetic spacer having a thickness adjustable to between 0,127 mm and 0,762 mm is interposed between the end of the core and the yoke. Non-magnetic screws shall be used to hold the yoke at the end having the non-magnetic spacer, and steel screws shall be used at the other end.

A coil having the winding characteristics shown in Figure B.1 surrounds one of the cores. The current in the coil, when energized at the test voltage, is adjusted to the value specified in the Table B.1 by means of a series resistor.

The thickness of the spacer is adjusted so that the coil current builds up from zero to 95 % of its full value within the limits shown in Figure 9. If the current curve falls below the minimum time limit, the cross section of the iron yoke is increased and if it falls above the maximum limit the cross section is reduced.

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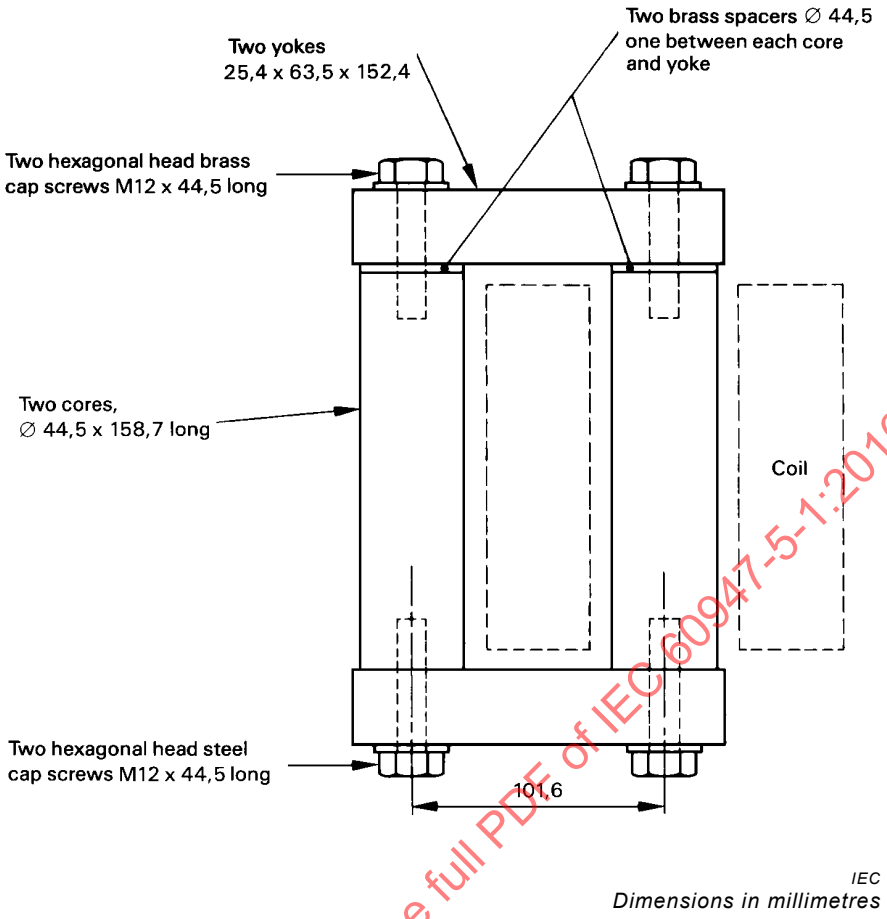

Figure B.1 – Construction of load for d.c. contacts

Table B.1 – DC loads

Coil construction					
Test voltage V	**Number of turns**	**Wire size** mm^2	**Approximate coil resistance** Ω	**Current limit with series resistor** A	**Wattage at test voltage** W
125	7 000	0,52	74	1,1	138
250	14 000	0,26	295	0,55	138
600	33 400	0,10	1 680	0,20	120

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Annex C
(normative)

Special tests – Durability tests

C.1 General

C.1.1 Durability declaration

The special durability tests (see 7.2.4.3) described in this annex are conducted at the discretion of the manufacturer. If the manufacturer declares a mechanical and/or electrical durability, the value shall correspond to the special tests described respectively in C.2 and/or C.3.

NOTE Both durability types apply to the complete control circuit device.

Both durability types are expressed as a number of operating cycles (see C.2.1 and/or C.3.1).

The preferred numbers of operating cycles declared for any type of durability are the following: 0,01 – 0,03 – 0,1 – 0,3 – 1 – 3 – 10 – 30 or 100 millions.

C.1.2 Test procedures

C.1.2.1 General

Every test shall be performed under the general conditions stated in 8.3.2.1, and at a rate equal or higher than that declared by the manufacturer. The moving parts of the device shall reach their maximum operating positions in both directions, as recommended by the manufacturer.

The test results are verified by statistical analysis according to the *single 8* (see C.1.2.2) or *double 3* (see C.1.2.3) test methods.

The manufacturer may declare mechanical durability based on experience with similar design.

NOTE The *single 8* or *double 3* test methods are both given in IEC 60410 (see Tables X-C-2 and X-D-2). These two tests have been chosen with the objective of testing a limited number of control circuit devices on the same statistical characteristics (acceptance level: 10 %). Other methods providing the 10 % acceptance level can be used.

C.1.2.2 Single 8 test

Eight control circuit devices shall be tested to the declared number of operating cycles.

If the number of failed devices does not exceed two, the test is considered passed.

C.1.2.3 Double 3 test

Three control circuit devices shall be tested to the declared number of operating cycles.

The test is considered passed if there is no failure, and failed if there is more than one failure. Should there be only one failure, then three additional control circuit devices are tested to the declared number of operating cycles and providing there is no additional failure, the test is considered passed.

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C.1.3 Failure criteria

During the tests described in C.2.2 and C.3.2, there shall be no electrical and/or mechanical failures. Following the tests, the switching element shall pass the dielectric test of 8.3.3.4 with a rated test voltage equal to 2 U_e with a minimum of 1 000 V.

C.2 Mechanical durability

C.2.1 General

The mechanical durability of a control circuit device is defined as the number of no-load operating cycles which will be attained or exceeded by 90 % of all devices tested without repair or replacement of any part.

C.2.2 Test procedures

Tests are carried out according to C.1.2.

During the test, periodically the contacts shall be checked at any voltage and current, selected by the manufacturer, and there shall be no failure (see C.1.3).

C.3 Electrical durability

C.3.1 General

The electrical durability of a control circuit device is defined as the number of on-load operating cycles which will be attained or exceeded by 90 % of all devices tested, without repair or replacement of any part.

C.3.2 Test procedures

C.3.2.1 General

Electrical durability tests are carried out by operating the device under the conditions defined in Table C.1, in accordance with C.3.2.2 for a.c. or with C.3.2.3 for d.c.

Each mechanical operating cycle shall include an interruption of test current.

The ON-duration of current shall be not more than 50 % and not less than 10 % of an operating cycle. If the test circuit shown in Figure C.1 is used, the ON-duration of current at ten times I_e shall not cause overheating.

Alternatively these tests may be performed on the actual load for which the control switch is intended.

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Table C.1 – Making and breaking conditions for electrical durability

Kind of current	Utilization category	Make			Break		
Alternating	AC-15	I	U	cos φ	I	U	cos φ
		10 I_e	U_e	0,7[1)]	I_e	U_e	0,4[1)]
Direct[2)]	DC-13	I	U	$T_{0,95}$	I	U	$T_{0,95}$
		I_e	U_e	6 × P[3)]	I_e	U_e	6 × P[3)]

I_e Rated operational current — I Current to be made or broken

U_e Rated operational voltage — U Voltage

$P = U_e \times I_e$ Steady-state power consumption, in W — $T_{0,95}$ Time to reach 95 % of the steady-state current, in milliseconds

1) The power-factors indicated are conventional values and apply only to the test circuits which simulate the electrical characteristics of coil circuits. It should be noted that, for circuits with power-factor 0,4, shunt resistors are used in the test circuit to simulate the damping effect on the eddy current losses of the actual electromagnet.

2) For d.c. electromagnetic loads provided with switching devices introducing an economy resistor, the rated operational current shall be at least equal to the maximum value of the inrush current.

3) The value "6 × 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 × 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.

C.3.2.2 AC tests

The circuit to be used shall be as shown in Figure C.1 below, comprising

- a making circuit, consisting of an air-cored inductor, in series with a resistor, having a power factor of 0,7 and drawing a current of 10 I_e;
- a breaking circuit, consisting of an air-cored inductor in series with a resistor, the whole being in parallel with a resistor in which flows about 3 % of the breaking current I_e, so that the total power factor be of 0,4.

If the contact element has a bounce time less than 3 ms, the test may be made with the simplified circuit shown in Figure C.2.

The test report shall record which test circuit has been used.

C.3.2.3 DC tests

Circuits to be used shall consist of:

a) an air-cored inductor in series with a resistor.

A resistor shall be connected across the complete test circuit to simulate the damping due to eddy currents; the resistance value shall be such that 1 % of the test current will pass through this resistor; or,

b) an iron-cored inductor, in series with a resistor, if required, to obtain a duration $T_{0,95}$ as indicated in Table C.1.

It shall be verified, by oscillograms, that the time to reach 95 % of the steady-state current is equal to the value given in Table C.1 ± 10 %, and the time to reach 63 % of the steady-state current is one-third of the value given in Table C.1 ± 20 %.

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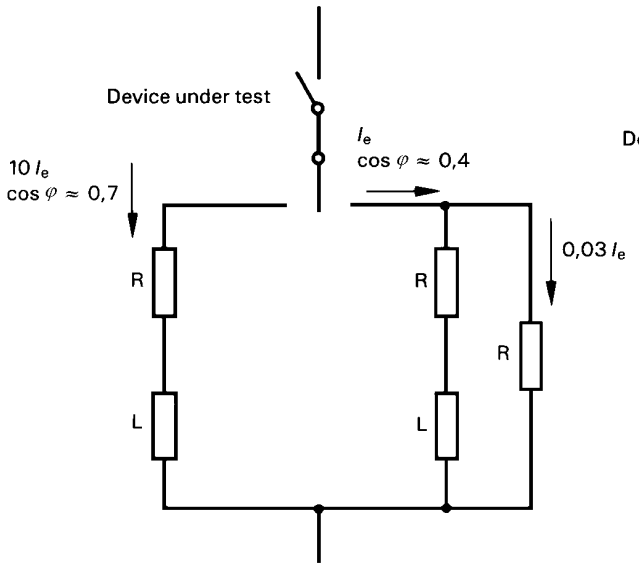

Figure C.1 – Normal circuit
(see C.3.2.2)

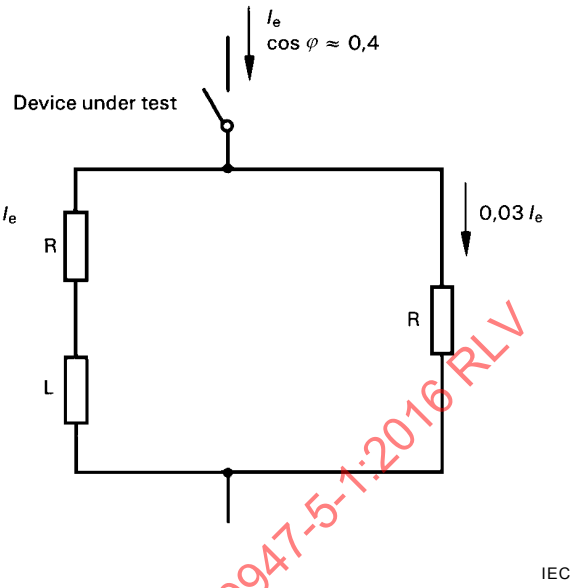

Figure C.2 – Simplified circuit
(see C.3.2.2)

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Annex D

Vacant

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Annex E
(normative)

Items subject to agreement between manufacturer and user

NOTE For the purpose of this annex:

- "agreement" is used in a very wide sense.
- "user" includes testing stations.

Annex J of IEC 60947-1:2007 applies, as far as covered by clauses and of this standard, with the following additions:

Clause or subclause number of this standard	Item
5.2.5	Relationship between the positions of the actuator of rotary switches and the associated contact element positions in the operating diagram (indication by the manufacturer)
5.2.6	Characteristics of the delay of time-delay contact elements with adjustable delay of contactors relays (indication by manufacturer)
K.6.1.1	Choice of connecting conductors for position switches with direct opening action
8.3.1	Test sequences made on one sample only (at the manufacturer's request)
8.3.4.3	Conditional short-circuit current test: – adjustment of the test circuit if the prospective current is different from 1 000 A (to be specified by the manufacturer) – power factor of the test circuit less than 0,5 (with the manufacturer's consent)

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Annex F
(normative)

Class II control circuit devices insulated by encapsulation Requirements and tests

NOTE The numbering of this annex is based on the numbering of the document.

F.1 General

This annex specifies constructional requirements and tests for class II control circuit devices or parts of devices in which insulation of class II according to IEC 61140 is achieved by encapsulation.

All non-encapsulated parts shall have clearances and creepage distances two times those specified in 7.1.4.

F.2 Terms and definitions

For the purposes of this annex, the following terms and definitions apply.

F.2.1
encapsulation
process by which all components, conductors and ends of integral cables are encased in an insulating compound by suitable means such as embedding or potting

F.2.1.1
embedding
process of completely encasing electrical device(s) by pouring a compound over it (them) in a mould, and removing the encased device(s) from the mould after solidification of the compound

F.2.1.2
potting
embedding process in which the mould remains attached to the encased electrical device(s)

F.2.2
compound
thermosetting, thermoplastic, catalytically cured and elastomeric materials with or without fillers and/or additives, after their solidification

F.2.3
temperature range of the compound
the ambient temperature range stated in 6.1.1 of IEC 60947-1:2007/AMD2:2014

F.5 Marking

Control devices according to this annex shall be marked with the following symbol

This symbol is 60417-5172.

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F.7 Instructional and functional requirements

F.7.1 Choice of compound

The compound shall be chosen so that the encapsulated control devices comply with the tests defined in F.8.

F.7.2 Adhesion of the compound

The adhesion of the compound shall be sufficient to prevent the ingress of moisture between the compound and all encapsulated parts and to prevent movement of the encapsulated portion of the cable if any.

Compliance shall be verified by tests of F.8.1.2.5 and F.8.1.2.2.

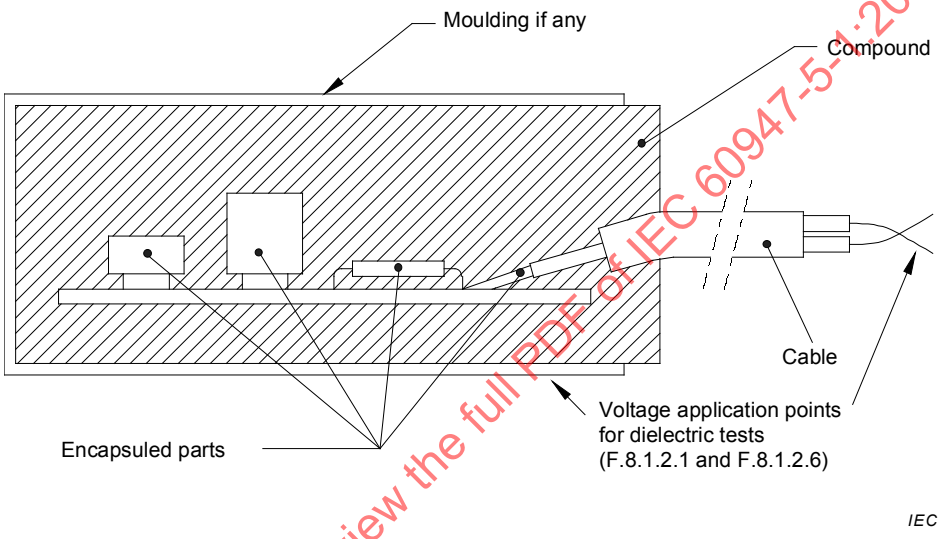

Figure F.1 – Insulation by encapsulation

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F.7.3 Dielectric properties

Subclause 7.2.3 applies with the following changes.

For the verification of the impulse withstand voltage, the test voltage U_{imp} shall be the next higher category of the maximum rated operational voltage in the first column of Table H.1 of IEC 60947-1:2007 for the stated overvoltage category.

For the verification of the power frequency withstand voltage, the test voltage shall be the sum of the voltage stated in Table 12A of IEC 60947-1:2007/AMD2:2014 plus 1 000 V.

F.8 Tests

F.8.1 Kind of tests

F.8.1.1 General

Subclause 8.1.1 of IEC 60947-1:2007 applies.

F.8.1.2 Type test

The following sequence of 6 tests shall be applied to each of 3 samples in the specified order.

F.8.1.2.1 Dielectric tests in new conditions

Subclause 8.3.3.4 of IEC 60947-1:2007/AMD1:2010/AMD2:2014 applies with the exception that the values of voltages shall be applied between the stripped joined ends of the cable or the shorted terminals and any point of the surface (or metallic foil on the surface) of the encapsulated device (see Figure F.1). No breakdown of the insulation shall occur.

F.8.1.2.2 Cable tests (if applicable)

Control circuit devices provided with integrally connected cables shall comply with requirements of Annex G.

F.8.1.2.3 Rapid change of temperature test

Test Na shall be performed in accordance with IEC 60068-2-14 with the following values:

T_A and T_B are the minimum and the maximum temperatures stated in F.2.3

Transition time t_2: 2 min to 3 min

Number of cycles: 5

Exposure time t_1: 3 h

After the test no visible damage shall be observed[3]

F.8.1.2.4 Impact test

The test is performed as follows (see Figure F.2). The sample is placed on a rigid support.

Three impacts of 0,5 J shall be applied near the centre of the largest surface or the longest axis (for cylindrical shape) of the encapsulated device.

The impacts are provided by dropping a steel ball of 0,25 kg from a height of 0,20 m.

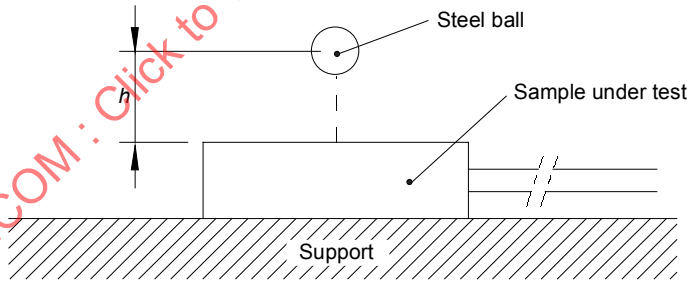

Figure F.2 – Test apparatus

The support is considered sufficiently rigid if its displacement under the impact energy is lower than 0,1 mm.

