



# UL 60947-5-1

## STANDARD FOR SAFETY

Low-Voltage Switchgear and  
Controlgear – Part 5-1: Control Circuit  
Devices and Switching Elements –  
Electromechanical Control Circuit  
Devices

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UL Standard for Safety for Low-Voltage Switchgear and Controlgear – Part 5-1: Control Circuit Devices and Switching Elements – Electromechanical Control Circuit Devices, UL 60947-5-1

Fourth Edition, Dated May 31, 2022

### **Summary of Topics**

***Adoption of the Fourth edition of IEC 60947-5-1, Standard for Low-Voltage Switchgear and Controlgear – Part 5-1: Control Circuit Devices and Switching Elements – Electromechanical Control Circuit Devices, as the Fourth edition ANSI/UL 60947-5-1.***

***This standard is an adoption of IEC 60947-5-1, Edition 4.0 published in May 2016 and corrigendum 1 issued July 2016. Please note that the national difference document incorporates all of the U.S. national differences for UL 60947-5-1.***

The requirements are substantially in accordance with Proposal(s) on this subject dated February 7, 2020 and September 27, 2021.

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UL 60947-5-1  
Fourth Edition

## Low-Voltage Switchgear and Controlgear – Part 5-1: Control Circuit Devices and Switching Elements – Electromechanical Control Circuit Devices

May 31, 2022

This national standard is based on IEC 60947-5-1, Edition 4 (2016) and corrigendum 1 (2016).



ANSI/UL 60947-5-1-2022



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## Preface

This is the harmonized CSA Group and UL standard for Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices. It is the second edition of CSA C22.2 No. 60947-5-1 and the fourth edition of UL 60947-5-1. This edition of CSA C22.2 No. 60947-5-1 supersedes the previous edition published in 2014 as CAN/CSA-C22.2 No. 60947-5-1 (adopted IEC 60947-5-1:2003).

This harmonized standard is based on IEC Publication 60947-5-1: fourth edition, Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices, issued May 2016. IEC 60947-5-1 is copyrighted by the IEC.

This harmonized standard was prepared by CSA Group and Underwriters Laboratories Inc. (UL). The efforts and support of the Technical Harmonization Committee for Industrial Control Equipment, of the Council on the Harmonization of Electrotechnical Standards of the Nations of the Americas (CANENA), are gratefully acknowledged.

This standard is considered suitable for use for conformity assessment within the stated scope of the standard.

This standard was reviewed by the CSA Integrated Committee on Industrial Control, under the jurisdiction of the CSA Technical Committee on Industrial Products and the CSA Strategic Steering Committee on Requirements for Electrical Safety, and has been formally approved by the CSA Technical Committee. This standard has been developed in compliance with Standards Council of Canada requirements for National Standards of Canada. It has been published as a National Standard of Canada by CSA Group.

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Note: Although the intended primary application of this Standard is stated in its scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.

CSA C22.2 No. 60947-5-1 is to be used in conjunction with the current edition of CSA C22.2 No. 60947-1. The requirements of this Standard, where stated, amend the requirements of CSA C22.2 No. 60947-1.

UL 60947-5-1 is to be used in conjunction with the current edition of UL 60947-1. Requirements of this standard, where stated, amend the requirements of UL 60947-1.

## Level of harmonization

This standard adopts the IEC text with national differences.

This standard is published as an identical standard for CSA and UL.

An identical standard is a standard that is exactly the same in technical content except for national differences resulting from conflicts in codes and governmental regulations and basic safety principles and requirements. Presentation is word for word except for editorial changes.

All national differences from the IEC text are included in the CSA Group and UL versions of the standard. While the technical content is the same in each organization's version, the format and presentation may differ.

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## NATIONAL DIFFERENCES

### GENERAL

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## FOREWORD

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International Standard IEC 60947-5-1 has been prepared by subcommittee 121A: Low-voltage switchgear and controlgear, of IEC technical committee 121: Switchgear and controlgear and their assemblies for low voltage.

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

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

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

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

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

| FDIS         | Report on voting |
|--------------|------------------|
| 121A/62/FDIS | 121A/76/RVD      |

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

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

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

The provisions of the general rules, IEC 60947-1, are applicable to this standard, where specifically called for. General rules, clauses and subclauses thus applicable, as well as tables, figures and annexes are identified by a reference to IEC 60947-1, for example 1.2.3, Table 4 or Annex A of IEC 60947-1:2007.

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

- 7.2.4.1: Making and breaking capacities (United States of America and Canada)
- 8.3.3.5.2: Test circuits and connections (United States of America and Canada)

A list of all the parts in the IEC 60947 series, under the general title *Low-voltage switchgear and controlgear*, can be found on the IEC website. The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

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

The contents of the corrigendum of July 2016 have been included in this copy.

**DV.1 DE Modification of the IEC Foreword by adding the following:**

The numbering system in the standard uses a space instead of a comma to indicate thousands and uses a comma instead of a period to indicate a decimal point. For example, 1 000 means 1,000 and 1,01 means 1.01.

**DV.2 D2 Modification of the IEC Foreword by adding the following:**

This standard shall be read in conjunction with Canadian and United States equivalent standards to the IEC 60947 series per [Table DVA.2](#). Where specifically called for, any reference to IEC 60947-5-1 or IEC 60947-1 shall be to the applicable clause, either the national difference “DV” clause or IEC clause, or a reference to the applicable standard listed in the Annex. The provisions of the general rules are applicable to this standard, where specifically called for.

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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).

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.

**1.1DV D2 Modification of 1.1 by adding the following:**

**This equipment is intended for installation in accordance with CSA C22.1, Canadian Electrical Code (CE Code, Part I), and the US National Electrical Code (NEC), NFPA 70.**

## 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<sup>1</sup>, *Graphical symbols for use on equipment*

IEC 60617-DB:2012<sup>2</sup>, *Graphical symbols for diagrams*

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

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

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

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<sup>2</sup> up to 35 mm<sup>2</sup> (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

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*

### 1.2DV DC Modification of 1.2 by adding the following:

For a list of normative standards, see [Table DVA.1](#) and [Table DVA.2](#). See [Table DVB.1](#) for component standards.

## 2 Terms and definitions

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

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## 2.1 Basic terms and definitions

### 2.1.1

#### **control circuit device**

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

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

### 2.1.2

#### **control switch** (for control and auxiliary circuits)

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

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

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

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

### 2.1.3

#### **control switch suitable for isolation**

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

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

### 2.1.4

#### **control station**

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

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

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

## 2.2 Control switches

### 2.2.1

#### **automatic control switches**

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

#### 2.2.1.1

##### **instantaneous contactor relay**

a contactor relay operating without any intentional time delay

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

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

## 2.2.1.2

**time-delay contactor relay**

a contactor relay with specified time-delay characteristics

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

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

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

## 2.2.1.3

**position switch**

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

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

## 2.2.1.4

**programmer**

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

## 2.2.2

**manually operated control switches**

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

## 2.2.2.1

**push-button**

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

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

## 2.2.2.2

**pull-button**

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

## 2.2.2.3

**push-pull button**

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

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

## 2.2.2.4

**rotary button**

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

EXAMPLE A selector switch.

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

## 2.2.2.5

**latched push-button**

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

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

## 2.2.2.6

**locked push-button**

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

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

## 2.2.2.7

**key-operated push-button**

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

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

## 2.2.2.8

**time-delay push-button**

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

## 2.2.2.9

**delayed action push-button**

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

## 2.2.2.10

**illuminated push-button**

a push-button incorporating a signalling lamp in the button

## 2.2.2.11

**covered push-button**

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

## 2.2.2.12

**shrouded push-button**

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

## 2.2.2.13

**free push-button**

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

## 2.2.2.14

**guided push-button**

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

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

## 2.2.2.15

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

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

## 2.2.2.16

**key-operated rotary switch**

a rotary switch where a key is used as the actuator

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

## 2.2.2.17

**limited movement rotary switch**

a rotary switch with a restricted angular movement of its actuator

## 2.2.2.18

**unidirectional movement rotary switch**

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

## 2.2.2.19

**joy stick**

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

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

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

## 2.2.2.20

**wobble stick**

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

## 2.2.2.21

**foot switch****pedal**

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

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

**2.3 Parts of control switches**

## 2.3.1

**switching element**

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

## 2.3.2

**semiconductor element**

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

### 2.3.3

#### **contact element**

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

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

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

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

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

#### 2.3.3.1

##### **single gap contact element**

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

Note 1 to entry: See [Figure 4 a\)](#) and [Figure 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 [Figure 4 b\)](#), [Figure 4 d\)](#) and [Figure 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 [Figure 4 c\)](#), [Figure 4 d\)](#) and [Figure 4 e\)](#).

#### 2.3.3.6

##### **pulse contact element**

##### **fleeting contact element**

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

#### 2.3.3.7

##### **electrically separated contact elements**

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

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

## 2.3.3.8

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

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

## 2.3.3.9

**dependent action contact element**

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

## 2.3.3.10

**contact unit**

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

## 2.3.4

**button**

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

## 2.3.4.1

**flush-button**

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

## 2.3.4.2

**recessed button**

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

## 2.3.4.3

**extended button**

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

## 2.3.4.4

**mushroom button**

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

## 2.3.5

**locating mechanism**

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

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

## 2.3.6

**end stop**

a device that limits the travel of a moving part

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



## 2.4 Operation of control switches

### 2.4.1 Operation of contactor relays

#### 2.4.1.1

##### **e-delay**

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

Example: delay to close make-contacts (ON delay).

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

#### 2.4.1.2

##### **d-delay**

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

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

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

#### 2.4.1.3

##### **fixed delay**

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

#### 2.4.1.4

##### **adjustable delay**

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

### 2.4.2 Operation of pilot switches

#### 2.4.2.1

##### **actuating quantity**

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

#### 2.4.2.2

##### **operating value**

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

#### 2.4.2.3

##### **return value**

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

#### 2.4.2.4

##### **differential value**

the difference between the operating value and the return value

### 2.4.3 Operation of rotary switches

#### 2.4.3.1

**definite position** (of a rotary switch)

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

#### 2.4.3.2

**position of rest**

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

#### 2.4.3.3

**transit position**

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

#### 2.4.3.4

**biased position**

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

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

#### 2.4.3.5

**latched position**

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

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

#### 2.4.3.6

**locked position**

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

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

#### 2.4.3.7

**operating diagram**

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

### 2.4.4 Operation of mechanically operated control switches

#### 2.4.4.1

**pre-travel of the actuator**

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

Note 1 to entry: See Dimension a on [Figure 2](#).

#### 2.4.4.2

**over-travel of the actuator**

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

## 2.4.4.3

**direct drive**

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

## 2.4.4.4

**positive drive**

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

## 2.4.4.5

**limited drive**

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

## 2.4.4.6

**minimum starting force****minimum starting moment**

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

## 2.4.4.7

**minimum actuating force****minimum actuating moment**

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

## 2.4.4.8

**pre-travel of the contact element**

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

Note 1 to entry: See Dimension *b* on [Figure 2](#).

## 2.4.4.9

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

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

Note 1 to entry: See Dimension *d* on [Figure 2](#).

## 2.4.4.10

**bounce time**

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

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

### 3 Classification

#### 3.1 Contact elements

Contact elements may be classified as follows:

- a) Utilization categories (see [4.4](#)).
- b) Electrical ratings based on utilization categories (see Annex [A](#)).

c) One of the following form letters (see [Figure 4](#)):

- 1) Form A – Single gap make-contact element;
- 2) Form B – Single gap break-contact element;
- 3) Form C – Single gap make-break three terminal change-over contact element;
- 4) Form X – Double gap make-contact element;
- 5) Form Y – Double gap break-contact element;
- 6) Form Z – Double gap make-break four terminal change-over contact element.

d) Other types not included in c).

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

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

## 3.2 Control switches

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

## 3.3 Control circuit devices

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

## 3.4 Time delay switching elements

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

## 3.5 Control switch mounting

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

# 4 Characteristics

## 4.1 Summary of characteristics

### 4.1.1 General

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

- type of equipment (see [4.2](#));
- rated and limiting values for switching elements (see [4.3](#));

- utilization categories of switching elements (see [4.4](#));
- normal and abnormal load characteristics (see [4.3.6](#)).

#### 4.1.2 Operation of a control switch

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

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

##### 4.1.2.1 Normal conditions of use

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

##### 4.1.2.2 Abnormal conditions of use

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

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

#### 4.2 Type of control circuit device or switching element

##### 4.2.1 Kind of control circuit device

The kind of control circuit device shall be stated:

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

##### 4.2.2 Kind of switching elements

The kind of switching elements shall be stated:

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

- control circuit contacts of overload relays.

#### **4.2.3 Number of poles**

The number of poles shall be stated.

#### **4.2.4 Kind of current**

The kind of current shall be stated:

Alternating current or direct current.

#### **4.2.5 Interrupting medium**

The interrupting medium shall be stated:

Air, oil, gas, vacuum, etc.

#### **4.2.6 Operating conditions**

##### **4.2.6.1 Method of operation**

The method of operation shall be stated:

Manual, electromagnetic, pneumatic, electro-pneumatic.

##### **4.2.6.2 Method of control**

The method of control shall be stated:

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

### **4.3 Rated and limiting values for switching elements**

#### **4.3.1 General**

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

#### **4.3.2 Rated voltages (of a switching element)**

##### **4.3.2.1 General**

A switching element is defined by the rated voltages described in [4.3.2.2](#) to [4.3.2.4](#).

##### **4.3.2.2 Rated operational voltage ( $U_e$ )**

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

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

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

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

#### **4.3.2.3 Rated insulation voltage ( $U_i$ )**

Subclause 4.3.1.2 of IEC 60947-1:2007 applies.

#### **4.3.2.4 Rated impulse withstand voltage ( $U_{imp}$ )**

Subclause 4.3.1.3 of IEC 60947-1 applies.

### **4.3.3 Currents**

A switching element is characterized by the currents described in [4.3.3.1](#) to [4.3.3.3](#).

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

Subclause 4.3.2.1 of IEC 60947-1:2007 applies.

#### **4.3.3.2 Conventional enclosed thermal current ( $I_{the}$ )**

Subclause 4.3.2.2 of IEC 60947-1:2007 applies.

#### **4.3.3.3 Rated operational current ( $I_e$ )**

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

### **4.3.4 Rated frequency**

Subclause 4.3.3 of IEC 60947-1:2007 applies.

### **4.3.5 Vacant**

### **4.3.6 Normal and abnormal load characteristics**

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

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

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

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

### 4.3.6.2 Making and breaking capacities under abnormal conditions

A switching element shall comply with the requirements given in [Table 5](#) corresponding to the assigned utilization category.