After test no visible damage shall be observed[4].

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[3] Small cracks of the moulding compounds, if any (see Figure F.1) are acceptable after tests F.8.1.2.3, F.8.1.2.4 and F.8.1.2.5.
They shall not impair the results of the final test of F.8.1.2.6.

[4] Small cracks of the moulding compounds, if any (see Figure F.1) are acceptable after tests F.8.1.2.3, F.8.1.2.4 and F.8.1.2.5.
They shall not impair the results of the final test of F.8.1.2.6.

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F.8.1.2.5 Damp heat, cyclic

The test Db shall be performed according to IEC 60068-2-30 with the following values:

Upper temperature: 55 °C

Number of cycles: 6

The test report shall state which variant is applied: variant 1 or variant 2.

After the test no visible damage shall be observed[5].

F.8.1.2.6 Dielectric test after stresses

Following Test F.8.1.2.5, the dielectric properties shall be checked by repeating tests specified in 8.3.3.4 with the test voltage of power-frequency withstand voltage being applied for 5 s.

The results to be obtained shall be as stated in 8.3.3.4 with the addition that the leakage current shall not exceed 2 mA at 1,1 U_i.

F.8.1.3 Routine tests

Subclause 8.1.3 applies but the dielectric test is mandatory.

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5 Small cracks of the moulding compounds, if any (see Figure F.1) are acceptable after tests F.8.1.2.3, F.8.1.2.4 and F.8.1.2.5.
They shall not impair the results of the final test of F.8.1.2.6.

Annex G
(normative)

Additional requirements for control circuit devices with integrally connected cables

NOTE The numbering of this annex is based on the numbering of the document.

G.1 General

This annex gives additional requirements applying to control circuit devices with integrally connected cables for electrical connection to other equipment and/or to the power source.

The cable integrally connected to such control circuit devices is not considered replaceable by the user. This annex states the constructional and performance requirements for the cable, the cable anchorage and the cable entrance seal.

G.2 Terms and definitions

For the purposes of this annex, the following terms and definitions apply.

G.2.1
cable connected control circuit device
control circuit devices having integrally connected leads for electrical connection to other equipment and/or to the power source

G.2.2
cable entrance sealing means
sealing means between the cable and device enclosure providing the required protection from cable abrasion and which may provide required sealing of enclosure and cable anchorage

G.2.3
cable anchorage
means to relieve mechanical stress from the cable termination so as to prevent damage to the electrical connection between the device and the cable

G.7 Constructional and performance requirements

G.7.1 Constructional requirements

G.7.1.1 Cable material

The control circuit device shall be provided with flexible cable of appropriate voltage, current and temperature rating and environmental condition.

NOTE The length of cable provided can be specified in the relevant product standard.

G.7.1.2 Cable anchorage

The cable anchorage shall be such that a force being applied to the cable is not transmitted to electrical connections integral to the device.

Movement of the cable into or out of the control circuit device shall not cause damage to the cable connection or internal parts of the device.

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G.7.1.3 Cable entrance sealing means

A sealing means shall be provided at the cable entrance to the control circuit device suitable for the degree of protection specified for the device (see Annex C of IEC 60947-1:2007/AMD1:2010/AMD2:2014).

NOTE The sealing means can be inherent in the device encapsulation.

G.7.2 Performance requirements

The cable and the cable entrance sealing means shall be capable of withstanding the tests given in G.8.

G.8 Tests

G.8.1 General

The purpose of these tests is to ensure integrity of the cable anchorage during handling and installation. Once installed, the control circuit device and cable should be fixed relative to each other.

G.8.2 Type tests

G.8.2.1 General

The following sequence of four tests shall be performed on a representative sample in the specified order.

G.8.2.2 Pull-out test

The cable shall be subjected to a steady pull along the axis of the cable entry, applied to the insulating jacket of the cable for a duration of 1 min.

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

In cases when cables consist of more than one conductor the pulling force is determined by multiplying the pulling force for a single conductor by the number of conductors in the cable. The maximum pulling force shall not exceed 160 N.

EXAMPLE A cable has three conductors, each with a cross section of 0,5 mm². From IEC 60947-1:2007/AMD1:2010 Table 5, the pulling force for one conductor is 20 N. Therefore the pulling force for the cable is 60 N.

G.8.2.3 Torque test

The cable shall be subjected to a torque of 0,1 N·m or limited to the value giving an angle of torque of 360°. The torque shall be applied clockwise for 1 min and then counter-clockwise for 1 min, to the cable at a distance of 100 mm from the control circuit device entrance.

G.8.2.4 Push test

The push force shall be applied along the axis of the cable as close as possible to the cable entrance.

The force is increased slowly to 20 N. The force shall be applied for 1 min for each time and with 1 min pause between applications.

After the tests, no visible damage of the cable entrance sealing means and no displacement of the cable shall be observed.

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G.8.2.5 Bend test

The cable shall be loaded and bent in the following manner:

a) suspend a 3 kg mass by attaching it to the cable, 1 m from the cable entrance and with the axis of the cable entrance vertical;

b) tilt the control circuit device 90° to cause a 90° bend in the cable, maintaining that position for 1 min;

c) tilt the control circuit device 90° in the opposite direction relative to vertical so as to cause an opposite 90° bend in the cable, maintaining the position for a duration of 1 min.

G.8.3 Results to be obtained

There shall be no damage to the cable, cable sealing means, cable entrance or the electrical connecting means of the control circuit device. This will be verified by visual examination and verification of compliance with the stated IP designation.

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Annex H
(normative)

Additional requirements for semiconductor switching elements for control circuit devices

NOTE The numbering of this annex is based on the numbering of the document.

H.1 General

This annex applies to control circuit devices with semiconductor switching elements for controlling, signalling, interlocking, etc. switchgear and controlgear. These devices shall also comply with the relevant requirements of this standard.

The object of this annex is to state additional requirements for semiconductor switching elements which are not contained in this standard.

H.2 Terms and definitions

In addition to this standard, the following terms and definitions apply.

H.2.1
voltage drop
U_d
the voltage measured across the semiconductor switching element when carrying the operational current under specified conditions

H.2.2
minimum operational current
I_m
the current that is necessary to maintain ON-state conduction of the semiconductor switching element

H.2.3
OFF-state current
I_r
the current which flows through the load circuit when the switching element is in the OFF-state

H.3 Classification

H.3.1 Semiconductor switching elements

Seminconductor switching elements may be classified as follows:

1) Utilization categories (see 4.4 and H.4.2).
2) Electrical ratings based on utilization categories (see Annex A).

H.4 Characteristics

H.4.1 Rated voltage

H.4.1.1 Rated operational voltage (U_e)

Subclause 4.3.2.2 applies.

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H.4.1.2 Operational voltage

The operational voltage may be stated as a single value or as a range. When it is stated as a range it shall include all the tolerances of U_e and shall be designated U_B. The relationship between U_e and U_B is shown in Figure H.1.

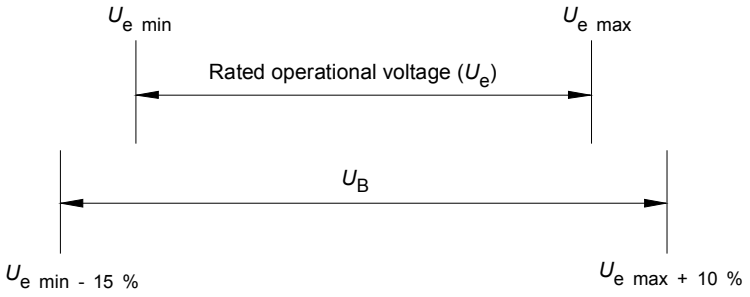

Figure H.1 – Relationship between U_e and U_B

H.4.2 Utilization categories

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

H.5 Product information

Nature of information

The following information shall be given by the manufacturer: 5.1 applies with the following additions:

Basic rated values and utilization

a) Voltage drop (see H.7.1.1)
b) Minimum operational current (see H.7.1.2)
c) OFF-state current (see H.7.1.3)
d) Making and breaking capacities (see H.7.2.1)
e) Conditional short-circuit current (see H.7.3)
f) Electromagnetic compatibility, EMC (see H.7.4)

H.7 Constructional and performance requirements

H.7.1 Performance requirements

Subclause 7.2 applies with the following additions:

H.7.1.1 Voltage drop (U_d)

The voltage drop, measured across the switching element in the conductive mode, shall be stated by the manufacturer and verified according to H.8.2.

H.7.1.2 Minimum operational current (I_m)

This shall be stated by the manufacturer and verified according to H.8.3.

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NOTE In Tables A.2 and A.3 the minimum operational currents are specified for the ratings shown.

H.7.1.3 OFF-state current (I_r)

The maximum current (I_r) which flows through the load in the OFF-state shall be in accordance with the values given in Tables A.2 and A.3, unless otherwise specified in the relevant product standard. The OFF-state current shall be verified according to H.8.4.

H.7.2 Ability to make under abnormal and normal conditions

H.7.2.1 Making and breaking capacities

See 4.3.6.

H.7.3 Conditional short-circuit current

The switching element shall withstand the stresses resulting from short-circuit currents under the conditions specified in H.8.6.

H.7.4 Electromagnetic compatibility (EMC)

Subclause 7.3 applies.

H.8 Tests

H.8.1 Type tests

Subclause 8.1.2 applies with the following additions:

a) Voltage drop (see H.8.2)
b) OFF-state current (see H.8.4)
c) Making and breaking capacities (see H.8.5)
d) Performance under short-circuit current conditions (H.8.6)
e) Verification of electromagnetic compatibility (see H.8.7)
f) Impulse voltage withstand test (see 8.3.3.4)

H.8.2 Voltage drop (U_d)

The voltage drop is measured across the active output of the switching element in the ON state and carrying the current range of I_m and I_e at an ambient temperature of 23 °C ± 5 °C and at the rated frequency. The measurement is performed with the circuit in Figure H.2, with the switch S closed. The loads shall be resistive and R_2 is adjusted to obtain the test current with the supply voltage U_e.

The measured voltage drop shall not exceed the value specified in H.7.1.1.

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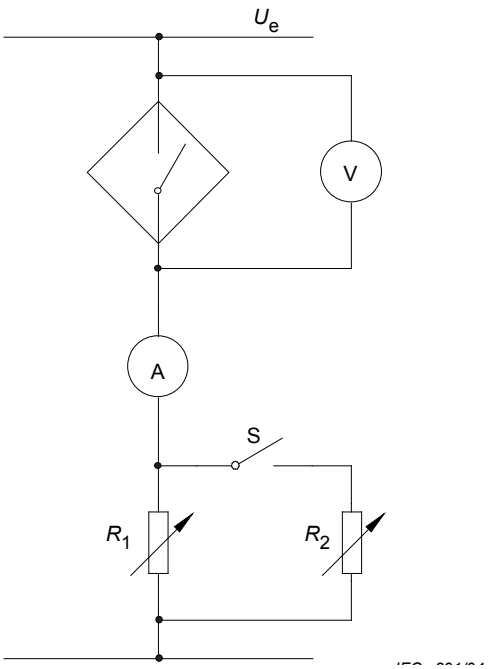

R_1 = Resistive load

R_2 = Resistive load

V = High impedance voltmeter, 0,2 MΩ/V

A = Ammeter

S = Switch

r.m.s. for a.c.
average for d.c.

Figure H.2 – Example of test circuit for the verification of voltage drop, minimum operational current and OFF-state current (see H.8.2, H.8.3 and H.8.4)

H.8.3 Minimum operational current (I_m)

The test is performed with the switching element connected to a test circuit shown in Figure H.2. With supply voltage (U_e), the switch open and the switching element in ON-state conduction, the resistive load R_1 is adjusted to obtain the current I_m. The measured value shall be according to H.7.1.2.

H.8.4 OFF-state current (I_r)

With the circuit in Figure H.2 and the S switch closed, the load R_2 is adjusted to obtain the rated operational current (I_e) when the highest supply voltage (U_e) is connected to the circuit. The switching element is then turned off and the OFF-state current is measured. The current shall be according to H.7.1.3.

H.8.5 Making and breaking capacities

Subclause 8.3.3.5 applies.

H.8.6 Performance under short-circuit current conditions

H.8.6.1 Test circuit and test procedure

A new switching element shall be mounted as in service, in free air, and connected to the test circuit using a 2 m total length cable suitable for the operational current of the switching element (see Figure H.3).

The short-circuit protective device (SCPD) shall be of the type and rating stated by the manufacturer. This SCPD shall be omitted if the switching element is integrally protected against short circuit.

The loads, R and L are so selected that the current flowing through the switching element is equal to its rated operational current at the rated operational voltage (U_e) and at the power factor or $T_{0,95}$ time constant stated in Table 5 or in Table H.3. The supply S shall be adjusted to a prospective short-circuit current of 1 000 A, or another value if stated by the manufacturer

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but not less than 100 A (see 8.3.4.3), at the rated operational voltage (U_e). The supply circuit shall have air-cored reactors connected in series with resistors to provide a power factor of 0,5 to 0,7. No damping load shall be added parallel with the reactors. The open circuit voltage shall be 1,1 times the maximum rated operational voltage of the switching element.

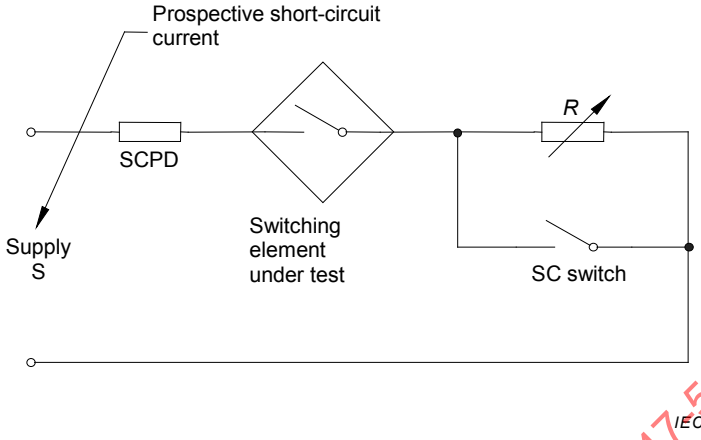

Figure H.3 – Short-circuit testing (see H.8.6.1)

The test shall be performed three times by randomly closing the "SC" switch. The test current is maintained until the SCPD operates or in the case of self-protecting elements, for 30 min. After each test the SCPD shall be replaced or reset. The interval between each of the three tests shall be not less than 3 min. The actual time between tests shall be stated in the test report.

H.8.6.2 Condition of the switching element after the test

Subclause 8.3.4.4 applies.

H.8.7 Verification of electromagnetic compatibility

H.8.7.1 General

Subclause 8.4.1 applies with the following addition:

The tests shall be performed:

a) with the switching element in the ON-state;
b) with the switching element in the OFF-state.

H.8.7.2 Immunity

Subclause 8.4.2 applies with the following additions:

H.8.7.2.4 Surges

Subclause 8.4.2.4 applies with the following addition:

The switching element is powered during the test.

H.8.7.3 Emission

The test shall be performed under worst case conditions according to CISPR 11 Group 1, Class A, and 7.3.3.2 of IEC 60947-1:2007/AMD2:2014.

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These limits are given for switching elements exclusively intended for use in industrial environment A. When they can be used in domestic environment B, the following notice shall be included in the instructions for use:

NOTICE
This is a Class A product. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

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Annex J
(normative)

Special requirements for indicator lights and indicating towers

J.1 General

This annex applies to indicator lights and indicating towers, which shall also comply with the relevant requirements of this standard.

This annex gives additional requirements applicable to indicator lights, together with definitions and terms useful for stating the required characteristics of design and performance.

J.2 Terms and definitions

The following additional terms and definitions are applicable.

J.2.1
indicator light
light signal giving information either by lighting or extinguishing

J.2.2
lens of an indicator light
visible part, removable or not, constituting the surface intentionally made transparent or translucent

J.2.3
bezel
holder of a lens

J.2.4
indicator light with a built-in voltage-reducing device
indicator light, the body of which contains a device (transformer, resistor, etc.) intended to supply, at the terminals of a lamp, a voltage different from the rated operational voltage of the light

J.2.5
indicating tower
assembly including one or more signalling units giving information by visible or audible signals

NOTE Other elements, e.g. network interface elements can be added.

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J.3 Classification

Indicator lights may be classified by:

- the rated electrical power;
- the colour;
- the fixing hole diameter;
- the means of connection;
- the nature of the current applied and its frequency, if any (for example lights with built-in transformers);

- the type of lamp socket;
- Nature of light source (for example: filament lamp, LED).

J.4 Characteristics

J.4.1 Rated operational voltage of an indicator light

A value of voltage, assigned by the manufacturer which determines the application of the indicator light.

J.4.2 Rated thermal power of an indicator light

The maximum lamp power which an indicator light is designed to tolerate under conditions specified for the temperature-rise test.

NOTE As the power of the light has an effect on the temperature rise, it can be useful to limit the power according to the mounting conditions; the manufacturer of the indicator light can assign two values of rated power (see J.8.3.3.3):

- the rated power of the light for mounting on a steel plate;
- the rated power of the light for mounting in an insulating enclosure.

J.4.3 Rated values of the lamp

Rated value of the lamp(s) indicated by the manufacturer and with which the indicator light operates without attaining temperatures likely to damage its parts.

NOTE 1 Rated power and voltage can be indicated by a type designation.

NOTE 2 It is assumed that a lamp does not dissipate a power higher than its rated power at its rated voltage.

J.5 Product information

The applicable requirements are:

Items a) and b) of 5.1;

c) the following markings shall appear on the indicator light:
   1) rated voltage of the indicator light;
   2) rated voltage of the lamp (if different from the rated voltage of the indicator light).
   3) rated power of the lamp or its type designation, or rated current for a LED.

J.6 Normal service, mounting and transport conditions

There are no supplementary requirements.

The following mounting dimensions for the indicating tower socket are recommended (see Figure J.1).

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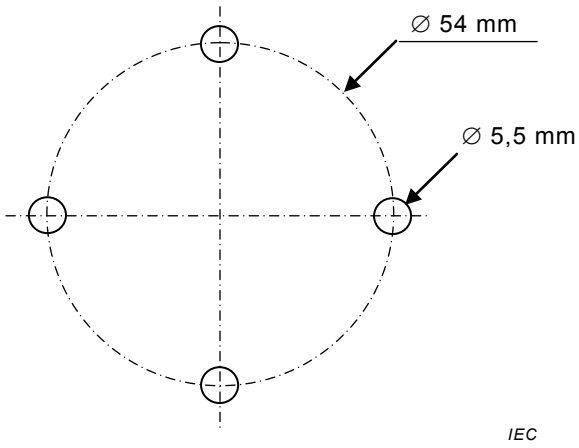

Figure J.1 – Mounting dimensions for indicating tower socket

J.7 Constructional and performance requirements

Clause 7 applies with the following additions:

J.7.1.12 Indicator lights with built-in transformers

The transformer shall have separate windings.