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

### 4.3.7 Short-circuit characteristics

#### 4.3.7.1 Rated conditional short-circuit current

Subclause 4.3.6.4 of IEC 60947-1:2007 applies.

### 4.4 Utilization categories for switching elements

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

**Table 1**  
**Utilization categories for switching elements**

| Kind of current     | Category | Typical applications                                                            |
|---------------------|----------|---------------------------------------------------------------------------------|
| Alternating current | AC-12    | Control of resistive loads and solid state loads with isolation by optocouplers |
|                     | AC-13    | Control of solid state loads with transformer isolation                         |
|                     | AC-14    | Control of small electromagnetic loads ( $\leq 72$ 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            |

**4.4DV D2 Modification of 4.4 by adding the following text and Table 4.4DV:**

The equipment rating and required load designation shall be in accordance with [Table 4.4DV](#). In addition, utilization categories and/or additional load designations may be marked.

**Table 4.4DV**  
**Ratings of a device controlling an external load**

| Load type     | Equivalent <sup>1</sup> utilization category | Equipment rating | Required load marking | Additional load designations |
|---------------|----------------------------------------------|------------------|-----------------------|------------------------------|
| AC pilot duty | AC-15, AC-14                                 | Amperes          | See NOTE              | See NOTE                     |
| DC pilot duty | DC-13                                        | Amperes          | See NOTE              | See NOTE                     |

Table 4.4DV Continued on Next Page



Table 4.4DV Continued

| Load type                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Equivalent <sup>1</sup> utilization category | Equipment rating | Required load marking | Additional load designations |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|------------------|-----------------------|------------------------------|
| AC general purpose – Noninductive or slightly inductive                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | AC-1                                         | Amperes          | None                  | General use; AC-1            |
| DC general purpose – Noninductive or slightly inductive                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | DC-1                                         | Amperes          | None                  | General use; DC-1            |
| AC resistance (not air heating)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | –                                            | Amperes          | Resistive             | Res.                         |
| DC resistance (not air heating)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | –                                            | Amperes          | Resistive             | Res.                         |
| Incandescent lamp                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | AC-5b                                        | Amperes or watts | Tungsten              | AC-5b                        |
| Incandescent lamp                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | DC-6                                         | Amperes or watts | Tungsten              | DC-6                         |
| Ballast (electric discharge lamp)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | AC-5a                                        | Amperes          | Ballast               | AC-5a                        |
| <p><b>NOTE:</b> Equipment marking may be:</p> <p>a) in the form of a code designation in accordance with <a href="#">Table A.1</a>, <a href="#">Table A.2</a> or <a href="#">Table A.3</a> as applicable;</p> <p>b) voltage and the words “standard duty” (codes B and P) or “heavy duty” (codes A and N); or</p> <p>c) volts, amperes, and inrush amperes; volts and volt-amperes; or volts, amperes, and the words “pilot duty”.</p> <p>(1) See Annex A of CSA C22.2 No. 60947-1/UL 60947-1 for utilization category-relevant product standards.</p> |                                              |                  |                       |                              |

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

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

**4.11 Actuating quantities for pilot switches**

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

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

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

#### 4.12 Pilot switches having two or more contact elements

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

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

### 5 Product information

#### 5.1 Nature of information

The following information shall be given by the manufacturer:

##### *Identification*

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

##### *Basic rated values and utilization*

- d) Rated operational voltages (see [4.3.2.2](#)).
- e) Utilization category and rated operational currents at the rated operational voltages of the control circuit device.
- f) Rated insulation voltage (see [4.3.2.3](#)).
- g) Rated impulse withstand voltage (see [4.3.2.4](#)).
- h) Vacant.
- i) IP code, in case of an enclosed control circuit device (see 5.1 and Annex C of IEC 60947-1:2007/AMD1:2010).
- j) Pollution degree (see [6.1.3.2](#)).
- k) Type and maximum ratings of short-circuit protective device (see [8.3.4.3](#)).
- l) Conditional short-circuit current.
- m) Suitability for isolation, where applicable, with the symbol S00288 of IEC 60617.

- n) Indication of contact elements of same polarity.
- o) Length of insulation to be removed before insertion of the conductor into the terminal.
- p) For non-universal screwless terminals:
  - "s" or "sol" for terminals declared for rigid-solid conductors;
  - "r" for terminals declared for rigid (solid and stranded) conductors;
  - "f" for terminals declared for flexible conductors.

**5.1DV D2 Modification of 5.1 by adding the following:**

**5.1DV.1 Items f) and l) are optional.**

**5.1DV.2 Item g) is optional except when evaluating creepage and clearance distances per 7.1.4 of CSA C22.2 No. 60947-1/UL 60947-1.**

**5.1DV.3 Item i) is optional and may be in addition to the required enclosure Type ratings according to 7.1.12DV of CSA C22.2 No. 60947-1/UL 60947-1.**

**5.1DV.4 Item m) does not apply.**

**5.1DV.5 Terminal markings for tightening torque, number of conductors, solid or stranded and wire range shall comply with 5.2 and 5.2DV.6 of CSA C22.2 No. 60947-1/UL 60947-1 for non-screwless terminals.**

**5.1DV.6 Items o) and p) are replaced by the following:**

**o) Length of insulation to be removed before insertion of the conductor into the screwless terminal.**

**p) For screwless terminals:**

- "s" or "sol" for terminals declared for solid conductors;
- "str" for terminals declared for stranded 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.

**5.2.1DV D2 Modification of 5.2.1 by adding the following:**

**5.2.1DV.1** The data specified in Items d) and e) of Clause [5.1](#) shall be marked on the control circuit device. Where space does not permit complete electrical ratings, one or more ratings shall be marked on the device, with additional rating(s) provided in the manufacturer's published literature.

**5.2.1DV.2** When the marked ratings described in Item e) are the code designations specified in [Table A.1](#), [Table A.2](#), and [Table A.3](#) of Annex [A](#), the information concerning the voltage and overload current ratings for each contact rating code designation shall be published in a catalog, contained on a marking sheet packed with the product, or otherwise made available to the user.

**5.2.1DV.3** The data specified in Item i) shall be marked in accordance with CSA C22.2 No. 94.1, CSA C22.2 No. 94.2, UL 50, and UL 50E on the component, its carton, or accompanying instruction sheet. Enclosure type ratings of open-type components for enclosure mounting shall comply with 5.2DV.10 and 7.1.1DV.6 of CSA C22.2 No. 60947-1/UL 60947-1.

**5.2.1DV.4** Individual contact blocks of a push-button or selector switch unit shall be marked to indicate the operators with which they are intended to be used unless the switch unit has been found acceptable for use with all operators to which they may be assembled that are made available by the manufacturer.

**5.2.1DV.5** For equipment that can be assembled in different combinations, all components shall be identified, and reference shall be made on the basic equipment to all components that can be assembled together. The marking can appear on the component or be provided in the accompanying instruction sheet.

**5.2.2 Terminal identification and marking**

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

**5.2.3 Functional markings**

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

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

Symbols shall be in accordance with IEC 60417.

## 5.2.4 Emergency stop

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

### 5.2.6DV D2 Modification of 5.2.6 as follows:

[5.2.6](#) is informative.