It is assumed that this condition is fulfilled if the indicator light passes the test described in 8.3.3.4.1.

J.7.2.1.6 Limits of operation

The limiting value of the supply voltage at the terminals of the indicator light shall be 1,1 times the rated operational voltage. This requirement is verified only for indicator lights with built-in transformer according to J.8.3.4.

J.7.2.5.1 Short-circuit withstandability of built-in transformer

The transformer shall be able to withstand permanently the short circuit of its secondary winding. It is assumed that this condition is fulfilled if the indicator light passes the test described in J.8.3.3.3.

J.8 Tests

J.8.3 Tests for indicator lights and indicating towers

The tests are type tests. No additional test (routine test or special test) is prescribed in this annex.

Each of the tests in J.8.3.3.3, J.8.3.3.4, J.8.3.4 and J.8.4 shall be made on new apparatus mounted in accordance with the test instructions.

J.8.3.3.3 Temperature-rise tests

The temperature-rise tests shall be conducted as follows:

a) If the indicator light has the same rated thermal power (see J.4.2) regardless of mounting conditions, a single test is made in an insulated enclosure.

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b) If the rated thermal power (see J.4.2) is dependent on the mounting conditions, two tests are made:

– on a steel plate, and

– in an insulated enclosure.

c) Mounting on a steel plate

Five indicator lights fitted with green lenses are fixed in accordance with the following diagram on a steel plate 2 mm thick, painted mat black (see Figure J.2).

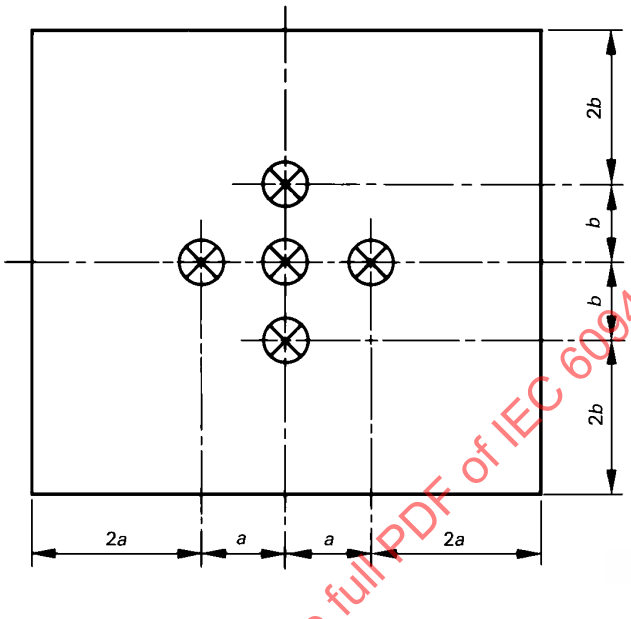

Figure J.2 – Mounting dimensions for temperature rise tests

Dimensions *a* and *b* are:

1) for indicator lights forming an integral part of a push-button range: in accordance with 6.3.1.3;

2) for other indicator lights: as stated by the manufacturer, but the values used shall be recorded in the test report.

The indicator lights are fitted with lamps as stated by the manufacturer and, if any, with built-in devices such as transformers, resistances, etc. The conductor sizes shall be as specified in 8.3.3.3.

The plate is located vertically on a table and the indicator lights are supplied at their rated voltage. The duration of the test shall be such that a steady-state temperature is reached.

d) Mounting in an insulating enclosure

The test described in item c) is carried out again with the indicator lights mounted into an enclosure of insulating material, such as bakelite-coated paper 2 mm thick, the front face of which has the same dimensions as the steel plate and the depth of which is 110 mm. The indicator lights are fitted with lamps and mounted as stated by the manufacturer for this type of use; they are supplied at their rated operational voltage.

The duration of the test shall be such that a steady-state temperature is reached.

e) Results to be obtained

At the end of each of the tests described in items c) and d) the temperatures are measured:

– on the body of the indicator light;

– on the terminals;

– on the accessible part of the lens.

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f) For indicating towers, an arrangement of five visual signalling units shall be mounted in a vertical position. The upper three signalling units, or the maximum number stated by the manufacturer if greater than three, shall be equipped with the maximum power lamp of signalling units as stated by the manufacturer and powered at the rated voltage. After the steady state temperature is reached, the temperature shall be measured on top of the tower and on the lens of the centre element of the complete tower.

None of the corresponding temperature-rises shall exceed the limits referred to in 7.2.2 of IEC 60947-1:2007.

J.8.3.3.4 Dielectric tests

8.3.3.4 applies.

J.8.3.3.4.3 Indicator lights with built-in transformers

Two additional dielectric tests shall be made, the duration of each being 1 min:

- between the primary and secondary windings of the transformer with the test voltage value specified in 8.3.3.4;
- between the secondary windings of the transformer and the frame of the indicator light with a test voltage value of 1 000 V.

J.8.3.4 Short-circuit test (on built-in transformers, if any)

The test shall be made under the following conditions:

- primary voltage: 1,1 × U_e;
- ambient air temperature: 20 °C ± 5 °C;
- duration of the test: 1 h.

The transformer shall be short-circuited by a conductor of negligible impedance.

After the test and after cooling to ambient temperature, the transformer shall withstand the dielectric test defined in J.8.3.3.4.3.

J.8.4 Shock and vibration

J.8.4.1 General

Tests for shock and vibration shall be carried out for indicating towers only. Indicator lights are not considered to be tested.

J.8.4.2 Direct mounting

J.8.4.2.1 General

An indicating tower with five signalling units shall be mounted as stated by the manufacturer without extension poles and the upper three units powered at the rated voltage.

The tests shall be performed as follows.

J.8.4.2.2 Shock

In accordance with IEC 60068-2-27 with the following conditions.

Six shocks applied in each direction along three mutually perpendicular axes (a total of 36 shocks):

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- pulse shape: half-sine;
- peak acceleration: 15 g_n;
- duration of the pulse: 11 ms.

J.8.4.2.3 Vibration

In accordance with IEC 60068-2-6 with the following conditions, along three mutually perpendicular axes:

- frequency range: 10 Hz to 55 Hz;
- amplitude: 0,5 mm;
- sweep cycle duration: 5 min;
- duration at resonant frequency or at 55 Hz: 30 min in each of the three axes (90 min in total).

J.8.4.3 Indirect support mounting

If the product literature includes other allowable mounting conditions (e.g. pole mounting), the manufacturer shall state the severity level for shock and vibration tests at which the requirements of J.8.4.4 are met.

J.8.4.4 Results to be obtained

After the tests, no visible damage shall be observed and the signalling shall not be impaired.

J.8.5 Degree of protection for indicating towers

If the manufacturer declares a degree of protection, the test shall be conducted according to Annex C of IEC 60947-1:2007/AMD1:2010 with all removable parts equipped as in normal service.

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Annex K
(normative)

Special requirements for control switches with direct opening action

K.1 General

This annex is applicable to control switches with direct opening action.

All control switches with direct opening action shall also comply with the relevant requirements of the standard and, where applicable, to those given in Annexes F, G, H and/or J.

This annex gives additional requirements applicable to control switches with direct opening action, together with definitions and terms useful for stating the required characteristics of design and performance.

K.2 Terms and definitions

The following additional terms and definitions apply:

K.2.1
control switch with direct opening action
control switch having one or more break-contact elements coupled to the switch actuator via non-resilient members so that full contact opening of the break-contact element(s) is obtained when the actuator is moved through the direct opening travel by applying the force stated by the manufacturer

K.2.2
direct opening action
<contact element> achievement of contact separation as the direct result of a specified movement of the switch actuator through non-resilient members (for example not dependent upon springs)

K.2.3
direct opening travel
travel from the beginning of actuation of the actuator and the position when the direct opening action of the opening contacts is completed

K.2.4
direct opening force (or moment)
actuation force, or actuating moment for a rotary control switch, applied to the actuator for the direct opening action

K.3 Classification

There are two types of control switches with direct opening action:

Type 1: Having one contact element only, this contact element is a direct opening break-contact element.

Type 2: Having one or more break-contact elements, and possibly, one or more make-contact elements and/or one or more change-over contact elements. All break-contact elements including the break part of change-over contact elements shall be direct opening break-contact elements.

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K.4 Characteristics

The following additional characteristics apply:

K.4.3.1.2 Rated insulation voltage

The minimum value of the rated insulation voltage of the contact elements shall be 250 V.

K.4.3.2.1 Conventional free air thermal current

The minimum value of the conventional free air thermal current of the contact elements shall be 2,5 A.

K.4.4 Utilization categories for switching elements

The utilization categories shall be AC-15 and/or DC-13.

In addition to AC-15 and/or DC-13, other utilization categories according to Table 1 (e.g. AC-14 or DC-12) are permitted.

K.5 Product information

Clause 5 is applicable with the following additions:

K.5.2 Marking

K.5.2.7 Direct opening action

Every contact element with direct opening action shall be indelibly and legibly marked on the outside by the symbol:  IEC 60617-S00226 (2001-07)

K.5.2.8 Electrical separation for change-over contact elements

Change-over contact elements with four terminals shall be indelibly and legibly marked with the relevant form Za or Zb as stated in Figure 4.

K.5.4 Additional information

K.5.4.1 Actuator travel and operating force

The manufacturer shall state the following:

a) the minimum direct opening travel;
b) the minimum force required to achieve direct opening action of all break contacts;
c) the maximum travel including travel beyond the minimum travel position (i.e. including overtravel);
d) for limit switches only the maximum speed of actuation;
e) for limit switches only the maximum frequency of actuation.

These statements shall appear in the marking or on the circuit diagram or other documents published by the manufacturers.

NOTE 1 See also K.7.1.5.3.

NOTE 2 Type 2 control switches can open with less travel than the direct opening travel stated by the manufacturer.

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K.5.4.2 Short-circuit protection

The type of short-circuit protective device shall be stated either as marking on the switch or in the installation instructions.

K.6 Normal service, mounting and transport conditions

Clause 6 applies, with the following additions:

K.6.1.1 Ambient air temperature

Subclause 6.1.1 of IEC 60947-1:2007/AMD2:2014 applies, except for position switches with direct opening action, for which the upper and lower limits of temperature are respectively +70 °C and −25 °C, and the average temperature, measured over a period of 24 h, does not exceed +35 °C.

NOTE The choice of the connecting conductors can, if applicable, be subject to agreement between manufacturer and user (see footnote b of Table 2 of IEC 60947-1:2007).

K.7 Constructional and performance requirements

Clause 7 applies with the following additions:

K.7.1.4.3.1 Robustness of the actuating system

In order to have sufficient robustness, the actuating system shall pass the test described in K.8.3.7.

K.7.1.4.3.2 Directness of opening action

A control switch with direct opening action shall pass the tests described in K.8.3.4, K.8.3.5 (in the case of a position switch with a direct opening action), and K.8.3.7 without any deformation that would reduce the impulse voltage withstand across the contact gap.

K.7.1.4.5 Automatic opening of cable operated control switches

Cable operated control switches with direct opening action shall return automatically to the open position in case of failure of the cable or its anchorage.

K.7.1.4.6 Conditions for direct opening action (see 2.4.10 of IEC 60947-1:2007)

For parts of the travel that separates the contacts, there shall be a positive drive with no resilient member (for example springs) between the moving contacts and the point of the actuator to which the actuating force is applied.

K.7.1.4.6.1 Contact element types

Control switches with direct opening action may be provided with snap action or dependent action contact elements.

The break-contact elements shall be electrically separated from each other and from the operating make-contact elements.

When the control switch has form C or form Za change-over contact elements (see Figures 4 c) and 4 d)), only one contact element (make or break) shall be used. In the case of form Zb change-over contact elements, both contacts may be used.

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K.7.1.5.3 Actuator travel indication

In order to facilitate the setting up of the switch actuator in relation to the external operating means, for example a cam, the switch may include means for indicating the minimum travel of the actuator required to ensure direct opening action, for example by the provision of a mark on the actuator plunger (see Note 1, item a) of K.5.4.1).

K.8 Tests

In addition to Clause 8, and Annex C, the following applies:

K.8.3.1 Test sequences

Subclause 8.3.1 applies with the following additions:

- Test sequence VII (sample No. 7) – Mechanical operation of position switches with direct opening action.

  Test No. 1 – Mechanical operation at limits of temperature (see K.8.3.5).

  Test No. 2 – Verification of direct opening action (see K.8.3.6).
- Test sequence VIII (sample No. 8)
- Verification of robustness of the actuating system (see K.8.3.7).

K.8.3.4 Performance under conditional short-circuit current

Subclause 8.3.4 applies with the following additions:

K.8.3.4.2.1 Verification of conditional short-circuit current

The test shall be made as stated in 8.3.4.2, except that the current is made by a direct opening contact element and not by the additional switching device and the test is made on the device by making the current three times by the same contact element in a single phase circuit.

For type 2 control switches, the contact element shall be chosen at random.

K.8.3.4.4.1 Operation ability after the test

After each test, the opening contact element shall open by the application of the force stated by the manufacturer through the direct opening travel (see items a) and b) of K.5.4.1).

The open position of the contact element shall be verified by the application of an impulse test voltage of 2 500 V across the contact gap.

K.8.3.5 Verification of mechanical operation of position switches at limits of temperature

This test applies only to position switches with direct opening action. The position switch shall be conditioned at +70 °C for 8 h.

At the end of the conditioning period and at the same temperature, the contacts shall be loaded with the maximum rated operational current for 10 min. The contacts shall then be operated 10 times by the application of the force stated by the manufacturer according to item b) of K.5.4.1.

The test shall be repeated after conditioning at –25 °C but without application of the current.

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After completion of this test, the open position of the contacts shall be verified according to K.8.3.6.

K.8.3.6 Verification of direct opening action

When the position switch is in the position corresponding to the direct opening travel stated in item a) of K.5.4.1, the contact gap shall withstand an impulse voltage of 2 500 V.

For position switches suitable for isolation, the value of the impulse withstand voltage shall be in accordance with Table 14 of IEC 60947-1:2007 corresponding to the rated impulse withstand voltage U_{imp} declared by the manufacturer.

K.8.3.7 Verification of robustness of the actuating system

The closed break contact(s) shall be loaded with a force F_1 of 10 N (see Figure K.1). A force (moment) F_2, higher than F_1, stated by the manufacturer, shall be applied to the actuator through the direct opening travel.

After this test, the actuating system and/or contacts shall remain functional and shall withstand an impulse test voltage in accordance with K.8.3.6.

For position switches suitable for isolation, the value of the impulse withstand voltage shall be in accordance with Table 14 of IEC 60947-1:2007 corresponding to the rated impulse withstand voltage U_{imp} declared by the manufacturer.

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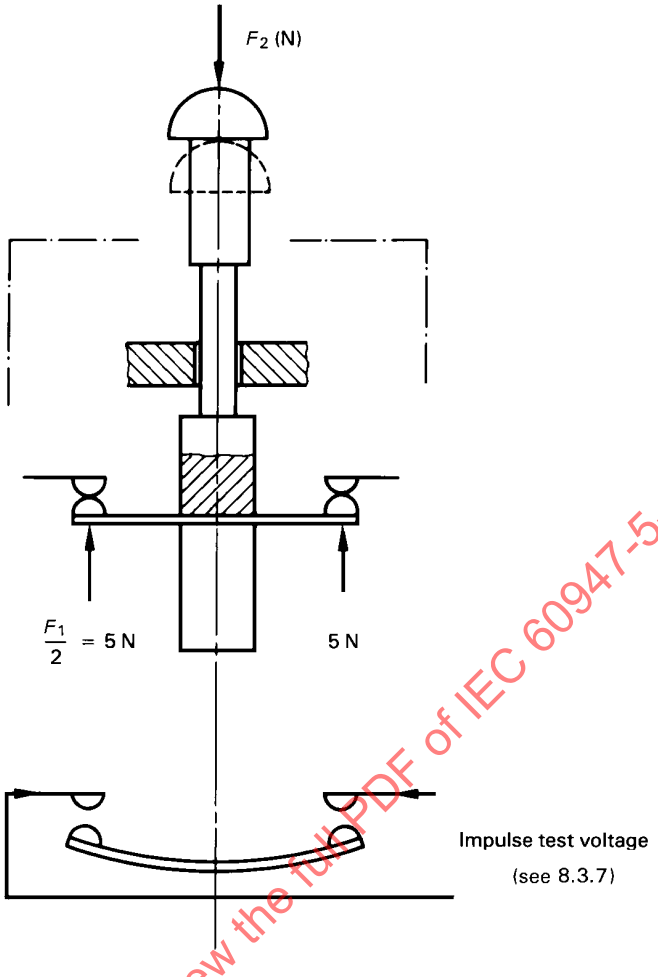

NOTE – F_1 = Required opening force = 10 N.
F_2 = Force (moment) stated by the manufacturer.

IEC

Figure K.1 – Verification of robustness of the actuating system

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Annex L
(normative)

Special requirements for mechanically linked contact elements

L.1 General

This annex applies to mechanically linked auxiliary contact elements included in control circuit devices where actuating force is provided internally, such as contactor-relays.

Linkage between the auxiliary and main contacts is not covered by this annex.

NOTE 1 A typical application of mechanically linked contact elements is e.g. self-monitoring in machine control circuits.

NOTE 2 Mechanically linked contact elements have previously been referred to as forced contacts, positively activated contacts, or linked contacts, or, in French: "contacts forcés" or in German: "Zwangsgeführte Kontakte".

NOTE 3 Control circuit devices actuated externally (e.g. push-button or limit-switches) do not have an actuating force limited to a maximum value (see L.8.4 a) 2)), so they cannot have mechanically linked contact elements. For such devices, safety applications generally use contacts with "direct opening action" (see Annex K).

NOTE 4 The meaning of “mechanically linked” is also applicable to additional contact units which can be mounted by the user.

This annex provides additional specifications (definition, requirements and tests) which shall be used for stating the required design characteristics, marking and performance of mechanically linked contact elements.

L.2 Terms and definitions

The following additional terms and definitions apply.

L.2.1
mechanically linked contact elements
combination of *n* Make contact element(s) and m Break contact element(s) designed in such a way that they cannot be in closed position simultaneously under conditions defined in L.8.4

Note 1 to entry: One control circuit device may have more than one group of mechanically linked contact elements.

Note 2 to entry: See also L.7.1.9.

L.3 Classification

Clause 3 applies.

L.4 Characteristics

All mechanically linked contact elements shall also comply with the relevant requirements given in this standard.

L.5 Product information

Clause 5 applies with the following addition:

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L.5.2.7 Mechanically linked contact elements identification and marking

Mechanically linked contact elements shall be clearly identified:

- on the control circuit device itself;
- or in the manufacturer's documentation;
- or both.

The mechanical linkage shall be identified in circuit diagrams by a double parallel line connecting a filled circle on each of the mechanically linked contact symbols. An example is given in Figure L.1.

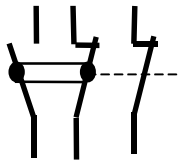

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Figure L.1 – Example of representation of NO and NC contacts which are mechanically linked and NC non-linked contact

If devices containing some or all mechanically linked contacts are marked, the symbol shown in Figure L.2 shall be used.

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Figure L.2 – Symbol for device containing mechanically linked contacts

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L.6 Normal service, mounting and transport conditions

There are no supplementary requirements.

L.7 Constructional and performance requirements

Clause 7 applies with the following addition:

L.7.1.9 Requirements for mechanically linked contact elements

While any of the *n* Make contact element(s) is closed, none of the *m* Break contact element(s) shall be closed.

While any of the *m* Break contact element(s) is closed, none of the *n* Make contact element(s) shall be closed.

L.8 Tests

Clause 8 applies with the following addition:

L.8.4 Special test for mechanically linked contact elements

This special test shall be carried out on a sample of (m + n) products where m is the number of break contact element(s) and n is the number of make contact element(s).

A different sample is used for each test.

The tests shall be carried out on products in new and clean condition. The test procedure shall be as follows:

a) Test of NC contact:

1) the NC contact element shall be maintained in the closed position by any means at each point of contact (e.g. for a double breaking contact, the attaching shall be done at the two contact points). The thickness of the means of attachment shall be such that the distance between the NC contacts is not reduced and not increased by more than 0,02 mm;

2) an actuating force shall be applied by energising the operating coil at 110 % of its rated voltage;

3) while applying the force, an impulse test voltage of 2,5 kV (1,2/50 µs at sea level; correction should be made according to Table 12 of IEC 60947-1:2007) shall be applied across every NO contact. There shall be no disruptive discharge.

NOTE 1 This test ensures a minimum gap of 0,6 mm in accordance with Table 13 of IEC 60947-1:2007.

b) Test of NO contact:

1) an actuating force shall be applied by energising the operating coil at its rated voltage;

2) the NO contact element shall be maintained in the closed position by any means at each point of contact (e.g. for a double breaking contact, the attaching shall be done at the two contact points). The thickness of the means of attachment shall be such that the distance between the NO contacts is not reduced and not increased by more than 0,02 mm;

3) an actuating force shall be applied by de-energising the operating coil;

4) with the operating coil de-energised, an impulse test voltage of 2,5 kV (1,2/50 µs at sea level; correction should be made according to Table 12 of IEC 60947-1:2007) shall be applied across every NC contact. There shall be no disruptive discharge.

NOTE 2 This test ensures a minimum gap of 0,6 mm in accordance with Table 13 of IEC 60947-1:2007.

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Annex M
(normative)

Terminal marking, distinctive number and distinctive letter for control circuit devices

M.1 Scope

This annex applies to control switches and contactor relays irrespective of their construction, having terminal marking.

The use of this annex is required where terminal marking is a requirement in this standard, or is usual practice.

M.2 Terminal marking rule

M.2.1 General

Terminal marking in accordance with this annex is based, in principle, on a two-digit number.

M.2.2 Function digit

Subclause L.3.2.1 of IEC 60947-1:2007 applies.

M.2.3 Sequence digit

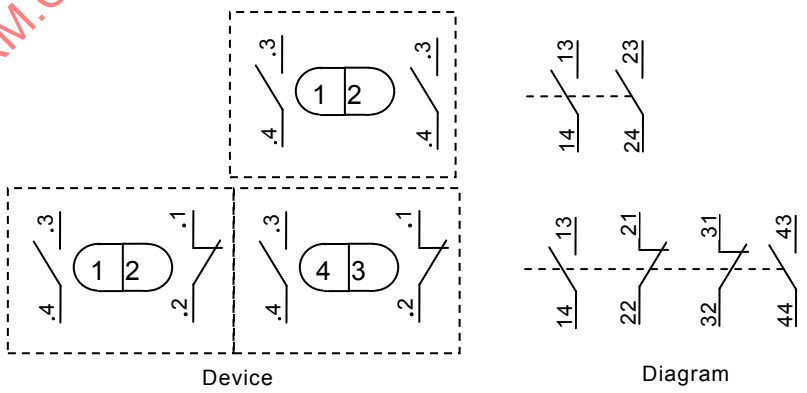
The tens digit is an ascending sequence number independent of the contact function.

Terminals belonging to the same contact are marked with the same sequence digit.

For contactor relays having 10 contact elements, the sequence digit 0 is used instead of 10.

The sequence digit may be omitted from the terminal marking only if additional information provided by the manufacturer or the user clearly gives such digit.

EXAMPLE For control switches



NOTE The dots before the function number shown in these examples are used merely to show the digit relationship, and do not need to be used in practice.

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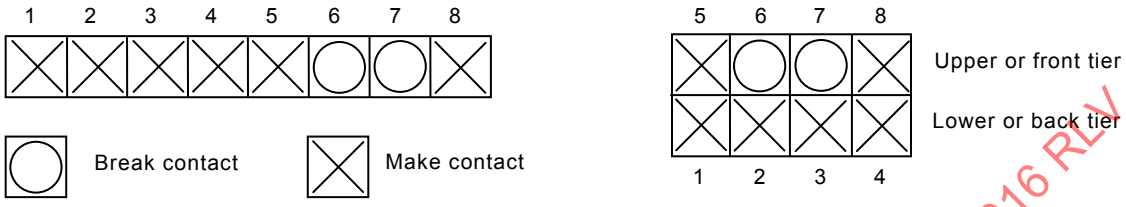
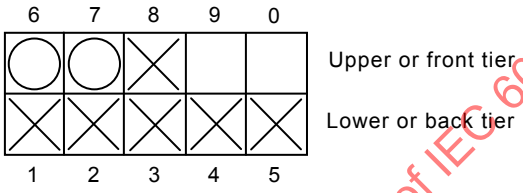
M.2.4 Numbering method

The contact terminals shall be numbered sequentially from left to right on the device; for devices with tiers of terminals, the numbering shall begin with the tier nearest to the mounting level.

EXAMPLE Contact numbering methods on contactor relays of various constructional types, but with the same distinctive number 62 E



The prescribed numbering method does not allow blank contact cells inside a contact series.



M.3 Distinctive number and distinctive letter

M.3.1 General

The quantity and type of the contact elements of a control switch according to this annex are indicated by a distinctive number. Contacts of contactor relays are indicated by a distinctive number followed by a distinctive letter.

M.3.2 Distinctive number

The first digit of the distinctive number gives the quantity of make contact elements and the second digit the quantity of break contact elements. The third digit, if any, shall give the quantity of change-over contact elements in control switches.

M.3.3 Distinctive letter

The distinctive letter indicates the location of the contact elements of a contactor relay in relation to each other and their terminal marking.

Clause M.5 defines the arrangement of contactor relays indicated by the distinctive letter E.

Clause M.6 gives information on permissible deviations, indicated by the distinctive letters X, Y or Z.

For new designs, the arrangement indicated by the distinctive letter E is preferred.

M.4 Terminal numbering sequence

For control switches having the same distinctive number, the preferred terminal marking is specified in Table M.1. Deviations from this numbering system are permitted.

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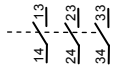
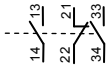
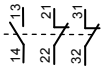
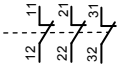
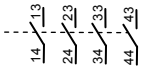
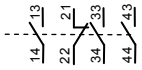
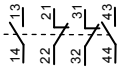
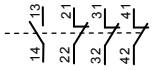
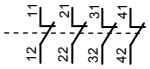
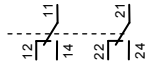
The position of the contact elements of the control switch need not correspond to that shown on diagrams of Table M.1.

Table M.1 – Diagrams of control switches

Distinctive number	Contact elements	Distinctive number	Contact elements	Distinctive number	Contact elements	Distinctive number	Contact elements	Distinctive number	Contact elements
10								01	
20		11						02	
30		21		12				03	
40		31		22		13		04	
001									
002									

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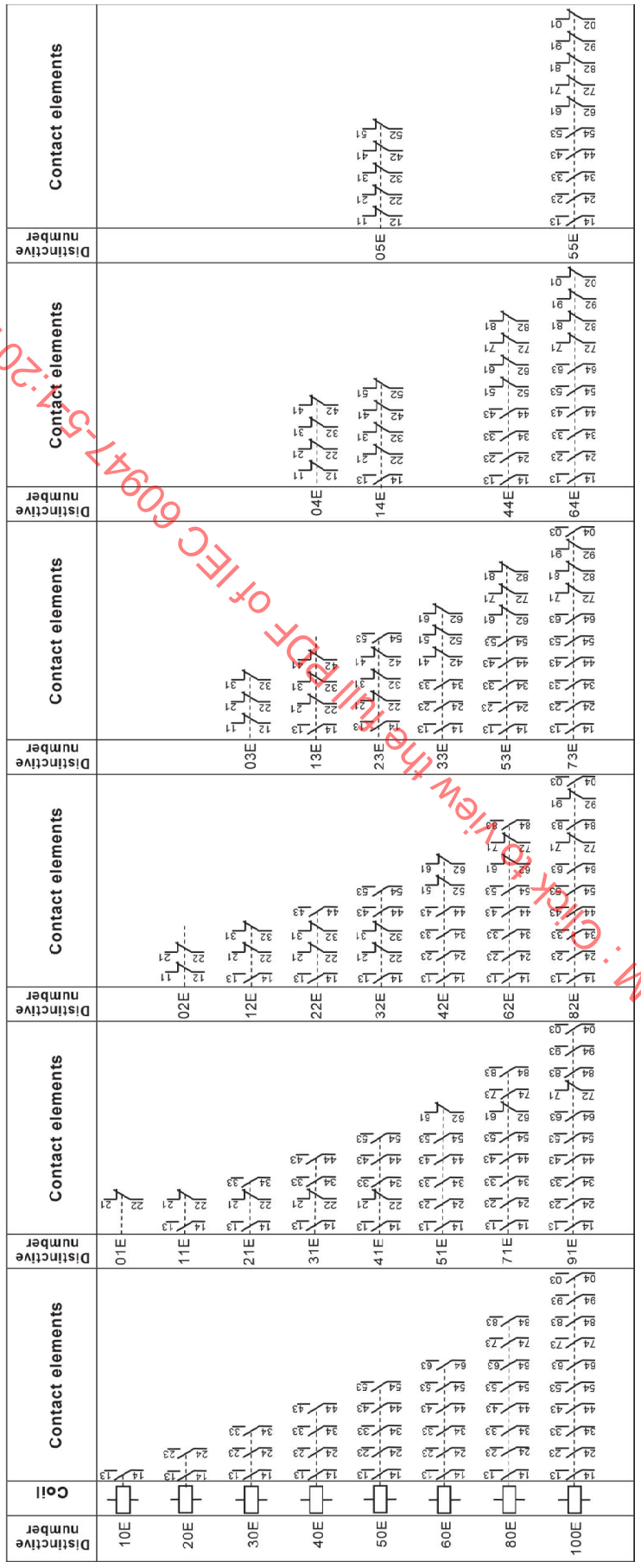
M.5 Contactor relays designated by the distinctive letter E

For contactor relays having the same distinctive number and the distinctive letter E, independently of their construction, the sequence of the contact elements within the device is specified in accordance with the diagrams of Table M.2.

As a result of this the sequence number becomes a location number and allows a given contact element terminal of a contactor relay in the equipment to be quickly found solely by counting the contacts.

Table M.2 – Diagrams of contactor relays designated by the distinctive letter E



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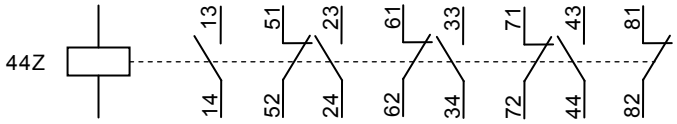
M.6 Contactor relays designated by distinctive letters X, Y or Z

M.6.1 Contactor relays designated by the distinctive letter Z

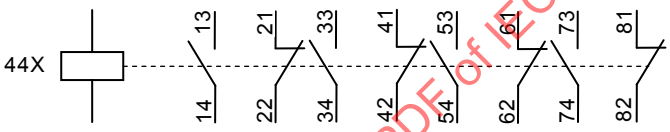
If the location of the contact elements within the device (but not the terminal marking) differs from the provisions of Clause M.5, the device shall be designated by the distinctive letter Z instead of the distinctive letter E.



M.6.2 Contactor relays designated by the distinctive letter X

If the location of the contact elements within the device and the terminal marking both differ from the requirements of Clause M.5, the device shall be designated by the distinctive letter X instead of the distinctive letter E.

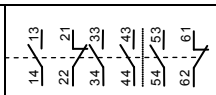
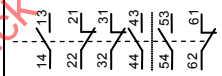
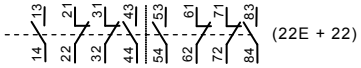
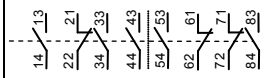
Such a device shall still comply with the requirements of Clauses M.2 and M.3.



M.6.3 Contactor relays designated by the distinctive letter Y

Devices consisting of combinations of contact elements and terminal marking in accordance with Table M.3 shall be designated by the distinctive letter Y instead of the distinctive letter E.

Table M.3 – Diagrams of contactor relays designated by the distinctive letter Y

42Y	 (31E + 11)	33Y	 (22E + 11)	44Y	 (22E + 22)
		53Y	 (31E + 22)		

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Annex N
(normative)

Procedure to determine reliability data for electromechanical devices in control circuits used in functional safety applications

N.1 General

N.1.1 Overview

Provision of these data is optional, at the discretion of the manufacturer.

N.1.2 Scope and object

K.1.2 of IEC 60947-1:2007/AMD2:2014 applies with the following addition:

This annex addresses only the intended use of electromechanical contacts in control circuit devices.

EXAMPLE: The intended use for normally closed contacts is to open the circuit.

N.1.3 General requirements

K.1.3 of IEC 60947-1:2007/AMD2:2014 applies.

N.2 Terms, definitions and symbols

K.2 of IEC 60947-1:2007/AMD2:2014 applies.

N.3 Method based on durability test results

N.3.1 General method

K.3.1 of IEC 60947-1:2007/AMD2:2014 applies.

N.3.2 Test requirements

N.3.2.1 General

The test environment shall be in accordance with Clause 6.

Every test shall be performed under the general conditions stated in 8.3.2.1 and at a rate equal or higher at the discretion of the manufacturer. The moving parts of the device shall reach their maximum operating positions in both directions, as recommended by the manufacturer. Reliability data to be published are described in Clause N.4.

N.3.2.2 Mechanical durability

The mechanical durability of a control circuit device is defined as the number of no-load operating cycles. For the no-make current or no-break current utilization the mechanical durability is applicable.

During the test, periodically the contacts shall be checked at any voltage and current, selected by the manufacturer, and there shall be no failure.

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N.3.2.3 Electrical durability

The electrical durability of a control circuit device is defined as the number of on-load operating cycles.

Electrical durability shall be determined in accordance with C.3.2 using utilization category AC-15 and / or DC-13 unless otherwise stated by the manufacturer.

N.3.3 Number of samples

K.3.3 of IEC 60947-1:2007/AMD2:2014 applies with the following addition:

The selection of samples to be tested for a series of devices with same fundamental design and without significant difference in construction shall be based on engineering judgment.

EXAMPLE If an auxiliary contact is in use for a range of devices (e.g. contactors), only one set can be tested with one contactor representative for the whole frame size.

N.3.4 Characterization of a failure mode

K.3.4 of IEC 60947-1:2007/AMD2:2014 applies.

N.3.5 Weibull modelling

K.3.5 of IEC 60947-1:2007/AMD2:2014 applies.

N.3.6 Useful life and upper limit of failure rate

K.3.6 of IEC 60947-1:2007/AMD2:2014 applies.

N.3.7 Reliability data

K.3.7 of IEC 60947-1:2007/AMD2:2014 applies.

N.4 Data information

K.4 of IEC 60947-1:2007/AMD2:2014 applies.

N.5 Example

K.5 of IEC 60947-1:2007/AMD2:2014 applies.

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Bibliography

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IEC 60050-441:1984/AMD1:2000

IEC 60050-444:2002, *International Electrotechnical Vocabulary – Part 444: Elementary relays*

IEC 60255 (all parts), *Electrical relays*

IEC 60410, *Sampling plans and procedures for inspection by attributes*

IEC 61000 (all parts*), Electromagnetic compatibility (EMC)*

IEC 61810 (all parts), *Electromechanical elementary relays*

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COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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APPAREILLAGE À BASSE TENSION –

Partie 5-1: Appareils et éléments de commutation pour circuits de commande – Appareils électromécaniques pour circuits de commande

AVANT-PROPOS

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La Norme internationale IEC 60947-5-1 a été établie par le sous-comité 121A: Appareillage à basse tension, du comité d'études 121 de l'IEC: Appareillages et ensembles d'appareillages basse tension.

Cette quatrième édition annule et remplace la troisième édition parue en 2003 et l'Amendement 1:2009. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) mise à jour des références normatives;
b) mise à jour et restructuration des paragraphes du 7.1;

c) addition des exigences et de l'essai relatif aux matériaux;

d) mise à jour des exigences CEM;

e) clarification des exigences et mise à jour du 8.2;

f) addition des exigences pour les organes de serrage sans vis;

g) mise à jour des Tableaux 4 et 5 existants;

h) addition des nouveaux Tableaux 6,7, 8 et 9;

i) addition de la nouvelle Figure 10;

j) addition de la nouvelle Annexe N.

Le texte de cette norme est issu des documents suivants:

FDIS	Rapport de vote
121A/62/FDIS	121A/76/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette norme.

Cette publication a été rédigée selon les Directives ISO/IEC, Partie 2.

Cette Norme internationale doit être utilisée conjointement avec l'IEC 60947-1.