## 5.3 Instructions for installation, operation and maintenance

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

## 5.4 Additional information

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

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

## 6 Normal service, mounting and transport conditions

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

### 6.1.3.2 Pollution degree

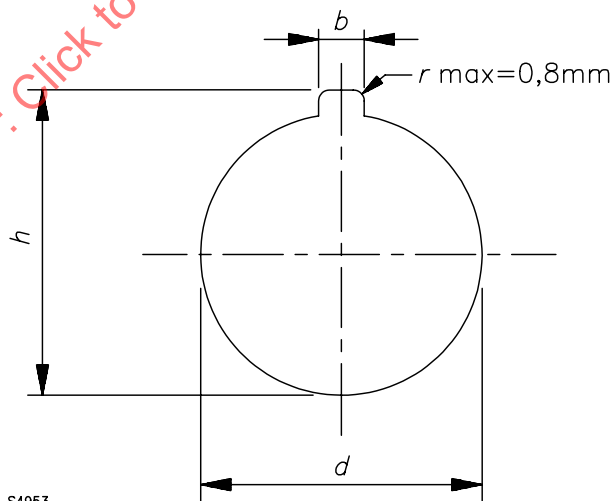
Unless otherwise stated by the manufacturer, a control circuit device is intended for installation under environmental conditions of pollution degree 3. However, other pollution degrees may apply, depending upon the micro-environment.

### 6.3.1 Mounting of single hole mounted devices

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

The dimensions are indicated in [Table 2](#):

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



| Size | Mounting hole diameter, $d$<br>mm | Key recess (if any) |                  |
|------|-----------------------------------|---------------------|------------------|
|      |                                   | Height, $h$<br>mm   | Width, $b$<br>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 | $a$<br>mm | $b$<br>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:

#### **7.1.1DV D2 Modification of 7.1.1 by adding the following:**

**Subclauses 7.1.2, 7.1.3 and 7.1.13 of CSA C22.2 No. 60947-1/UL 60947-1 apply.**

## 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
- 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.

##### **7.1.4DV D2 Modification of 7.1.4 by adding the following:**

Creepage and clearance distances at field wiring terminals shall be evaluated in accordance with Annex DVC. Where the design of the field wiring terminals is such that it precludes the possibility of reduced spacing due to stray strands or improper wiring installation, Clause 7.1.4 of CSA C22.2 No. 60947-1/UL 60947-1 applies. Creepage and clearance distances at other than field wiring terminals shall be evaluated in accordance with Annex DVC or Clause 7.1.4 of CSA C22.2 No. 60947-1/UL 60947-1.

#### 7.1.5.3 Actuating force (or moment)

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

#### 7.1.5.4 Limitation of rotation (of a rotary switch)

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

#### 7.1.5.5 Emergency stop

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

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

#### 7.1.7 Conditions for control switches suitable for isolation

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

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

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

##### **7.1.7DV D2 Modification of 7.1.7 by replacing it with the following:**

**This Clause does not apply.**

#### 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](#).

##### **7.1.14DV D2 Modification of 7.1.14 by replacing it with the following:**

**This Clause does not apply.**

#### 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](#).

##### **7.2.3DV D2 Modification of 7.2.3 by adding the following:**

**The requirements in Annex [F](#) do not apply.**

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

##### **7.2.4.1 Making and breaking capacities**

###### *a) Making and breaking capacities under normal conditions*

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

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

###### *b) Making and breaking capacities under abnormal conditions*

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

**7.2.4.1DV D2 Modification of 7.2.4.1 by adding the following:**

Item b) is optional.

**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.

**7.2.7DV D2 Modification of 7.2.7 by replacing it with the following:**

**This Clause does not apply.**

**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.

### **7.2.8DV D2 Modification of 7.2.8 as follows:**

**This requirement is optional.**

## **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.

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

### **7.3.2 Immunity**

#### **7.3.2.1 Equipment not incorporating electronic circuits**

Subclause 7.3.2.1 of IEC 60947-1:2007 applies.

#### **7.3.2.2 Equipment incorporating electronic circuits**

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

Tests shall be made according to [8.4](#).

#### **7.3.2.3 Acceptance criteria**

[Table 7](#) gives acceptance criteria.

#### **7.3.2.4 Electrostatic discharges**

Requirements are stated in IEC 61000-4-2 and [Table 8](#).

#### **7.3.2.5 Radiated radio-frequency electromagnetic fields**

Requirements are stated in IEC 61000-4-3 and [Table 8](#).

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

### **7.3.2.6 Electrical fast transients/bursts**

Requirements are stated in IEC 61000-4-4 and [Table 8](#).

### **7.3.2.7 Surges**

Requirements are stated in IEC 61000-4-5 and [Table 8](#).

### **7.3.2.8 Conducted disturbances induced by radio-frequency fields**

Requirements are stated in IEC 61000-4-6 and [Table 8](#).

### **7.3.2.9 Power-frequency magnetic fields**

Requirements are stated in IEC 61000-4-8 and [Table 8](#).

### **7.3.2.10 Voltage dips and interruptions**

Requirements are stated in IEC 61000-4-11 and [Table 8](#).

### **7.3.2.11 Harmonics in the supply**

Requirements are stated in IEC 61000-4-13 and [Table 8](#).

## **7.3.3 Emission**

### **7.3.3.1 Equipment not incorporating electronic circuits**

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

### **7.3.3.2 Equipment incorporating electronic circuits**

#### **7.3.3.2.1 Limits for high-frequency emissions**

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

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

#### **7.3.3.2.2 Limits for low-frequency emissions**

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

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

#### **7.3.3.2.3 Conditions during measurement**

Each measurement shall be performed in defined and reproducible conditions.



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

| Utilization category                                                                                                                                                                                                                                        | Make <sup>a</sup> |         |                  | Break <sup>a</sup> |         |                  | Minimum on-time                   | Making and breaking operation |                 |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|---------|------------------|--------------------|---------|------------------|-----------------------------------|-------------------------------|-----------------|
|                                                                                                                                                                                                                                                             | $I/I_e$           | $U/U_e$ |                  | $I/I_e$            | $U/U_e$ |                  |                                   | Number                        | Rate per minute |
| <b>AC</b>                                                                                                                                                                                                                                                   |                   |         | <b>cos φ</b>     |                    |         | <b>cos φ</b>     | <b>Cycles (at 50 Hz or 60 Hz)</b> |                               |                 |
| AC-12                                                                                                                                                                                                                                                       | —                 | —       | —                | —                  | —       | —                | —                                 | —                             | —               |
| AC-13 <sup>b</sup>                                                                                                                                                                                                                                          | 10                | 1,1     | 0,65             | 1,1                | 1,1     | 0,65             | 2 <sup>c</sup>                    | 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               |
| <b>DC</b>                                                                                                                                                                                                                                                   |                   |         | $T_{0,95}$<br>ms |                    |         | $T_{0,95}$<br>ms | <b>Time<br/>ms</b>                |                               |                 |
| DC-12                                                                                                                                                                                                                                                       | —                 | —       | —                | —                  | —       | —                | —                                 | —                             | —               |
| DC-13 <sup>(3)</sup>                                                                                                                                                                                                                                        | —                 | —       | —                | —                  | —       | —                | —                                 | —                             | —               |
| DC-14                                                                                                                                                                                                                                                       | 10                | 1,1     | 15               | 10                 | 1,1     | 15               | 25 <sup>c</sup>                   | 10                            | 6               |
| $I_e$ Rated operational current<br>$U_e$ Rated operational voltage<br>$P = U_e \times I_e$ Steady-state power consumption, in W<br>$I$ Current to be made or broken<br>$U$ Voltage before make<br>$T_{0,95}$ Time to reach 95 % of the steady-state current |                   |         |                  |                    |         |                  |                                   |                               |                 |
| NOTE The abnormal condition is to simulate a blocked open electromagnet. See <a href="#">8.3.3.5.4</a> .                                                                                                                                                    |                   |         |                  |                    |         |                  |                                   |                               |                 |
| <sup>a</sup> For tolerances on test quantities, see <a href="#">8.3.2.2</a> .                                                                                                                                                                               |                   |         |                  |                    |         |                  |                                   |                               |                 |
| <sup>b</sup> For semiconductor switching devices an overload protective device specified by the manufacturer should be used to verify the abnormal conditions.                                                                                              |                   |         |                  |                    |         |                  |                                   |                               |                 |
| <sup>c</sup> 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).                                                                                                                            |                   |         |                  |                    |         |                  |                                   |                               |                 |
| <sup>d</sup> 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 <sup>a</sup>                      |
| Part which is a small part according to 3.15 of IEC 60695-2-11:2014                                                                 | Test is not required <sup>a</sup>                      |
| 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 <sup>b</sup> |
| <sup>a</sup> Alternative tests do not have to be conducted.                                                                         |                                                        |
| <sup>b</sup> Glow wire temperature can be reduced to 550 °C if it can be demonstrated that the residual risk of fire is acceptable. |                                                        |