Les dispositions des règles générales de l'IEC 60947-1 sont applicables à la présente norme lorsque celle-ci le précise. Les articles, paragraphes, tableaux et figures des règles générales qui sont ainsi applicables sont identifiés par référence à l'IEC 60947-1, par exemple: paragraphe 1.2.3, Tableau 4 ou Annexe A de l'IEC 60947-1:2007.

Les différentes pratiques suivantes, à caractère moins permanent, existent dans les pays indiqués ci-après:

– 7.2.4.1: Pouvoirs de fermeture et de coupure en conditions normales (États-Unis d'Amérique et Canada)

– 8.3.3.5.2: Circuits d'essai et connexions (États-Unis d'Amérique et Canada)

Une liste de toutes les parties de la série IEC 60947, présentées sous le titre général *Appareillage à basse tension*, peut être consultée sur le site web de l'IEC.

Le comité a décidé que le contenu de cette publication ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "http://webstore.iec.ch" dans les données relatives à la publication recherchée. A cette date, la publication sera

- reconduite,
- supprimée,
- remplacée par une édition révisée, ou
- amendée.

Le contenu des corrigenda de juillet 2016 et avril 2020 a été pris en considération dans cet exemplaire.

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APPAREILLAGE À BASSE TENSION –

Partie 5-1: Appareils et éléments de commutation pour circuits de commande – Appareils électromécaniques pour circuits de commande

1 Généralités

1.1 Domaine d'application et objet

La présente partie de l'IEC 60947 est applicable aux appareils pour circuits de commande et aux éléments de commutation destinés à la commande, la signalisation, le verrouillage, etc., de l'appareillage.

Elle est applicable aux appareils pour circuits de commande dont la tension assignée ne dépasse pas 1 000 V en courant alternatif (à une fréquence ne dépassant pas 1 000 Hz) ou 600 V en courant continu.

Toutefois, pour des tensions d'emploi, alternatives ou continues, inférieures à 100 V, voir 4.3.2.2.

La présente norme s'applique à des types déterminés d'appareils pour circuits de commande, tels que:

- auxiliaires manuels de commande, par exemple boutons-poussoirs, commutateurs rotatifs, interrupteurs à pédale, etc.;
- auxiliaires électromagnétiques de commande, soit temporisés, soit instantanés, par exemple contacteurs auxiliaires;
- auxiliaires automatiques de commande, par exemple détecteurs de pression à contacts, détecteurs de température à contacts (thermostats), programmateurs, etc.;
- interrupteurs de position, par exemple auxiliaires de commande actionnés par une partie d'une machine ou d'un mécanisme;
- matériel de commande associé, par exemple voyants lumineux, etc.

NOTE 1 Un appareil pour circuits de commande comprend un (des) auxiliaire(s) de commande et des appareils associés, tels que voyant(s) lumineux.

NOTE 2 Un auxiliaire de commande comprend un (des) élément(s) de commutation et un mécanisme transmetteur.

NOTE 3 Un élément de commutation peut être un élément de contact ou un élément à semi-conducteurs.

Elle s'applique également à des types déterminés d'éléments de commutation associés à d'autres appareils (dont les circuits principaux font l'objet d'autres normes), tels que:

- contacts auxiliaires d'un appareil de connexion (par exemple contacteur, disjoncteur, etc.) qui ne sont pas prévus pour être utilisés exclusivement avec la bobine de cet appareil;
- contacts de verrouillage de portes d'enveloppes;
- contacts de circuits de commande d'interrupteurs rotatifs;
- contacts de circuits de commande de relais de surcharge.

Les contacteurs auxiliaires satisfont également aux exigences et aux essais de l'IEC 60947-4-1, sauf en ce qui concerne la catégorie d'emploi qui satisfait à la présente norme.

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La présente norme ne prend pas en compte les relais couverts par l'IEC 60255, la série IEC 61810 ou les dispositifs de commande électrique automatiques à usage domestique et analogue.

Les exigences relatives aux couleurs des voyants lumineux, boutons-poussoirs, etc., figurent dans l'IEC 60073 et également dans la publicaiton CIE S 0004/E-2001 de la Commission Internationale de l'Eclairage (CIE).

La présente norme a pour objet de fixer:

a) les caractéristiques des appareils pour circuits de commande;
b) les qualités électriques et mécaniques requises en ce qui concerne:
   1) les différentes fonctions qui doivent être remplies;
   2) la signification des caractéristiques assignées et des indications portées sur les appareils;
   3) les essais de vérification des caractéristiques assignées;
c) les conditions de fonctionnement auxquelles doivent répondre les appareils pour circuits de commande en ce qui concerne:
   1) les conditions d'environnement y compris celles concernant le matériel sous enveloppe;
   2) les propriétés diélectriques;
   3) les bornes.

1.2 Références normatives

Les documents de référence suivants sont indispensables pour l'application du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60068-2-6:2007, *Essais d'environnement – Partie 2-6: Essais – Essai Fc: Vibrations (sinusoïdales)*

IEC 60068-2-14:2009, *Essais d'environnement – Partie 2-14: Essais – Essai N: Variations de température*

IEC 60068-2-27:2008, *Essais d'environnement – Partie 2-27: Essais – Essai Ea et guide – Chocs*

IEC 60068-2-30:2005, *Essais d'environnement – Partie 2-30: Essais – Essai Db: Essai cyclique de chaleur humide (cycle de 12 h + 12 h)*

IEC 60073:2002, *Principes fondamentaux et de sécurité pour l'interface homme-machine, le marquage et l'identification – Principes de codage pour les indicateurs et les organes de commande*

IEC 60417-DB:2002[1], *Symboles graphiques utilisables sur le matériel*

IEC 60617-DB:2012[2], *Symboles graphiques pour schémas*

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1 "DB" fait référence ici à la base de données en ligne de la CEI, disponible à l'adresse: http://www.graphical-symbols.info/equipment

2 "DB" fait référence là à la base de données en ligne de la CEI, disponible à l'adresse: http://std.iec.ch/iec60617

IEC 60695-2-10:2013, *Essais relatifs aux risques du feu – Partie 2-10: Essais au fil incandescent/chauffant – Appareillage et méthode commune d'essai*

IEC 60695-2-11:2014, *Essais relatifs aux risques du feu – Partie 2-11: Essais au fil incandescent/chauffant – Méthode d'essai d'inflammabilité pour produits finis (GWEPT)*

IEC 60695-2-12:2010, *Essais relatifs aux dangers du feu – Partie 2-12: Essais au fil incandescent/chauffant – Méthode d'essai d'indice d'inflammabilité au fil incandescent (GWFI) pour matériaux*
IEC 60695-2-12:2010/AMD1:2014

IEC 60947-1:2007, *Appareillage à basse tension – Partie 1: Règles générales*
IEC 60947-1:2007/AMD1:2010
IEC 60947-1:2007/AMD2:2014

IEC 60947-4-1:2009, *Appareillage à basse tension – Partie 4-1: Contacteurs et démarreurs de moteurs – Contacteurs et démarreurs électromécaniques*
IEC 60947-4-1:2009/AMD1:2012

IEC 60947-5-5:1997, *Appareillage à basse tension – Partie 5-5: Appareils et éléments de commutation pour circuits de commande – Appareils d'arrêt d'urgence électrique à accrochage mécanique*
IEC 60947-5-5:1997/AMD1:2005
IEC 60947-5-5:1997/AMD2:2016

IEC 60999-1:1999, *Dispositifs de connexion – Conducteurs électriques en cuivre – Prescriptions de sécurité pour organes de serrage à vis et sans vis – Partie 1: Prescriptions générales et particulières pour les organes de serrage pour les conducteurs de 0,2 mm^2 à 35 mm^2 (inclus)*

IEC 61000-3-2, *Compatibilité électromagnétique (CEM) – Partie 3-2: Limites – Limites pour les émissions de courant harmonique (courant appelé par les appareils < 16 A par phase)*

IEC 61000-3-3, *Compatibilité électromagnétique (CEM) – Partie 3-3: Limites – Limitation des variations de tension, des fluctuations de tension et du papillotement dans les réseaux publics d'alimentation basse tension, pour les matériels ayant un courant assigné <16 A par phase et non soumis à un raccordement conditionnel*

IEC 61000-4-2:2008, *Compatibilité électromagnétique (CEM) – Partie 4-2: Techniques d'essai et de mesure – Essai d'immunité aux décharges électrostatiques*

IEC 61000-4-3:2006, *Compatibilité électromagnétique (CEM) – Partie 4-3: Techniques d'essai et de mesure – Essai d'immunité aux champs électromagnétiques rayonnés aux fréquences radioélectriques*
IEC 61000-4-3:2006/AMD1:2007
IEC 61000-4-3:2006/AMD2:2010

IEC 61000-4-4:2012, *Compatibilité électromagnétique (CEM) – Partie 4-4: Techniques d'essai et de mesure – Essais d'immunité aux transitoires électriques rapides en salves*

IEC 61000-4-5:2014, *Compatibilité électromagnétique (CEM) – Partie 4-5: Techniques d'essai et de mesure – Essai d'immunité aux ondes de choc*

IEC 61000-4-6:2013, *Compatibilité électromagnétique (CEM) – Partie 4-6: Techniques d'essai et de mesure – Immunité aux perturbations conduites, induites par les champs radioélectriques*

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IEC 61000-4-8:2009, *Compatibilité électromagnétique (CEM) – Partie 4-8: Techniques d'essai et de mesure – Essai d'immunité au champ magnétique à la fréquence du réseau*

IEC 61000-4-11:2004, *Compatibilité électromagnétique (CEM) – Partie 4-11: Techniques d'essai et de mesure – Essais d'immunité aux creux de tension, coupures brèves et variations de tension*

IEC 61000-4-13:2002, *Compatibilité électromagnétique (CEM) – Partie 4-13: Techniques d'essai et de mesure – Essais d'immunité basse fréquence aux harmoniques et inter-harmoniques incluant les signaux transmis sur le réseau électrique alternatif*
IEC 61000-4-13:2002/AMD1:2009
IEC 61000-4-13:2002/AMD2:2015

IEC 61140:2015, *Protection contre les chocs électriques – Aspects communs aux installations et aux matériels*
IEC 61140:2015/AMD1:2004

CISPR 11:2015, *Appareils industriels, scientifiques et médicaux – Caractéristiques de perturbations radioélectriques – Limites et méthodes de mesure*

CIE S 004/E-2001, *Colours of Light Signals* (disponible en anglais seulement)

2 Termes et définitions

Pour les besoins de ce document, les termes et définitions donnés dans l'IEC 60947-1, ainsi que les suivants s'appliquent.

Index alphabétique des définitions Références

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2.1 Termes et définitions fondamentaux

2.1.1
appareil pour circuits de commande
appareil électrique destiné à la commande, la signalisation, le verrouillage, etc., de l'appareillage

Note 1 à l'article: Les appareils pour circuits de commande peuvent comprendre des appareils associés qui font l'objet d'autres normes, tels que les instruments, les potentiomètres, les relais, pour autant que les appareils associés soient utilisés aux fins spécifiées ci-dessus.

2.1.2
auxiliaire de commande (pour circuits auxiliaires de commande)
appareil mécanique de connexion dont la fonction est de commander la manœuvre d'un appareillage, y compris la signalisation, le verrouillage électrique, etc.

Note 1 à l'article: Un auxiliaire de commande comporte un ou plusieurs éléments de commutation et un mécanisme de commande commun.

Note 2 à l'article: Un auxiliaire de commande peut comporter des éléments à semi-conducteurs ou des éléments de contact (voir 2.3.2 et 2.3.3).

[SOURCE: IEC 60050-441:1984, 441-14-46, modifiée – Addition d'une nouvelle Note 2 à l'article.]

2.1.3
auxiliaire de commande apte au sectionnement
auxiliaire de commande qui satisfait, en position d'ouverture, aux exigences spécifiées pour la fonction de sectionnement (voir 2.1.19 et 7.1.7 de l'IEC 60947-1:2007)

Note 1 à l'article: De tels auxiliaires de commande sont destinés à assurer un plus haut degré de sécurité au personnel travaillant sur le matériel ainsi commandé. Pour cette raison, ils doivent être à commande manuelle, en se basant sur l'aptitude de l'intelligence des personnes averties à réagir en cas de défaillance éventuelle, par exemple dans le cas de contacts insuffisamment ouverts.

2.1.4
poste de commande
ensemble constitué par un ou plusieurs auxiliaires de commande fixés sur le même panneau ou situés dans la même enveloppe

Note 1 à l'article: Un panneau ou une enveloppe d'un poste de commande peut aussi contenir des appareils d'équipement associés, par exemple: potentiomètres, lampes de signalisation, appareils de mesure, etc.

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

2.2 Auxiliaires de commande

2.2.1
auxiliaire automatique de commande

Note 1 à l'article: Les auxiliaires de commande à manœuvre automatique sont actionnés par une commande automatique (voir 2.4.5 de l'IEC 60947-1:2007). Voir aussi 2.2.18 de l'IEC 60947-1:2007.

2.2.1.1
contacteur auxiliaire instantané
contacteur auxiliaire sans temporisation intentionnelle

Note 1 à l'article: Sauf indication contraire, un contacteur auxiliaire est un contacteur auxiliaire instantané.

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

2.2.1.2
contacteur auxiliaire temporisé
contacteur auxiliaire ayant des caractéristiques de temporisation spécifiées

Note 1 à l'article: La temporisation peut être associée avec la mise sous tension (retard *e*), avec la mise hors tension (retard *d*) ou avec les deux.

Note 2 à l'article: Un contacteur auxiliaire temporisé peut aussi contenir des éléments de contact instantanés.

[SOURCE: IEC 60050-441:1984, 441-14-37, modifiée – addition d'une nouvelle Note 2 à l'article.]

2.2.1.3
interrupteur de position
auxiliaire automatique de commande dont le mécanisme transmetteur est actionné par une partie mobile de machine lorsque cette partie atteint une position prédéterminée

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

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2.2.1.4
programmateur
auxiliaire de commande ayant de multiples éléments de commutation qui, après une manœuvre de départ, fonctionne suivant une séquence définie

2.2.2
auxiliaires de commande à manœuvre manuelle

Note 1 à l'article: Les auxiliaires de commande à manœuvre manuelle sont actionnés par une commande manuelle (voir 2.4.4 de l'IEC 60947-1:2007).

2.2.2.1
bouton-poussoir
auxiliaire de commande muni d'un organe de commande destiné à être actionné par l'effort exercé par une partie du corps humain, généralement le doigt ou la paume de la main, et possédant une énergie de rappel accumulée (ressort)

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

2.2.2.2
bouton à tirer
tirette
auxiliaire de commande muni d'un organe de commande destiné à être actionné en le tirant à la main et possédant une énergie de rappel accumulée (ressort)

2.2.2.3
bouton «pousser-tirer»
auxiliaire de commande muni d'un organe de commande destiné à être actionné en le poussant à la main puis en le tirant à la main vers sa position initiale, ou vice versa

Note 1 à l'article: Il existe aussi des boutons «pousser-pousser» ou «pousser-tourner» ou d'autres combinaisons de boutons.

2.2.2.4
bouton rotatif
combinaison d'éléments de commutation du type bouton-poussoir dont l'organe de commande est actionné manuellement par rotation (voir aussi 2.2.2.15 à 2.2.2.18 inclus)

EXEMPLE Un commutateur.

Note 1 à l'article: Un bouton-poussoir rotatif peut avoir plus de deux positions; il peut posséder ou ne pas posséder un ressort de rappel.

2.2.2.5
bouton-poussoir à accrochage
bouton-poussoir muni d'un ressort de rappel, mais qui demeure dans la position active jusqu'à ce qu'un verrou soit relâché par une action séparée

Note 1 à l'article: Le décrochage peut être obtenu par une nouvelle action (telle que pousser, tourner, etc.) sur le même bouton-poussoir, par une action sur un bouton-poussoir adjacent, ou par l'action d'un électro-aimant, etc.

2.2.2.6
bouton-poussoir à verrouillage
bouton-poussoir qui peut être maintenu dans une ou plusieurs de ses positions par une action séparée

Note 1 à l'article: Le verrouillage peut être obtenu par rotation du bouton, par rotation d'une clef, par action sur un levier, etc.

2.2.2.7
bouton-poussoir à clef
bouton-poussoir qui ne peut être actionné qu'aussi longtemps qu'une clef demeure introduite

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Note 1 à l'article: La possibilité de retirer la clef dans n'importe quelle position peut être prévue.

2.2.2.8
bouton-poussoir à retour différé
bouton-poussoir dont les contacts ne reviennent en position initiale qu'au bout d'un laps de temps prédéterminé après la suppression de l'effort de commande

2.2.2.9
bouton-poussoir à action différée
bouton-poussoir dont la manœuvre électrique ne se produit qu'après maintien de l'effort sur le bouton pendant un laps de temps prédéterminé.

2.2.2.10
bouton-poussoir lumineux
bouton-poussoir dans le bouton duquel est incorporée une lampe de signalisation

2.2.2.11
bouton-poussoir couvert
bouton-poussoir dont le bouton est protégé contre une manœuvre intempestive par un capot ou un couvercle

2.2.2.12
bouton-poussoir à garde
bouton-poussoir dont le bouton est protégé contre une manœuvre intempestive dans certaines directions

2.2.2.13
bouton-poussoir libre
bouton-poussoir dont la rotation de l'organe de commande autour de son axe n'est pas limitée

2.2.2.14
bouton-poussoir guidé
bouton-poussoir dont la rotation de l'organe de commande autour de son axe est empêchée

Note 1 à l'article: Exemples de boutons-poussoirs guidés: boutons-poussoirs dont l'organe de commande est muni d'un ergot, est carré ou rectangulaire, etc.

2.2.2.15
commutateur rotatif de commande
commutateur rotatif
auxiliaire de commande muni d'un organe de commande destiné à être actionné par rotation

2.2.2.16
commutateur rotatif à clef
commutateur rotatif pour lequel une clef est utilisée comme organe de commande

Note 1 à l'article: La possibilité de retirer la clef dans n'importe quelle position peut être prévue.

2.2.2.17
commutateur rotatif à manœuvre limitée
commutateur rotatif dont l'organe de commande a un mouvement angulaire limité

2.2.2.18
commutateur rotatif unidirectionnel
commutateur rotatif dont le mécanisme transmetteur ne permet la rotation que dans un seul sens

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2.2.2.19
auxiliaire à tige guidée
auxiliaire de commande muni d'un organe de commande consistant en une tige, sensiblement perpendiculaire au panneau ou à l'enveloppe lorsqu'elle se trouve dans l'une de ses positions, destinée à être actionnée par déplacement angulaire

Note 1 à l'article: Un auxiliaire à tige guidée peut avoir plus de deux positions associées à différentes directions de déplacement de la tige et manœuvrant les éléments de contact de façons différentes; un tel auxiliaire à tige de manœuvre est appelé commutateur à tige.