**Table 7**  
**Acceptance criteria**

| Item                                                                                                                                                                                                                                                                                                                                                          | Acceptance criteria<br>(performance criteria during tests)                                                                                                                                                                               |                                                                                               |                                                                                                                                                      |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                                                                                                                                                                                               | a                                                                                                                                                                                                                                        | b                                                                                             | c                                                                                                                                                    |
| Overall performance                                                                                                                                                                                                                                                                                                                                           | No noticeable changes of the operating characteristic.<br><br>Operating as intended <sup>a</sup>                                                                                                                                         | Temporary degradation or loss of performance which is self-recoverable <sup>b</sup>           | 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.<br><br>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.<br><br>Undesired optical or audible signal. | Shut down, permanent loss of display or wrong information.<br><br>Unpermitted operating mode.<br><br>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.<br><br>Undetected loss of data and/or information.<br><br>Errors in communication.<br><br>Not self-recoverable. |
| <sup>a</sup> The manufacturer shall state in his literature the operating frequency and bandwidth where conducted radio frequencies may cause malfunction.<br><sup>b</sup> The recovery time shall not exceed the maximum time which can be measured when the device is started by power-on at the power supply terminals (maximum recovery time, see 7.2.8). |                                                                                                                                                                                                                                          |                                                                                               |                                                                                                                                                      |

**Table 8**  
**Immunity tests**

| Type of test                                                                     | Basic standard | Test level required                                                                   | Acceptance criteria |
|----------------------------------------------------------------------------------|----------------|---------------------------------------------------------------------------------------|---------------------|
| Electrostatic discharge immunity test                                            | IEC 61000-4-2  | 8 kV / air discharge<br>or 4 kV / contact discharge                                   | B <sup>k</sup>      |
| Radiated radio-frequency electromagnetic field immunity test<br>80 MHz to 1 GHz  | IEC 61000-4-3  | 10 V/m                                                                                | A                   |
| Radiated radio-frequency electromagnetic field immunity test<br>1,4 GHz to 2 GHz | IEC 61000-4-3  | 3 V/m                                                                                 | A                   |
| Radiated radio-frequency electromagnetic field immunity test<br>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 <sup>a</sup><br>1 kV / 5 kHz on signal ports <sup>b</sup> | B <sup>k</sup>      |
| Surge immunity test<br>(1,2/50 µs – 8/20 µs) <sup>c</sup>                        | IEC 61000-4-5  | 2 kV (line to earth)<br>1 kV (line to line)                                           | B                   |

**Table 8 Continued on Next Page**



Table 8 Continued

| Type of test                                                                              | Basic standard | Test level required                                     |                                                                                                                  | Acceptance criteria |
|-------------------------------------------------------------------------------------------|----------------|---------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|---------------------|
| 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 <sup>d</sup>                                 | IEC 61000-4-8  | 30 A/m                                                  |                                                                                                                  | A                   |
| Voltage dips immunity test <sup>h</sup>                                                   | IEC 61000-4-11 | Class 2 <sup>e, f</sup><br>0 % during 0,5 cycle         | Class 3 <sup>e, f</sup><br>0 % during 0,5 cycle                                                                  | B <sup>k, l</sup>   |
|                                                                                           |                | Class 2 <sup>e, f</sup><br>0 % during 1 cycle           | Class 3 <sup>e, f</sup><br>0 % during 1 cycle                                                                    | B                   |
|                                                                                           |                | Class 2 <sup>e, f, g</sup><br>70 % during 25/30 cycles  | Class 3 <sup>e, f, g</sup><br>40 % during 10/12 cycles<br>70 % during 25/30 cycles<br>80 % during 250/300 cycles | C                   |
| Voltage interruptions immunity test <sup>h</sup>                                          | IEC 61000-4-11 | Class 2 <sup>e, f, g</sup><br>0 % during 250/300 cycles | Class 3 <sup>e, f, g</sup><br>0 % during 250/300 cycles                                                          | C                   |
| Immunity to harmonics in the supply                                                       | IEC 61000-4-13 | No requirements <sup>i</sup>                            |                                                                                                                  |                     |

<sup>a</sup> 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.

<sup>b</sup> 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.

<sup>c</sup> Not applicable for extra-low voltage a.c. ports ( $\leq 30$  V) and extra-low voltage d.c. input/output ports ( $\leq 60$  V), when the secondary circuits (isolated from the a.c. mains) are not subject to transient overvoltages.

<sup>d</sup> Applicable only to equipment containing devices susceptible to power frequency magnetic fields.

<sup>e</sup> 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.

<sup>f</sup> The given percentage means percentage of the rated operational voltage, e.g. 0 % means 0 V.

<sup>g</sup> The value before the solidus (/) is for 50 Hz and the value behind is for 60 Hz tests.

<sup>h</sup> Applicable for a.c. equipment only.

<sup>i</sup> Requirements are under study for the future.

<sup>k</sup> 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.

<sup>l</sup> 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 [E](#), the inspection is supplemented by a dielectric test.

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

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

#### 8.1.4 Sampling tests

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

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

### 8.1.5 Special tests

These tests are subject to agreement between manufacturer and user.

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

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

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

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

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

## 8.2 Compliance with constructional requirements

### 8.2.1 Materials

#### 8.2.1.1 Test of resistance to abnormal heat and fire

##### 8.2.1.1.1 Glow-wire test (on equipment)

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

The conditions specified in [7.1.2.2](#) of this document and [Table 6](#) applies.

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

Subclause 8.2.1.1.2 of IEC 60947-1:2007 applies.

### 8.2.2 Equipment

Subclause 8.2.2 of IEC 60947-1:2007 applies.

### 8.2.3 Enclosures for equipment

Subclause 8.2.3 of IEC 60947-1:2007 applies.

### 8.2.4 Mechanical and electrical properties of terminals

#### 8.2.4.1 General conditions for tests

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

#### 8.2.4.2 Tests of mechanical strength of terminals

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

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

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

#### 8.2.4.4 Pull-out test

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

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

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

#### 8.2.4.7 Electrical performance of screwless-type clamping units

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

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

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

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

NOTE 2 See [C.1.2.2](#) for a description of the single 8 test.

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

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

The test current applied shall be according to [Table 9](#).

The voltage drop shall not exceed 15 mV.

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

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

#### **8.2.4.8 Ageing test for screwless-type clamping units**

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

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

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

The test current shall be according to [Table 9](#).

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

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

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

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

#### **8.2.5 Verification of actuating force (or moment)**

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

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

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

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

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

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

Subclause 8.2.7 of IEC 60947-1:2007 applies.

## 8.3 Performance

### 8.3.1 Test sequences

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

– **Test sequence I** (sample No. 1)

Test No. 1 – Operating limits of contactor relays ([8.3.3.2](#)), if applicable

Test No. 2 – Temperature rise ([8.3.3.3](#))

Test No. 3 – Dielectric properties ([8.3.3.4](#))

Test No. 4 – Mechanical and electrical properties of terminals ([8.2.4](#))

– **Test sequence II** (sample No. 2)

Test No. 1 – Making and breaking capacities of switching elements under normal conditions ([8.3.3.5.3](#))

Test No. 2 – Dielectric verification ([8.3.3.5.6](#) b))

– **Test sequence III** (sample No. 3)

Test No. 1 – Making and breaking capacities of switching elements under abnormal conditions ([8.3.3.5.4](#))

Test No. 2 – Dielectric verification ([8.3.3.5.6](#) b))

– **Test sequence IV** (sample No. 4)

Test No. 1 – Performance under conditional short-circuit current ([8.3.4](#))

Test No. 2 – Dielectric verification ([8.3.3.5.6](#) b))

– **Test sequence V** (sample No. 5)

Test No. 1 – Degree of protection of enclosed control circuit devices (Annex C of IEC 60947-1:2007/AMD2:2014)

Test No. 2 – Verification of actuation force or moment ([8.2.5](#))

– **Test sequence VI** (sample No. 6)

Test No. 1 – Measurement of clearances and creepage distances, if applicable (7.1.4 of IEC 60947-1:2007/AMD2:2014)

Test No. 2 – Verification of limitation of rotation of a rotary switch ([8.2.6](#)).

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

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

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

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

**8.3.1DV D2 Modification of 8.3.1 by replacing it with the following:**

**8.3.1DV.1** 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 sequence I-A (sample No. 2)

Test No. 1 – Mechanical and electrical properties of terminals ([8.2.4](#))

– Test sequence II (sample No. 3)

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 V-A (sample No. 4)

Enclosure tests – enclosed control circuit devices shall be evaluated in accordance with the applicable requirements in CSA C22.2 No. 94.1, CSA C22.2 No. 94.2, UL 50, and UL 50E.

– Test sequence VI (sample No. 5)

Test No. 1 – Measurement of clearances and creepage distances, if applicable (7.1.4 of IEC 60947-1:2007/AMD2:2014)

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

**8.3.1DV.1.1** 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.

**8.3.1DV.1.2** For control circuit devices with integrally connected cables, the number of samples required is specified in Annex [G](#).

**8.3.1DV.2** The following tests are optional:

– Making and breaking capacities of switching elements under abnormal conditions ([8.3.3.5.4](#));

- Performance under conditional short-circuit current (8.3.4);
- Degree of protection of enclosed control circuit devices (Annex C of IEC 60947-1:2007/AMD2:2014);
- Verification of actuation force or moment (8.2.5); and Verification of limitation of rotation of a rotary switch (8.2.6).

## 8.3.2 General test conditions

### 8.3.2.1 General requirements

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

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

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

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

- the maximum force (or moment) exerted on the actuator shall not exceed 1,5 times the force (or moment) required for maximum over-travel of the contact element(s);
- the cover-travel of the contact elements shall be between 50 % and 80 % of the over-travel inherent in the design of the contact elements.

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

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

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

c) For limited movement rotary switches, operation shall be at a speed of 1 to 4 revolutions per second unless otherwise declared by the manufacturer in the test report.

### 8.3.2.2 Test quantities

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

### 8.3.2.3 Evaluation of test results

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



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

#### 8.3.2.4 Test reports

Subclause 8.3.2.4 of IEC 60947-1:2007 applies.

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

#### 8.3.3.1 Operation

Subclause 8.3.3.1 of IEC 60947-1:2007 applies.

#### 8.3.3.2 Operating limits of contactor relays

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

#### 8.3.3.3 Temperature rise

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

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

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

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

##### **8.3.3.3DV.1 D2 Modification of 8.3.3.3 by adding the following:**

**8.3.3.3DV.1.1** The device terminals shall be torqued to a value of 0,8 N·m. Other values of torque may be used for the evaluation provided that the equipment is marked with the torque value.

**8.3.3.3DV.1.2** Devices with contact rating code letter designations as noted in [Table A.1](#), [Table A.2](#), and [Table A.3](#) shall be temperature tested based on 100% of their thermal continuous test current. When not marked with a code designation, the device shall be tested at its maximum rated steady state current.

**8.3.3.3DV.1.3** Equipment that is marked with a minimum as well as a maximum voltage rating along with a volt-ampere rating, or the equivalent, shall be tested at its highest calculated steady-state-current value, which is the volt-ampere rating divided by the minimum voltage rating.

#### 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 [E](#).

#### 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 [Figure 5](#) and [Figure 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 [Table 4](#) and [Table 5](#). The test circuit applied shall be stated in the test report.

#### **8.3.3.5.2DV D2 Modification of 8.3.3.5.2 by adding the following:**

##### **8.3.3.5.2DV.1 Air-core inductive load**

**8.3.3.5.2DV.1.1** In lieu of the electromagnetic loads described in Clause [8.3.3.5.2](#), an air-core inductive load may be used to produce the normal (break) and inrush (make) currents as required in [Table 4](#), provided that the duration of the inrush (make) current is at least 2 cycles at 50 or 60 hertz.

**8.3.3.5.2DV.1.2** If an auxiliary device is integral with a controller, the test shall be conducted with the intended electromagnet as the load.

#### **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).

### 8.3.3.5.3DV D2 Modification of 8.3.3.5.3 by adding the following text and Table 8.3.3.5.3DV:

For non-pilot duty ratings in [Table 4.4DV](#), the 6 050 operating cycles shall be performed in accordance with [Table 8.3.3.5.3DV](#).