Note 2 à l'article: La tige peut posséder ou ne pas posséder un ressort de rappel.

2.2.2.20
auxiliaire à tige libre
auxiliaire à tige guidée qui manœuvre tous les éléments de contact de la même façon, quelle que soit la direction de déplacement

2.2.2.21
interrupteur à pédale
auxiliaire de commande muni d'un organe de commande spécialement destiné à être actionné par l'effort exercé par un pied

[SOURCE: IEC 60050-441:1984, 441-14-52, modifiée – ajout de "effort exercé par".]

2.3 Parties d'auxiliaires de commande

2.3.1
élément de commutation
un élément de commutation peut être un élément à semi-conducteur (voir 2.3.2) ou un élément de contact (voir 2.3.3)

2.3.2
élément à semi-conducteur
élément conçu pour commuter le courant dans un circuit électrique au moyen de la commande de la conductivité d'un semi-conducteur

2.3.3
élément de contact
<auxiliaire de commande> parties, fixes et mobiles, conductrices et isolantes, constitutives d'un auxiliaire de commande, nécessaires à la fermeture et à l'ouverture d'un seul chemin conducteur d'un circuit.

Note 1 à l'article: L'élément de contact et le mécanisme transmetteur peuvent constituer une unité indivisible, mais fréquemment un ou plusieurs éléments de contact peuvent être combinés avec un ou plusieurs mécanismes transmetteurs. Les mécanismes transmetteurs peuvent être différents.

Note 2 à l'article: Les termes et définitions relatifs à diverses sortes d'éléments de contact sont donnés de 2.3.3.1 à 2.3.3.10 inclus.

Note 3 à l'article: Cette définition ne comprend pas les bobines et aimants de commande.

Les définitions suivantes se rapportent à un seul élément de contact d'un auxiliaire de commande:

2.3.3.1
élément de contact à simple coupure
élément de contact qui ouvre ou ferme le chemin conducteur de son circuit en un seul point

Note 1 à l'article: Voir Figures 4 a) et 4 c).

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2.3.3.2
élément de contact à double coupure
élément de contact qui ouvre ou ferme le chemin conducteur de son circuit en deux points disposés en série

Note 1 à l'article: Voir Figures 4 b), 4 d) et 4 e).

2.3.3.3
élément de contact à fermeture
élément de contact normalement ouvert
élément de contact qui ferme un chemin conducteur quand on agit sur l'auxiliaire de commande

2.3.3.4
élément de contact à ouverture
élément de contact normalement fermé
élément de contact qui ouvre un chemin conducteur quand on agit sur l'auxiliaire de commande

2.3.3.5
éléments de contact à deux directions
combinaison d'éléments de contact comprenant un élément de contact de fermeture et un élément de contact à ouverture

Note 1 à l'article: Voir Figures 4 c), 4 d) et 4 e).

2.3.3.6
élément de contact de passage
élément de contact qui ouvre ou ferme un circuit pendant une partie de la course durant le passage de l'organe de commande d'une position à une autre

2.3.3.7
éléments de contact électriquement séparés

éléments de contact appartenant à un même auxiliaire de commande, néanmoins isolés les uns des autres de manière qu'ils puissent être reliés à des circuits électriquement séparés, qui peuvent être de même polarité ou de polarité opposée

[SOURCE: IEC 60050-441:1984, 441-15-24, modifiée – complétée par la mention de la polarité]

2.3.3.8
élément de contact à action brusque indépendante
élément de contact d'un appareil automatique ou à commande manuelle dont la vitesse de déplacement des contacts est pratiquement indépendante de la vitesse du mécanisme transmetteur

2.3.3.9
élément de contact à action dépendante
élément de contact d'un appareil de commande automatique ou à commande manuelle dont la vitesse du mouvement des contacts dépend de la vitesse du mouvement de l'organe de commande

2.3.3.10
unité de contact
élément de contact ou combinaison d'éléments de contact qui peuvent être combinés avec des unités semblables manœuvrées par un mécanisme transmetteur commun

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2.3.4
bouton
extrémité extérieure de l'organe de commande d'un bouton-poussoir, à laquelle est appliqué l'effort de commande

2.3.4.1
bouton affleurant
bouton qui, dans sa position initiale, est sensiblement au niveau de la surface fixe avoisinante et se trouve au-dessous de cette surface quand il est actionné

2.3.4.2
bouton en retrait
bouton qui se trouve au-dessous de la surface fixe avoisinante aussi bien dans sa position initiale que quand il est actionné

2.3.4.3
bouton dépassant
bouton qui forme une protubérance au-dessus des surfaces fixes voisines aussi bien dans sa position initiale que lorsqu'il est actionné

2.3.4.4
bouton coup de poing
bouton dont la partie en protubérance a un diamètre élargi

2.3.5
mécanisme de maintien en position
<commutateur rotatif> partie du mécanisme transmetteur qui maintient l'organe de commande et/ou les éléments de contact dans leur position

Note 1 à l'article: D'autres dispositifs (par exemple un bouton-poussoir avec deux positions, ou un arrêt d'urgence) peuvent disposer de la même fonction.

2.3.6
butée
dispositif limitant le déplacement d'une pièce mobile

Note 1 à l'article: Une butée peut exercer son action soit sur l'organe de commande soit sur l'élément de contact.

2.4 Manœuvre des auxiliaires de commande

2.4.1 Manœuvre des contacteurs auxiliaires

2.4.1.1
temporisation *e*
<élément de contact> temporisation dans le fonctionnement d'un élément de contact d'un contacteur auxiliaire à la suite de la mise sous tension de la bobine de l'électro-aimant de ce contacteur auxiliaire

EXEMPLE: Temporisation de fermeture de contacts à fermeture.

Note 1 à l'article: Les expressions «temporisation *e*» et «temporisation *d*» peuvent être appliquées à n'importe quelle sorte d'éléments de contact (voir 2.3.3).

2.4.1.2
temporisation *d*
<élément de contact> temporisation dans le fonctionnement d'un élément de contact d'un contacteur auxiliaire à la suite de la mise hors tension de la bobine de l'électro-aimant de ce contacteur auxiliaire

EXEMPLE: Temporisation d'ouverture de contacts à fermeture.

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Note 1 à l'article: Les expressions «temporisation *e*» et «temporisation *d*» peuvent être appliquées à n'importe quelle sorte d'éléments de contact (voir 2.3.3).

2.4.1.3
temporisation fixe
<élément de contact> temporisation dans le fonctionnement d'un élément de contact d'un contacteur auxiliaire, dont la valeur n'est pas prévue pour être réglée

2.4.1.4
temporisation réglable
<élément de contact> temporisation dans le fonctionnement d'un élément de contact d'un contacteur auxiliaire, qui est prévue pour être réglée à différentes valeurs après l'installation du contacteur auxiliaire

2.4.2 Manœuvre des auxiliaires automatiques de commande

2.4.2.1
grandeur d'action
grandeur physique dont la valeur provoque le fonctionnement ou le non-fonctionnement d'un auxiliaire automatique de commande

2.4.2.2
valeur de fonctionnement
valeur de la grandeur d'action suffisante pour provoquer le fonctionnement d'un auxiliaire automatique de commande

2.4.2.3
valeur de retour
valeur de la grandeur d'action qui doit être atteinte à nouveau pour provoquer le retour à sa position de repos d'un auxiliaire automatique de commande qui se trouve en position de fonctionnement

2.4.2.4
valeur différentielle
différence entre la valeur de fonctionnement et la valeur de retour

2.4.3 Manœuvre des commutateurs rotatifs

2.4.3.1
position définie (d'un commutateur rotatif)
position dans laquelle le mécanisme de mise en position pousse le commutateur rotatif et l'y maintient tant que le moment de commande ne dépasse pas une certaine valeur

2.4.3.2
position de repos
position (définie) stable dans laquelle le mécanisme de mise en position tend, par énergie accumulée, à ramener et à maintenir le commutateur rotatif

2.4.3.3
position transitoire
position (définie) dans laquelle le mécanisme de mise en position produit une variation importante intentionnelle dans le moment de commande, mais dans laquelle l'organe de commande ne peut rester par lui-même

2.4.3.4
position de rappel
position (définie) d'un commutateur rotatif dans laquelle l'organe de commande est pressé contre une butée et à partir de laquelle il reviendra à une position de repos par énergie accumulée (par exemple: au moyen d'un ressort)

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Note 1 à l'article: Au cours de déplacement d'une position de rappel à la position de repos adjacente, le commutateur rotatif peut passer par une ou plusieurs positions intermédiaires.

2.4.3.5
position d'accrochage
position de rappel dans laquelle le mécanisme de rappel est maintenu par un dispositif d'accrochage

Note 1 à l'article: Le dispositif d'accrochage peut être relâché à la main ou d'une autre façon.

2.4.3.6
position verrouillée
position (définie) dans laquelle un commutateur rotatif est maintenu par une action séparée

Note 1 à l'article: Le verrouillage peut être obtenu par rotation d'une clef, par action sur un levier, etc.

2.4.3.7
diagramme de fonctionnement
représentation de l'ordre prévu dans lequel les éléments de contact d'un commutateur rotatif fonctionnent lorsque ce commutateur est manœuvré

2.4.4 Manœuvre des auxiliaires de commande à commande mécanique

2.4.4.1
course d'approche de l'organe de commande
précourse de l'organe de commande
déplacement maximal de l'organe de commande qui ne produit aucun déplacement des éléments de contact

Note 1 à l'article: Voir Cote *a* de la Figure 2.

2.4.4.2
course résiduelle de l'organe de commande
surcourse de l'organe de commande
déplacement de l'organe de commande après que tous les contacts ont atteint leur position de fermeture (d'ouverture)

2.4.4.3
liaison directe
liaison entre l'organe de commande et l'élément de contact, excluant toute course d'approche de l'organe de commande

2.4.4.4
liaison dépendante
liaison entre l'organe de commande et l'élément de contact, telle que l'effort appliqué à l'organe de commande est directement transmis à l'élément de contact

2.4.4.5
liaison indépendante
liaison entre l'organe de commande et l'élément de contact, limitant l'effort transmis à l'élément de contact

2.4.4.6
effort initial minimal
moment initial minimal
valeur la plus faible de l'effort (ou du moment) provoquant le commencement de la course d'approche de l'organe de commande

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2.4.4.7
effort d'action minimal
moment d'action minimal
valeur minimale de l'effort (ou du moment) à appliquer à l'organe de commande pour que tous les contacts atteignent leur position de fermeture (d'ouverture)

2.4.4.8
course d'approche de l'élément de contact
précourse de l'élément de contact
déplacement relatif apparaissant dans l'élément de contact avant que les contacts se ferment (s'ouvrent)

Note 1 à l'article: Voir Cote *b* de la Figure 2.

2.4.4.9
course résiduelle de l'élément de contact
surcourse de l'élément de contact
déplacement relatif apparaissant dans l'élément de contact après que les contacts ont atteint la position de fermeture (d'ouverture)

Note 1 à l'article: Voir Cote *d* de la Figure 2.

2.4.4.10
temps de rebondissement
intervalle de temps entre l'instant où un circuit de contact se ferme ou s'ouvre pour la première fois et l'instant où un circuit de contact est définitivement fermé ou ouvert

[SOURCE: IEC 60050-444:2002, 444-05-04, modifiée – Figure 1 supprimée]

3 Classification

3.1 Eléments de contact

Les éléments de contact peuvent être classés comme suit:

a) Catégories d'emploi (voir 4.4).
b) Caractéristiques électriques assignées suivant les catégories d'emploi (voir Annexe A).
c) L'une des lettres de formes suivantes (voir Figure 4):
   1) Forme A – Elément de contact à fermeture à simple coupure;
   2) Forme B – Elément de contact à ouverture à simple coupure;
   3) Forme C – Elément de contact à deux directions à simple coupure à trois bornes;
   4) Forme X – Elément de contact à fermeture à double coupure;
   5) Forme Y – Elément de contact à ouverture à double coupure;
   6) Forme Z – Elément de contact à deux directions à double coupure à quatre bornes;
d) Autres types ne figurant pas en c).

NOTE 1 En ce qui concerne la Figure 4e), les deux parties mobiles de l'élément de contact sont électriquement séparées (voir 2.3.3.7).

NOTE 2 On distingue les éléments de contact à deux directions à fermeture avant coupure (chevauchement) pour lesquels les deux circuits sont simultanément fermés pendant une partie de la course des contacts mobiles d'une position à l'autre, et les éléments de contact à deux directions à coupure avant fermeture (sans chevauchement) pour lesquels les deux circuits sont simultanément ouverts pendant une partie de la course des contacts mobiles d'une position à une autre. Sauf spécification contraire, les éléments de contact à deux directions sont à coupure avant fermeture.

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3.2 Auxiliaires de commande

Les auxiliaires de commande peuvent être classés en fonction de leur élément de contact et de la nature de leur mécanisme de commande, par exemple boutons-poussoirs, forme X.

3.3 Appareils pour circuits de commande

Les appareils pour circuits de commande peuvent être classés en fonction de leur auxiliaire de commande et du matériel associé de commande de circuits, par exemple boutons-poussoirs et voyants lumineux.

3.4 Eléments de commutation temporisée

On distingue suivant la manière dont est réalisée la temporisation, par exemple temporisation électrique, magnétique, mécanique ou pneumatique.

3.5 Montage des auxiliaires de commande

Le montage des auxiliaires de commande peut être classé en fonction des dimensions du trou de montage, par exemple D12, D16, D22, D30 (voir 6.3.1).

4 Caractéristiques

4.1 Enumération des caractéristiques

4.1.1 Généralités

Il convient de préciser les caractéristiques des appareils et des éléments de commutation pour circuits de commande dans les termes suivants lorsque ceux-ci s'appliquent:

- le type de matériel (voir 4.2);
- les valeurs assignées et les valeurs limites des éléments de commutation (voir 4.3);
- les catégories d'emploi des éléments de commutation (voir 4.4);
- les caractéristiques dans les conditions de charge normales et anormales (voir 4.3.6).

4.1.2 Fonctionnement d'un auxiliaire de commande

Le principal emploi d'un auxiliaire de commande est la commutation de charges, comme indiqué au Tableau 1 pour les différentes catégories d'emploi.

D'autres emplois, par exemple la commande de lampes à filament de tungstène, celle de petits moteurs, etc., ne sont pas traités en détail dans la présente norme mais ils sont mentionnés en 4.3.6.2.

4.1.2.1 Conditions normales d'emploi

L'emploi normal d'un auxiliaire de commande est de fermer, de maintenir fermés et d'ouvrir des circuits conformément à la catégorie d'emploi donnée dans le Tableau 1. Consulter également le Tableau 4.

4.1.2.2 Conditions anormales d'emploi

Des conditions anormales peuvent se produire, par exemple quand le circuit magnétique d'un électro-aimant, bien que la bobine soit alimentée, ne s'est pas fermé. Consulter le Tableau 5.

Un auxiliaire de commande doit être capable d'interrompre le courant correspondant à de telles conditions d'emploi.

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4.2 Type de l'appareil pour circuits de commande ou de l'élément de commutation

4.2.1 Nature de l'appareil pour circuit de commande

La nature de l'appareil pour circuit de commande doit être précisée:

- auxiliaires manuels de commandes, par exemple boutons-poussoirs, commutateurs rotatifs, interrupteurs à pédale, etc.;
- auxiliaires électromagnétiques de commande, soit temporisés, soit instantanés, par exemple contacteurs auxiliaires;
- auxiliaires automatiques de commande, par exemple détecteurs de pression à contacts, détecteurs de température à contacts (thermostats), programmateurs, etc.;
- interrupteurs de position;
- matériel de commande associé, par exemple voyants lumineux, etc.

4.2.2 Nature des éléments de commutation

La nature des éléments de commutation doit être précisée:

- contacts auxiliaires d'un appareil de connexion (par exemple contacteur, disjoncteur, etc.) qui ne sont pas prévus pour être utilisés exclusivement avec la bobine de ces appareils;
- contacts de verrouillage de portes d'enveloppes;
- contacts de circuits de commande d'interrupteurs rotatifs;
- contacts de circuits de commande de relais de surcharge.

4.2.3 Nombre de pôles

La nombre de pôles doit être précisé.

4.2.4 Nature du courant

La nature du courant doit être précisée:

Courant alternatif ou courant continu.

4.2.5 Milieu de coupure

Le milieu de coupure doit être précisé:

Air, huile, gaz, vide, etc.

4.2.6 Conditions de fonctionnement

4.2.6.1 Mode de manœuvre

Le mode de manœuvre doit être précisé:

Manuelle, électromagnétique, pneumatique, électropneumatique.

4.2.6.2 Mode de commande

Le mode de commande doit être précisé:

- automatique;
- non automatique;
- semi-automatique.

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4.3 Valeurs assignées et valeurs limites pour les éléments de commutation

4.3.1 Généralités

Les valeurs assignées relatives aux éléments de commutation des appareils pour circuits de commande doivent être fixées conformément de 4.3.2 à 4.3.6, mais il n'est pas nécessaire de spécifier toutes les valeurs énumérées.

4.3.2 Tensions assignées (d'un élément de commutation)

4.3.2.1 Généralités

Un élément de commutation est défini par les tensions assignées données de 4.3.2.2 à 4.3.2.4.

4.3.2.2 Tension assignée d'emploi (U_e)

Le paragraphe 4.3.1.1 de l'IEC 60947-1:2007 est applicable avec les compléments suivants:

Pour des circuits triphasés, U_e est exprimée en valeur efficace de la tension entre phases.

NOTE Un même élément de commutation peut être caractérisé par plusieurs combinaisons de valeurs assignées de tension d'emploi et de courant d'emploi.

Les auxiliaires de commande objet de la présente norme ne sont pas normalement prévus pour être utilisés à de très basses tensions et ils peuvent ne pas être appropriés à un tel usage. Il est donc recommandé de demander l'avis du constructeur, lorsqu'il s'agit d'une utilisation à une faible valeur de la tension d'emploi, par exemple en dessous de 100 V, alternatif ou continu.

4.3.2.3 Tension assignée d'isolement (U_i)

Le paragraphe 4.3.1.2 de l'IEC 60947-1:2007 est applicable.

4.3.2.4 Tension assignée de tenue aux chocs (U_{imp})

Le paragraphe 4.3.1.3 de l'IEC 60947-1:2007 est applicable.

4.3.3 Courants

Un élément de commutation est caractérisé par les courants donnés de 4.3.3.1 à 4.3.3.3.

4.3.3.1 Courant thermique conventionnel à l'air libre (I_{th})

Le paragraphe 4.3.2.1 de l'IEC 60947-1:2007 est applicable.

4.3.3.2 Courant thermique conventionnel sous enveloppe (I_{the})

Le paragraphe 4.3.2.2 de l'IEC 60947-1:2007 est applicable.

4.3.3.3 Courant assigné d'emploi (I_e)

Le premier alinéa de 4.3.2.3 de l'IEC 60947-1:2007 est applicable.

4.3.4 Fréquence assignée

Le paragraphe 4.3.3 de l'IEC 60947-1:2007 est applicable.

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4.3.5 Disponible

4.3.6 Caractéristiques en conditions normales et anormales de charge

4.3.6.1 Pouvoirs assignés de fermeture et de coupure et comportement des éléments de commutation dans des conditions normales

Un élément de commutation doit satisfaire aux exigences contenues dans le Tableau 4 correspondant à la catégorie d'emploi qui lui est attribuée et aux exigences correspondant à sa tension assignée d'emploi.

NOTE Il n'est pas nécessaire de préciser séparément un pouvoir de fermeture et un pouvoir de coupure à un élément de commutation pour lequel une catégorie d'emploi a été attribuée.

Un élément de commutation conçu pour la commande de petits moteurs et de lampes à filament de tungstène doit avoir une catégorie d'emploi assignée en accord avec l'IEC 60947-4-1 et satisfaire aux exigences correspondantes de cette publication.

4.3.6.2 Pouvoirs de fermeture et de coupure dans des conditions anormales

Un élément de commutation doit satisfaire aux exigences du Tableau 5 correspondant à la catégorie d'emploi qui lui est attribuée.

NOTE Un exemple de condition anormale d'emploi correspond au cas où l'électro-aimant ne fonctionne pas et où les éléments de commutation doivent couper le courant d'établissement.

4.3.7 Caractéristiques de court-circuit

4.3.7.1 Courant assigné de court-circuit conditionnel

Le paragraphe 4.3.6.4 de l'IEC 60947-1:2007 est applicable.

4.4 Catégories d'emploi des éléments de commutation

Les catégories d'emploi mentionnées au Tableau 1 sont considérées comme normales. Tout autre type d'emploi doit faire l'objet d'un accord entre le constructeur et l'utilisateur, mais les informations données dans les catalogues ou les devis du constructeur peuvent tenir lieu d'un tel accord.

Tableau 1 – Catégories d'emploi des éléments de commutation

Nature du courant	Catégorie	Applications caractéristiques
Courant alternatif	AC-12	Commande de charges ohmiques et de charges statiques isolées par photocoupleur
	AC-13	Commande de charges statiques isolées par transformateur
	AC-14	Commande de faibles charges électromagnétiques d'électro-aimants (≤ 72 VA)
	AC-15	Commande de charges électromagnétiques d'électro-aimants (> 72 VA)
Courant continu	DC-12	Commande de charges ohmiques et de charges statiques isolées par photocoupleur
	DC-13	Commande d'électro-aimants
	DC-14	Commande d'électro-aimants ayant des résistances d'économie

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4.5 Disponible

4.6 Disponible

4.7 Disponible

4.8 Disponible

4.9 Disponible

4.10 Séparation électrique des éléments de contact

Le constructeur doit préciser si les éléments de contact d'un appareil pour circuit de commande sont électriquement séparés ou non (voir 2.3.3.7). Les éléments de contact séparés doivent être présumés de polarité opposée, sauf indication contraire du fabricant.

4.11 Grandeurs d'action des auxiliaires automatiques de commande

Les valeurs de fonctionnement et de retour doivent être déterminées d'après les valeurs uniformes croissantes et normales décroissantes de la grandeur d'action. Sauf spécification contraire, la vitesse de changement doit être régulière et telle que la valeur de fonctionnement (ou de retour) soit atteinte en 10 s au moins.

La valeur de fonctionnement et celle de retour peuvent être toutes deux des valeurs fixes, ou l'une d'elles, ou les deux peuvent être réglables (ou la valeur différentielle peut être réglable).

Le cas échéant, le constructeur doit indiquer une valeur de tenue, soit une valeur maximale supérieure à celle du réglage le plus haut de la valeur de fonctionnement, soit une valeur minimale inférieure au réglage le plus bas de la valeur de retour. Une valeur de tenue implique que l'auxiliaire automatique de commande ne subit aucun dommage et que ses caractéristiques ne sont pas modifiées.

4.12 Auxiliaires automatiques de commande ayant deux éléments de contact ou plus

Les auxiliaires automatiques de commande ayant deux éléments de contact ou plus, non réglables séparément, peuvent avoir des valeurs de fonctionnement et de retour différentes pour chaque élément de contact.

Un auxiliaire automatique de commande ayant deux éléments de contact ou plus, réglés séparément, est considéré comme une combinaison d'auxiliaires automatiques de commande.

5 Informations sur le matériel

5.1 Nature des informations

Les informations suivantes doivent être données par le constructeur:

Identification

a) Nom du constructeur ou marque de fabrique.

b) Désignation du type ou numéro de série permettant d'obtenir les renseignements relatifs à l'élément de commutation (ou à l'auxiliaire de commande complet) auprès du constructeur ou d'après son catalogue ou d'après l'Annexe A.

c) IEC 60947-5-1 si le constructeur déclare la conformité à la présente norme.

Valeurs assignées et emplois fondamentaux

d) Tensions assignées d'emploi (voir 4.3.2.2).

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e) Catégorie d'emploi et courants assignés d'emploi aux tensions assignées d'emploi de l'appareil pour circuits de commande.

f) Tension assignée d'isolement (voir 4.3.2.3).

g) Tension assignée de tenue aux chocs (voir 4.3.2.4).

h) Disponible.

i) Code IP, dans le cas d'un appareil pour circuit de commande sous enveloppe (voir 5.1 et Annexe C de l'IEC 60947-1:2007/AMD1:2010).

j) Degré de pollution (voir 6.1.3.2).

k) Type et valeurs maximales des caractéristiques assignées des dispositifs de protection contre les courts-circuits (voir 8.3.4.3).

l) Courant de court-circuit conditionnel.

m) Aptitude au sectionnement, le cas échéant, avec le symbole S00288 de l'IEC 60617.

n) Indication des éléments de contact de même polarité.

o) Longueur d'isolant à enlever avant d'insérer le conducteur dans la borne.

p) Pour les bornes sans vis non universelles:

– "s" ou "sol" pour les bornes déclarées comme étant destinées aux conducteurs rigides-solides;

– "r" pour les bornes déclarées comme étant destinées aux conducteurs rigides (solides et toronnés);

– "f" pour les bornes déclarées comme étant destinées aux conducteurs flexibles.

5.2 Marquage

5.2.1 Généralités

Le marquage des informations figurant en a) et b) de 5.1 est obligatoire sur la plaque signalétique de l'appareil pour circuits de commande, de manière à pouvoir obtenir des informations complètes auprès du constructeur.

Le marquage des informations données en n) du 5.1 doit figurer sur la plaque signalétique de l'appareil pour circuits de commande afin d'assurer le bon câblage de l'installation.

Les marques doivent être indélébiles et facilement lisibles et ne doivent pas être apposées sur des vis ou des rondelles amovibles.

Lorsqu'il y a suffisamment de place, les informations figurant en c) à m) et en o) du 5.1 doivent figurer sur la plaque signalétique ou sur l'appareil pour circuits de commande ou par défaut dans les documents publiés par le fabricant.

L'indication "s", "sol", "r" ou "f" pour bornes sans vis non universelles doit figurer sur l'appareil ou, si l'espace disponible n'est pas suffisant, sur le plus petit élément d'emballage ou dans les informations techniques fournies avec le produit.

5.2.2 Identification et marquage des bornes

Le Paragraphe 7.1.8.4 de l'IEC 60947-1:2007 s'applique, avec les exigences additionnelles identifiées dans l'Annexe M.

5.2.3 Repères de fonction

Les organes de commande peuvent être repérés par des symboles gravés. Si un bouton d'arrêt porte un symbole gravé ou marqué sur l'organe de commande, ce symbole doit être un cercle ou un ovale (signifiant la valeur zéro). Les symboles cercle ou ovale ne doivent être utilisés que pour les boutons d'arrêt.

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Des lettres et des mots peuvent être utilisés quand l'espace est suffisant pour fournir une identification précise. Dans tous les autres cas, le repère nécessaire à l'identification du bouton sera placé sur une plaquette fixée autour de chaque organe de commande ou située tout à côté de lui.

Les symboles doivent être conformes à l'IEC 60417.

5.2.4 Arrêt d'urgence

La forme et la couleur de l'organe de commande, la couleur de la surface située à l'arrière et la direction du déverrouillage des appareils d'arrêt d'urgence à accrochage mécanique doivent être conformes au 4.2 de l'IEC 60947-5-5:1997/AMD2:2016.

5.2.5 Diagramme de fonctionnement

5.2.5.1 Généralités

Etant donné que les commutateurs rotatifs peuvent avoir un grand nombre d'éléments de contact et un grand nombre de positions de l'organe de commande, il est nécessaire que le constructeur indique la relation entre les positions de l'organe de commande et les positions correspondantes des éléments de contact.

Il est recommandé que cette relation soit donnée sous forme d'un diagramme de fonctionnement dont la Figure 1 donne des exemples accompagnés de notes explicatives.

5.2.5.2 Indication de la position et position de contact

Le paragraphe 7.1.6.1 de l'IEC 60947-1:2007/AMD1:2010 s'applique avec l'addition suivante:

L'indication de la position doit être nette; le texte ou les symboles associés doivent être indélébiles et facilement lisibles.

5.2.5.3 Marques des bornes pour les diagrammes de fonctionnement

Les marques des bornes doivent être clairement identifiables compte tenu du diagramme de fonctionnement. Voir aussi l'Annexe M.

5.2.6 Indication de la temporisation

Pour les contacteurs auxiliaires temporisés, le marquage doit indiquer la valeur de la temporisation dans le cas d'une temporisation fixe et le domaine de temporisation dans le cas d'une temporisation réglable.

Dans le cas de plusieurs éléments de contact temporisés, l'écart de temps relatif entre le fonctionnement de chaque élément de contact et de celui qui le suit peut être indiqué pour les éléments de contact qui suivent la première temporisation.

Si plusieurs éléments de contact ont des temporisations réglables, on doit indiquer si elles sont réglables individuellement ou non.

Le constructeur doit indiquer, pour chaque élément de contact temporisé, les caractéristiques du retard selon 2.4.1.1 ou 2.4.1.2.

5.3 Instructions d'installation, de fonctionnement et d'entretien

Le paragraphe 5.3 de l'IEC 60947-1:2007/AMD1:2010/AMD2:2014 est applicable.

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5.4 Informations complémentaires

Les informations complémentaires nécessaires pour certains types d'appareils pour circuits de commande doivent être présentées conformément aux règles correspondantes des Annexes J et K.

Ces informations complémentaires doivent être fournies par le constructeur et peuvent être présentées sous la forme d'un schéma de câblage ou figurer dans les instructions d'emploi fournies avec l'appareil pour circuits de commande.

6 Conditions normales de service, de montage et de transport

L'Article 6 de l'IEC 60947-1:2007/AMD1:2010/AMD2:2014 est applicable avec les compléments suivants:

6.1.3.2 Degré de pollution

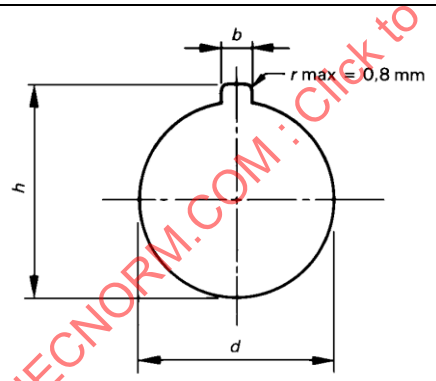
Sauf spécification contraire du constructeur, un appareil pour circuits de commande est prévu pour être installé dans les conditions d'environnement du degré de pollution 3. Toutefois, d'autres degrés de pollution peuvent s'appliquer en fonction du micro-environnement.

6.3.1 Montage des appareils fixés en un seul trou

Les boutons-poussoirs et voyants lumineux fixés en un seul trou sont placés dans un trou circulaire du support, comportant éventuellement un logement rectangulaire pour un ergot.

Les cotes sont indiquées dans le Tableau 2.

Tableau 2 – Diamètre du trou de fixation et cotes du logement éventuel d'ergot



Taille	Diamètre du trou de fixation, *d* mm	Logement éventuel d'ergot	
		Hauteur, *h* mm	Largeur, *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 Position du logement éventuel d'ergot

La position normalisée du logement d'ergot est en haut (12 heures), elle est associée avec la dimension *b* du Tableau 3.

6.3.1.2 Epaisseur de serrage

L'appareil, muni ou non du joint d'étanchéité prévu par le constructeur, doit pouvoir être monté sur un support de toute épaisseur comprise entre 1 mm et 6 mm, au besoin à l'aide d'une ou de plusieurs pièces d'assemblage fournies à cet effet.

NOTE Le joint d'étanchéité n'est pas normalisé.

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6.3.1.3 Groupement des appareils

Lorsque plusieurs appareils de la taille donnée en 6.3.1 sont montés en rangées sur un panneau, les entraxes *a* dans une même rangée et les distances *b* entre les lignes médianes des rangées ne doivent pas, sauf indication contraire du constructeur, être inférieurs aux valeurs données au Tableau 3.

Tableau 3 – Distances minimales préférentielles entre les centres des trous de fixation

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

Les distances *a* et *b* peuvent être interverties.

Ces valeurs ont pour but de servir de guide à l'évolution du matériel; cependant, lorsque des appareils de construction différente doivent être montés ensemble, il appartient à l'utilisateur de vérifier la compatibilité de ces appareils et de s'assurer du respect des distances d'isolement et des lignes de fuite une fois les appareils installés et raccordés.

NOTE Suivant les détails de conception, les raccordements, les étiquettes, etc., certains appareils sont susceptibles d'être montés à des distances inférieures à celles données au Tableau 3 selon les indications du constructeur des appareils. D'autre part, certains types d'appareils peuvent exiger des distances plus grandes que celles données au Tableau 3.

7 Dispositions relatives à la construction et au fonctionnement

7.1 Dispositions constructives

7.1.1 Généralités

Le paragraphe 7.1 de l'IEC 60947-1:2007/AMD1:2010/AMD2:2014 s'applique sauf pour 7.1.2, 7.1.3, 7.1.7, 7.1.9 et 7.1.13 avec les additions suivantes:

7.1.2 Matériaux

7.1.2.1 Exigences générales relatives aux matériaux

Le paragraphe 7.1.2.1 de l'IEC 60947-1:2007/AMD1:2010 s'applique avec l'ajout suivant:

L'attention doit être spécialement attirée sur les qualités de résistance à l'humidité et sur la nécessité de protéger certains isolants contre l'humidité.

Le paragraphe 7.1.2.2 de la présente norme s'applique en remplacement du 7.1.2.2 de l'IEC 60947-1:2007/AMD1:2010/AMD2:2014.

7.1.2.2 Essais au fil incandescent

L'aptitude à l'utilisation des matériaux se vérifie par:

a) la mise à l'essai de l'appareil; ou

b) la mise à l'essai de parties prélevées sur l'appareil; ou

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c) la mise à l'essai de toute partie d'un matériau identique présentant une épaisseur représentative; ou

d) la communication d'informations provenant du fournisseur du matériau isolant et satisfaisant aux exigences de l'IEC 60695-2-12.

L'aptitude à l'utilisation doit être déterminée suivant la résistance à la chaleur anormale et au feu. Le fabricant doit indiquer quelles méthodes – parmi a), b), c) et d) – doivent être utilisées.

Si un matériau identique présentant des sections représentatives a déjà satisfait aux exigences de l'un des essais du 8.2.1 de l'IEC 60947-1:2007/AMD1:2010, il n'est pas nécessaire de répéter ces essais.

Les essais de matériel doivent être effectués conformément à l'essai au fil incandescent des produits finis de l'IEC 60695-2-10 et de l'IEC 60695-2-11.

Les essais doivent se faire conformément au 8.2.1.1.1 de l'IEC 60947-1:2007/AMD1:2010 aux conditions visées au Tableau 6.

NOTE Pour les petites parties et les parties dont la masse est inférieure à 2 g, comme spécifié dans l'IEC 60695-2-11, aucun autre essai n'est exigé.

7.1.2.3 Essai basé sur la catégorie d'inflammabilité

Le paragraphe 7.1.2.3 de l'IEC 60947-1:2007/AMD1:2010 s'applique.

7.1.3 Parties transportant le courant et leurs connexions

Les parties transportant le courant doivent avoir la résistance mécanique et le courant de régime nécessaires à l'usage duquel elles sont destinées.

Pour les connexions électriques, aucune pression des contacts ne doit être transmise par des matériaux isolants autres que la matière céramique ou autres matériaux présentant des caractéristiques au moins équivalentes, à moins que les parties métalliques ne possèdent une élasticité suffisante pour compenser tout rétrécissement ou fléchissement éventuel du matériau isolant.

7.1.4 Distances d'isolement et lignes de fuite

Le paragraphe 7.1.4 de la CEI 60947-1:2007/AMD2:2014 s'applique.

7.1.5.3 Effort (ou moment) de commande

L'effort (ou le moment) nécessaire pour actionner l'organe de commande doit être compatible avec l'usage prévu. On prendra en considération la taille de l'organe de commande, le type de l'enveloppe ou du panneau, ce qui se trouve autour de l'installation et l'usage auquel l'organe de commande est destiné.

7.1.5.4 Limitation de la rotation (d'un commutateur rotatif)

Si les organes de commande utilisés ont un mouvement limité ou unidirectionnel, ils doivent être munis de moyens robustes de limitation capables de supporter cinq fois le moment maximal de commande réel.

7.1.5.5 Arrêt d'urgence

L'organe de commande doit, de préférence, être accroché en position actionnée, le contact de commande étant ouvert. Cet accrochage doit être relâché par une action distincte, par exemple une traction, une rotation ou l'emploi d'une clef.

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NOTE Des exigences supplémentaires pour les appareils d'arrêt d'urgence à accrochage sont données dans l'IEC 60947-5-5.