**Table 8.3.3.5.3DV**  
**Make and break test conditions for non-pilot duty load types**

| Load type                                               | Utilization category | Make and break test conditions |             |             |                |                          |                 |                            |                       |
|---------------------------------------------------------|----------------------|--------------------------------|-------------|-------------|----------------|--------------------------|-----------------|----------------------------|-----------------------|
|                                                         |                      | Test <sup>a</sup> order        | $I_c / I_e$ | $U_r / U_e$ | $\cos \varphi$ | On-time <sup>a</sup> , s | Off-time, s     | Number of operating cycles | Operations per minute |
| AC general purpose; non-inductive or slightly inductive | AC-1                 | 1                              | 1,5         | 1,05        | 0,8            | 0,05                     | 10              | 50                         | 6                     |
|                                                         |                      | 2 <sup>f</sup>                 | 1,0         | 1,05        | 0,8            | 0,05                     | 10 <sup>f</sup> | 6 000                      | 6                     |
| AC resistance (not air heating)                         | —                    | 1                              | 1,5         | 1,05        | 1,0            | 0,05                     | 10              | 50                         | 6                     |
|                                                         |                      | 2 <sup>f</sup>                 | 1,0         | 1,05        | 1,0            | 0,05                     | 10              | 6 000                      | 6                     |
| Ballast (electric discharge lamp)                       | AC-5a                | 1                              | 3,0         | 1,05        | 0,45           | 0,05                     | 10              | 50                         | 6                     |
|                                                         |                      | 2                              | 2,0         | 1,05        | 0,45           | 0,05                     | 10              | 6 000                      | 6                     |
| Incandescent lamp, AC                                   | AC-5b                | 1                              | 1,5         | 1,05        | b              | 0,05                     | 10              | 50                         | 6                     |
|                                                         |                      | 2                              | 1,0         | 1,05        | b              | 0,05                     | 60              | 6 000                      | 1                     |
| DC general purpose; non-inductive or slightly inductive | DC-1                 | 1                              | 1,5         | 1,05        | 1,0            | 0,05                     | 10              | 50 <sup>c</sup>            | 6                     |
|                                                         |                      | 2 <sup>f</sup>                 | 1,0         | 1,05        | 1,0            | 0,05                     | 10              | 6 000 <sup>d</sup>         | 6                     |
| DC resistance (not air heating)                         | —                    | 1                              | 1,5         | 1,05        | 1,0            | 0,05                     | 10              | 50 <sup>c</sup>            | 6                     |
|                                                         |                      | 2 <sup>f</sup>                 | 1,0         | 1,05        | 1,0            | 0,05                     | 10              | 6 000 <sup>d</sup>         | 6                     |
| Incandescent lamp, DC                                   | DC-6                 | 1                              | 1,5         | 1,05        | b              | 0,05                     | 10              | 50 <sup>c</sup>            | 6                     |
|                                                         |                      | 2                              | 1,0         | 1,05        | b              | 0,05                     | 60              | 6 000 <sup>d</sup>         | 1                     |

$I_c$  = current made or broken. Except for AC-5b or DC-6 categories, the making current is expressed in d.c. or a.c.  
r.m.s. symmetrical values, but it is understood that for a.c., the actual peak value during the making operation may assume a higher value than the symmetrical peak value  
 $I_e$  = rated operational current  
 $U_r$  = power frequency or d.c. recovery voltage  
 $U_e$  = rated operational voltage  
 $\cos \varphi$  = power factor of test circuit  
 $L / R$  = time-constant of test circuit

<sup>a</sup> The time may be less than 0,05 s, provided that contacts are allowed to become properly seated before reopening.  
<sup>b</sup> Tests are to be carried out with an incandescent light load, or a synthetic load having an inrush current of at least ten times the steady state current rating and the peak value of the inrush current shall be reached within 4,167 ms.  
<sup>c</sup> If polarity is not marked on the device, 25 operating cycles with one polarity and 25 operating cycles with reverse polarity.  
<sup>d</sup> If polarity is not marked on the device, 3 000 operating cycles with one polarity and 3 000 operating cycles with reverse polarity.  
<sup>e</sup> For all utilization categories, the test sequence shall be in the order given.  
<sup>f</sup> The test is not required for solid state switching devices

### 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](#).

## 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](#).

### 8.4 Tests for EMC

#### 8.4DV D2 Modification of 8.4 by adding the following:

[8.4](#) and all subclauses are optional.

#### 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  $(300 \pm 50)$  mm and the thickness  $1,5_0^{+0,5}$  mm.

– If not required otherwise by horizontal standard the connecting leads shall be  $2_0^{+0,1}$  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;
- 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  $U_{\text{imp}}$  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

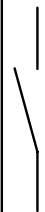
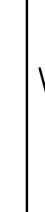
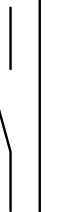
The test results shall be documented in a comprehensive test report. The test report shall present the objective, the results and all relevant information of the tests. The test report shall define the control circuit device under test, including the layout of the connecting leads and if applicable the 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).

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

| Conductor size<br>mm <sup>2</sup> | Test current<br>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                        |                                                |

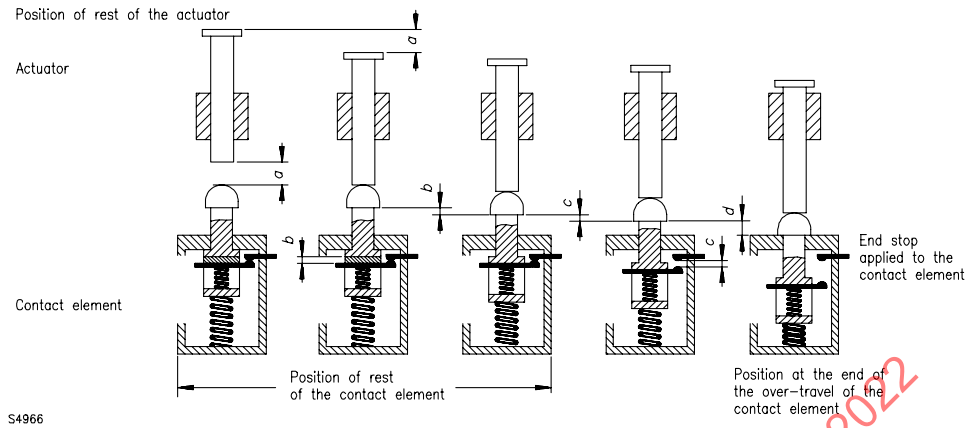


| Number of the example                                                                                                                                                                                        | Disposition of the contact element(s)                                                 | Actuator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

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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

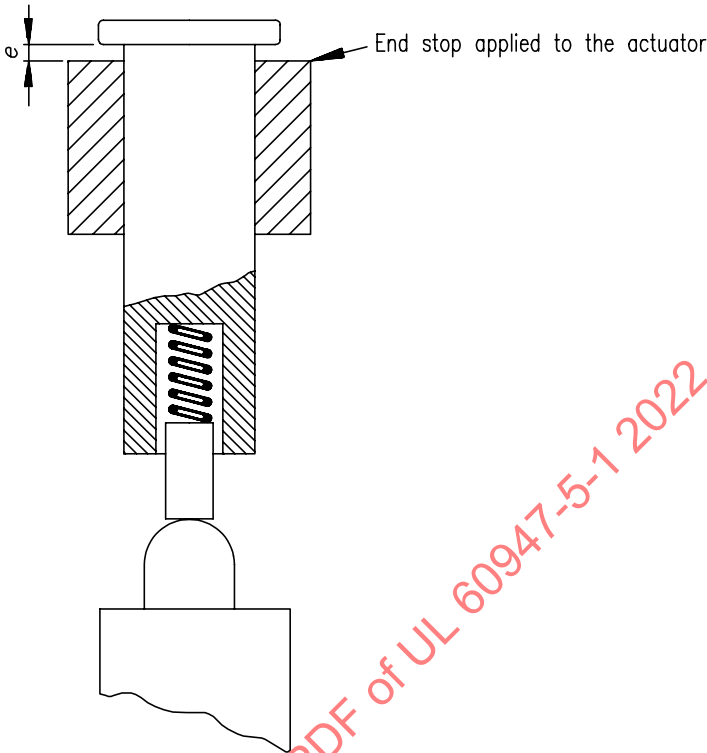
$b + c + d$  Total travel of the contact element

$a + b + c + d + e)^*$  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 can exceed the over-travel of the contact element by a length e.