7.1.7 Dispositions relatives aux auxiliaires de commande aptes au sectionnement

Un auxiliaire de commande apte au sectionnement doit être à commande manuelle avec manoeuvre positive d'ouverture (voir Annexe K) et assurer, en position d'ouverture, la fonction de sectionnement (voir 2.1.19 et 7.1.7 de l'IEC 60947-1:2007/AMD1:2010/AMD2:2014).

La position d'ouverture d'un auxiliaire de commande apte au sectionnement doit être une position dans laquelle celui-ci peut demeurer lorsque aucun effort de commande ne lui est appliqué.

Afin d'empêcher la refermeture inopinée, la manœuvre des auxiliaires de commande aptes au sectionnement doit pouvoir être empêchée lorsque les éléments de contact sont en position d'ouverture. Cela peut être réalisé par un cadenas ou un verrou ne pouvant être relâché que par un outil spécial ou une clef.

7.1.8 Bornes

Les exigences de ce paragraphe doivent être vérifiées au moyen des essais visés en 8.2.4 de la présente norme.

7.1.14 Appareils de classe II pour circuit de commande

Ces appareils ne doivent pas être munis de dispositifs de protection de mise à la terre (voir l'IEC 61140).

Pour les appareils de classe II pour circuit de commande isolés par encapsulation, voir l'Annexe F.

7.1.15 Exigences pour les appareils pour circuit de commande avec câble faisant partie intégrante de l'appareil

Voir l'Annexe G.

7.2 Dispositions relatives au fonctionnement

Les paragraphes 7.2.1.1 et 7.2.2 de l'IEC 60947-1:2007/AMD1:2010/AMD2:2014 sont applicables avec les compléments suivants:

7.2.1.2 Limites de fonctionnement des contacteurs auxiliaires

Les limites de fonctionnement des contacteurs auxiliaires doivent être conformes à l'IEC 60947-4-1.

7.2.3 Propriétés diélectriques

Le paragraphe 7.2.3 de l'IEC 60947-1:2007/AMD1:2010/AMD2:2014 est applicable avec le complément suivant.

Pour les appareils de Classe II pour circuit de commande isolés par encapsulation, voir l'Annexe F.

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7.2.4 Aptitude à l'établissement et à la coupure dans les conditions normales et anormales de charge

7.2.4.1 Pouvoirs de fermeture et de coupure

a) *Pouvoirs de fermeture et de coupure en conditions normales*

Les éléments de commutation doivent pouvoir établir et couper sans défaillance les courants, conformément au Tableau 4, pour les catégories d'emploi et le nombre de cycles de manœuvres indiqués, dans les conditions spécifiées en 8.3.3.5.3.

NOTE Aux États-Unis d'Amérique et au Canada, il est établi que les éléments de commutation sont en mesure d'établir et de couper sans défaillance des courants dans les conditions indiquées pour les caractéristiques électriques basées sur les catégories d'emploi (par exemple, A600) visées au Tableau A.1 de l'Annexe A. Voir la réglementation fédérale et les normes de produit.

b) *Pouvoirs de fermeture et de coupure en conditions anormales*

Les éléments de commutation doivent pouvoir établir et couper sans défaillance les courants dans les conditions visées en 8.3.3.5.4 et précisées au Tableau 5, pour les catégories d'emploi exigées et le nombre de cycles de manœuvres spécifiés au Tableau 5.

7.2.4.2 Disponible

7.2.4.3 Durabilité

Le paragraphe 7.2.4.3 de l'IEC 60947-1:2007/AMD1:2010 est applicable avec les compléments suivants:

a) *Durabilité mécanique*

La durabilité mécanique d'un appareil pour circuits de commande est vérifiée, si nécessaire, par un essai spécial effectué à la discrétion du constructeur. Les instructions pour effectuer cet essai figurent en Annexe C.

b) *Durabilité électrique*

La durabilité électrique d'un appareil pour circuits de commande est vérifiée, si nécessaire, par un essai spécial effectué à la discrétion du constructeur. Les instructions pour effectuer cet essai figurent en Annexe C.

7.2.5 Courant de court-circuit conditionnel

Les éléments de commutation doivent pouvoir supporter les contraintes occasionnées par les courants de court-circuit dans les conditions spécifiées en 8.3.4.

7.2.6 Vacant

7.2.7 Exigences supplémentaires pour les auxiliaires de commande aptes au sectionnement

Les auxiliaires de commande aptes au sectionnement doivent être essayés conformément à 8.3.3.4 de l'IEC 60947-1:2007/AMD1:2010/AMD2:2014 avec une tension d'essai de valeur spécifiée au Tableau 14 de l'IEC 60947-1:2007 correspondant à la valeur de tension assignée de tenue aux chocs U_{imp} déclarée par le constructeur.

Les autres exigences supplémentaires applicables à de tels auxiliaires de commande sont à l'étude.

7.2.8 Temps de récupération maximum après défaillance

Pour le matériel comprenant des circuits électroniques, le temps de récupération maximum après défaillance et la méthode de mesure doivent être indiqués par le fabricant.

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7.3 Compatibilité électromagnétique (CEM)

7.3.1 Généralités

Le paragraphe 7.3.1 de l'IEC 60947-1:2007/AMD1:2010 s'applique avec les ajouts suivants:

L'appareil pour circuits de commande à soumettre à l'essai doit avoir tous les détails de conception essentiels du type qu'il représente et doit être dans un état propre et neuf.

Les essais de CEM doivent être effectués à la tension assignée d'emploi U_e ou, si la tension assignée d'emploi est donnée sous forme de plage, à une tension représentant la condition la plus défavorable.

L'entretien ou le remplacement de certaines parties durant ou après un cycle d'essai n'est pas autorisé.

En général, deux environnements A et B sont définis. Les produits couverts par la présente norme sont prévus pour une utilisation dans un environnement A.

Les contacteurs auxiliaires intégrant des circuits électroniques doivent satisfaire aux exigences du 8.3.2.2 de l'IEC 60947-4-1:2009.

7.3.2 Immunité

7.3.2.1 Matériel n'intégrant pas de circuits électroniques

Le paragraphe 7.3.2.1 de l'IEC 60947-1:2007 s'applique.

7.3.2.2 Matériel intégrant des circuits électroniques

Le paragraphe 7.3.2.2 de l'IEC 60947-1:2007/AMD1:2010 s'applique.

Les essais doivent être réalisés conformément au 8.4.

7.3.2.3 Critères d'acceptation

Au Tableau 7 figurent les critères d'acceptation.

7.3.2.4 Décharges électrostatiques

Les exigences sont précisées dans l'IEC 61000-4-2 et le Tableau 8.

7.3.2.5 Champs électromagnétiques rayonnés aux fréquences radioélectriques

Les exigences sont précisées dans l'IEC 61000-4-3 et le Tableau 8.

Si la direction correspondant au cas le plus défavorable est connue, alors l'essai est effectué seulement dans cette direction. Dans le cas contraire, le champ électromagnétique doit être dirigé vers l'appareil en essai selon trois directions mutuellement perpendiculaires.

7.3.2.6 Transitoires électriques rapides en salves

Les exigences sont précisées dans l'IEC 61000-4-4 et le Tableau 8.

7.3.2.7 Ondes de choc

Les exigences sont précisées dans l'IEC 61000-4-5 et le Tableau 8.

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7.3.2.8 Perturbations conduites, induites par les champs radioélectriques

Les exigences sont précisées dans l'IEC 61000-4-6 et le Tableau 8.

7.3.2.9 Champs magnétiques à la fréquence du réseau

Les exigences sont précisées dans l'IEC 61000-4-8 et le Tableau 8.

7.3.2.10 Creux de tension et interruptions

Les exigences sont précisées dans l'IEC 61000-4-11 et le Tableau 8.

7.3.2.11 Harmoniques du réseau

Les exigences sont précisées dans l'IEC 61000-4-13 et le Tableau 8.

7.3.3 Emission

7.3.3.1 Matériel n'intégrant pas de circuits électroniques

Le paragraphe 7.3.3.1 de l'IEC 60947-1:2007/AMD1:2010/AMD2:2014 s'applique.

7.3.3.2 Matériel intégrant des circuits électroniques

7.3.3.2.1 Limites des émissions en haute fréquence

Les appareils pour circuits de commande comprenant des circuits électroniques peuvent générer des perturbations électromagnétiques continues.

Ces émissions ne doivent pas dépasser les limites données par la CISPR 11 pour l'environnement A. Ces essais doivent être réalisés uniquement lorsque les circuits de commande et/ou auxiliaires contiennent des composants présentant des fréquences de commutation fondamentales supérieures à 9 kHz.

7.3.3.2.2 Limites des émissions en basse fréquence

Le paragraphe 7.3.3.2.2 de l'IEC 60947-1:2007/AMD1:2010 s'applique.

NOTE Ces exigences ne s'appliquent pas aux appareils qui ne seront pas connectés au réseau électrique public.

7.3.3.2.3 Conditions durant la mesure

Chaque mesure doit être réalisée dans des conditions définies et reproductibles.

La description des essais, méthodes et montages d'essai est indiquée dans la CISPR 11. Cependant, certaines modifications ou informations complémentaires nécessaires à l'application pratique des essais sont données dans la présente norme.

Les appareils pour circuits de commandes destinés à être alimentés par le réseau électrique public, et entrant donc dans le domaine d'application de l'IEC 61000-3-2 et de l'IEC 61000-3-3 pour ce qui concerne les émissions à basse fréquence, doivent aussi satisfaire aux exigences de ces normes.

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Tableau 4 – Vérification des pouvoirs de fermeture et de coupure des éléments de commutation dans les conditions normales correspondant aux catégories d'emploi

Catégorie d'emploi	Etablissement [a]			Coupure [a]			Durée minimale de passage	Séquence, nombre et cadence des manœuvres			
	I/I_e	U/U_e		I/I_e	U/U_e						
AC			cos φ			cos φ	**Cycles (à 50 Hz ou 60 Hz)**	**N° d'ordre** [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	**Temps** ms				
DC-12	1	1	1	1	1	1	25	50	10	990	5 000
DC-13	1	1	$6 \times_c P$	1	1	$6 \times_c P$	$T_{0,95}$				
DC-14	10	1	15	1	1	15	25 [b]				

I_e Courant assigné d'emploi
U_e Tension assignée d'emploi
$P = U_e \times I_e$ Energie absorbée en régime établi, en W
I Courant à établir ou à couper
U Tension avant établissement
$T_{0,95}$ Temps mis pour atteindre 95 % du courant en régime établi

NOTE Voir 8.3.3.5.3 pour l'objectif de l'essai.

[a] Pour les tolérances sur les grandeurs d'essai, voir 8.3.2.2.

[b] Chacune des deux durées de passage du courant (pour $I_{établissement}$ et pour $I_{coupure}$) doit être au moins égale à 2 cycles (ou 25 ms en DC-14).

[c] La valeur "$6 \times P$" résulte d'une relation empirique dont il s'avère qu'elle représente la plupart des charges magnétiques en courant continu jusqu'à une limite supérieure de P = 50 W, soit $6 \times P$ = 300 ms. Les charges dont la puissance absorbée est supérieure à 50 W sont présumées se composer de plus petites charges en parallèle.
En conséquence, la valeur 300 ms doit constituer une limite supérieure quelle que soit la puissance absorbée.
Pour les appareils de connexion à semi-conducteur, la valeur maximale de la constante de temps doit être 60 ms, soit $T_{0,95}$ = 180 ms (3 x constante de temps).

[d] Pour toutes les catégories d'emploi, la séquence d'essais doit être dans l'ordre donné.

[e] Le taux pour l'essai doit être le suivant:

Pour l'ordre n°1: 6 cycles de manœuvres par minute, qui doivent être effectués avec la tension d'essai augmentée à $U_e \times 1,1$, le courant d'essai I_e ayant été d'abord réglé avec la tension à U_e.

Pour l'ordre n°2: aussi rapidement que possible tout en assurant une fermeture et une ouverture complètes des contacts.

Pour l'ordre n°3: 60 cycles de manœuvres par minute.

Pour l'ordre n°4: 6 cycles de manœuvres par minute.

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Tableau 5 – Vérification des pouvoirs de fermeture et de coupure des éléments de commutation dans les conditions anormales correspondant aux catégories d'emploi

Catégorie d'emploi	Etablissement [a]			Coupure [a]			Durée minimale de passage	Manœuvres d'établissement et de coupure	
	I/I_e	U/U_e		I/I_e	U/U_e			Nombre	Cadence par minute
AC			cos φ			cos φ	**Cycles (à 50 Hz ou 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	**Temps** ms		
DC-12	–	–	–	–	–	–	–	–	–
DC-13 [d]	–	–	–	–	–	–	–	–	–
DC-14	10	1,1	15	10	1,1	15	25 [c]	10	6

I_e Courant assigné d'emploi
U_e Tension assignée d'emploi
$P = U_e \times I_e$ Energie absorbée en régime établi, en W
I Courant à établir ou à couper
U Tension avant établissement
$T_{0,95}$ Temps mis pour atteindre 95 % du courant en régime établi

NOTE La condition anormale consiste à simuler un électro-aimant bloqué en position ouverte. Voir 8.3.3.5.4.

[a] Pour les tolérances sur les grandeurs d'essai, voir 8.3.2.2.

[b] Pour les appareils de connexion à semi-conducteur, il convient d'utiliser un dispositif de protection contre les surcharges spécifié par le fabricant pour vérifier les conditions anormales.

[c] Chacune des deux durées de passage du courant (pour $I_{établissement}$ et pour $I_{coupure}$) doit être au moins égale à 2 cycles (ou 25 ms en DC-14).

[d] L'essai de DC-13 dans des conditions anormales est couvert par l'essai dans des conditions normales.

Tableau 6 – Conditions d'essai pour l'essai au fil incandescent

Partie en essai	Condition d'essai
Partie ayant une masse inférieure à 2 g (voir 3.14 de l'IEC 60695-2-11:2014)	L'essai n'est pas nécessaire [a]
Partie constituant une petite partie conformément au 3.15 de l'IEC 60695-2-11:2014	L'essai n'est pas nécessaire [a]
Partie maintenant en position des parties transportant le courant	Essai au fil incandescent à la température de 750 °C
Toutes les autres parties	Essai au fil incandescent à la température de 650 °C [b]

[a] Il n'est pas nécessaire de réaliser d'autres essais.

[b] La température du fil incandescent peut être réduite à 550 °C s'il peut être démontré que le risque résiduel d'incendie est acceptable.

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Tableau 7 – Critères d'acceptation

Point	Critère d'acceptation (critères de performance au cours des essais)		
	A	B	C
Performance globale	Pas de changement décelable de la caractéristique de fonctionnement. Fonctionnement comme prévu [a].	Dégradation temporaire ou perte de performance qui est autorécupérable [b].	Dégradation temporaire ou perte des performances nécessitant l'intervention d'un opérateur ou la réinitialisation du système.
Fonctionnement des composants d'affichage et de signalisation	Pas de changement de l'information affichée. Seulement une légère fluctuation de l'intensité de la lumière ou du son de la source du signal optique ou sonore, ou un léger mouvement des caractères ou un léger changement de fréquence de la source du signal sonore.	Changements temporaires visibles ou perte d'informations. Signal optique ou sonore non souhaité.	Arrêt, perte permanente de l'affichage ou mauvaise information. Mode de fonctionnement non autorisé. Non autorécupérable.
Fonctions de traitement de l'information et de détection	Communication non perturbée et échange de données vers des appareils externes qui restent dans la spécification.	Communication temporairement perturbée, qui est détectée et autorécupérable.	Traitement erroné de l'information. Perte de données et/ou de l'information non détectée. Erreurs dans les communications. Non autorécupérable.

[a] Le fabricant doit indiquer dans sa documentation la fréquence de fonctionnement et la bande passante lorsque les fréquences radioélectriques conduites peuvent causer des dysfonctionnements.

[b] Le temps de récupération après défaillance ne doit pas dépasser la durée maximale pouvant être mesurée lorsque l'appareil est mis en fonctionnement par mise sous tension aux bornes d'alimentation (temps de récupération maximum après défaillance, voir 7.2.8).

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Tableau 8 – Essais d'immunité

Type de l'essai	Norme de base	Niveau d'essai exigé		Critère d'acceptation
Essai d'immunité aux décharges électromagnétiques	IEC 61000-4-2	8 kV / décharge dans l'air ou 4 kV / décharge au contact		B [k]
Essai d'immunité aux champs électromagnétiques rayonnés aux fréquences radioélectriques 80 MHz à 1 GHz	IEC 61000-4-3	10 V/m		A
Essai d'immunité aux champs électromagnétiques rayonnés aux fréquences radioélectriques 1,4 GHz à 2 GHz	IEC 61000-4-3	3 V/m		A
Essai d'immunité aux champs électromagnétiques rayonnés aux fréquences radioélectriques 2 GHz à 2,7 GHz	IEC 61000-4-3	1 V/m		A
Essais d'immunité aux transitoires électriques rapides en salves (avec pince de couplage capacitive)	IEC 61000-4-4	2 kV / 5 kHz aux accès de puissance [a] 1 kV / 5 kHz aux accès de signaux [b]		B [k]
Essai d'immunité aux ondes de choc (1,2/50 µs – 8/20 µs) [c]	IEC 61000-4-5	2 kV (phase-terre) 1 kV (phase-phase)		B
Essai d'immunité aux perturbations conduites, induites par les champs radioélectriques (150 kHz à 80 MHz)	IEC 61000-4-6	10 V		A
Essai d'immunité au champ magnétique à la fréquence du réseau [d]	IEC 61000-4-8	30 A/m		A
Essai d'immunité aux creux de tension [h]	IEC 61000-4-11	Classe 2 [e, f] 0 % pendant 0,5 cycle	Classe 3 [e, f] 0 % pendant 0,5 cycle	B [k, l]
		Classe 2 [e, f] 0 % pendant 1 cycle	Classe 3 [e, f] 0 % pendant 1 cycle	B
		Classe 2 [e, f, g] 70 % pendant 25/30 cycles	Classe 3 [e, f, g] 40 % pendant 10/12 cycles 70 % pendant 25/30 cycles 80 % pendant 250/300 cycles	C
Essai d'immunité aux interruptions de tension [h]	IEC 61000-4-11	Classe 2 [e, f, g] 0 % pendant 250/300 cycles	Classe 3 [e, f, g] 0 % pendant 250/300 cycles	C
Immunité aux harmoniques du réseau	IEC 61000-4-13	Pas d'exigences [i]		

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