**Figure 2**

### Operation of push-buttons



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Figure 3

Difference  $e$  between the over-travel of the actuator and that of the contact element

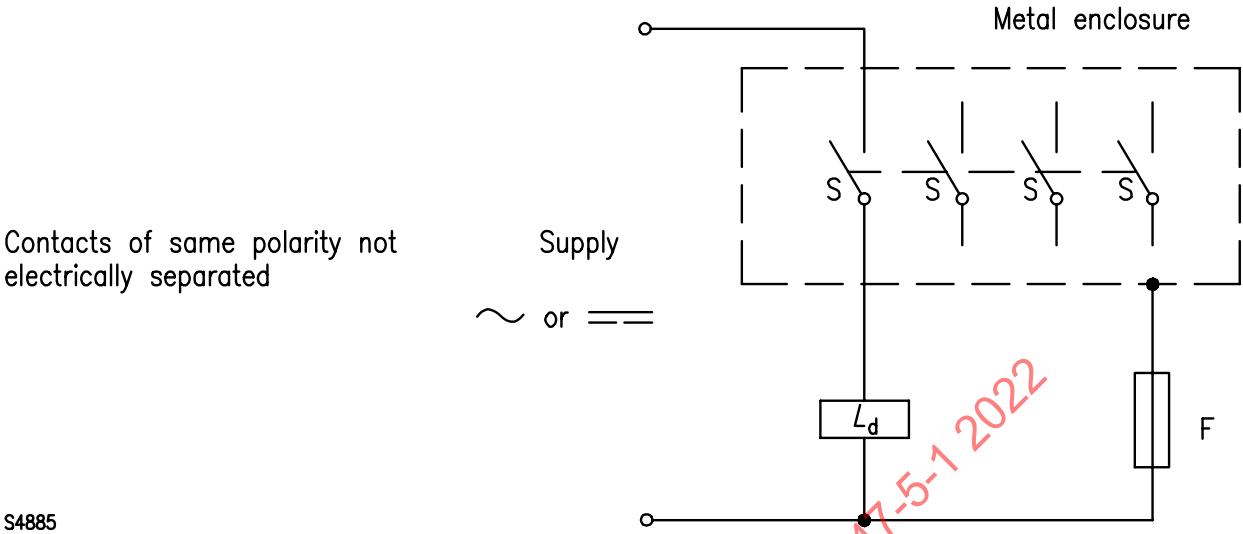
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| Figure No. | Figure | Symbols    | Forms | Description                                                                                                          |
|------------|--------|------------|-------|-------------------------------------------------------------------------------------------------------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

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NOTE 1 Symbols according to IEC 60617.

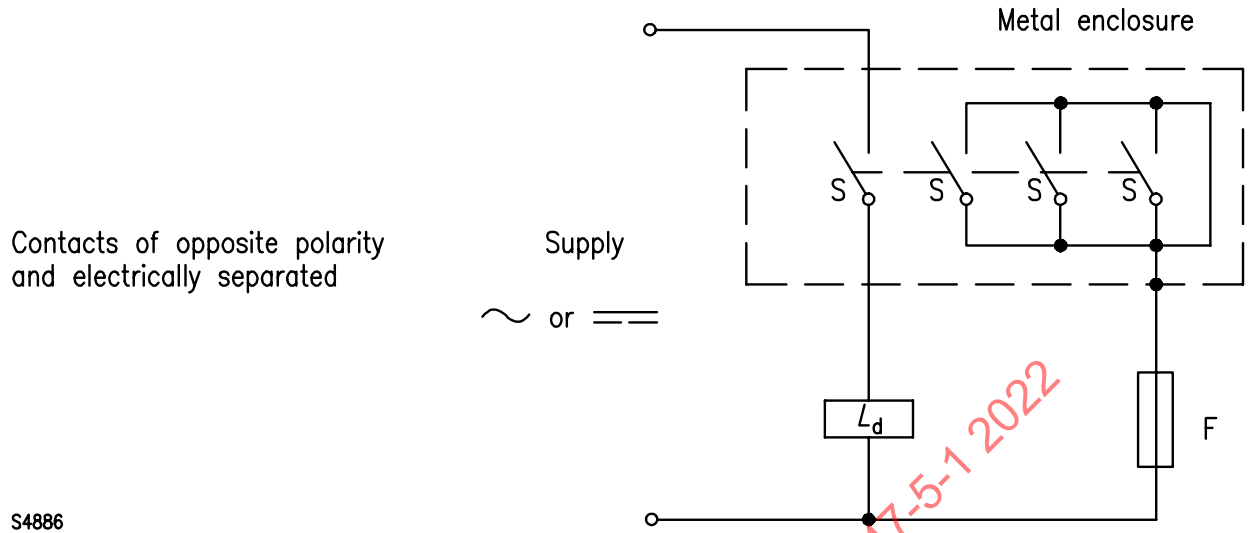
**Figure 4**  
**Examples of contact elements (schematic sketches)**



$L_d$ : 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**

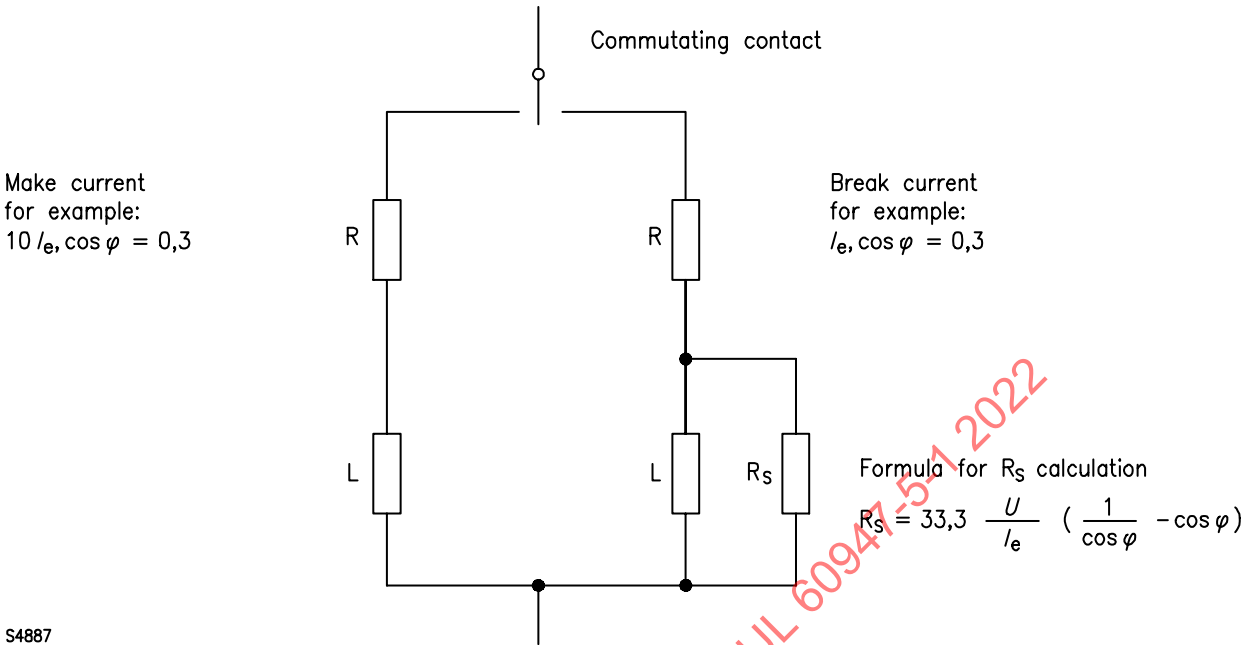
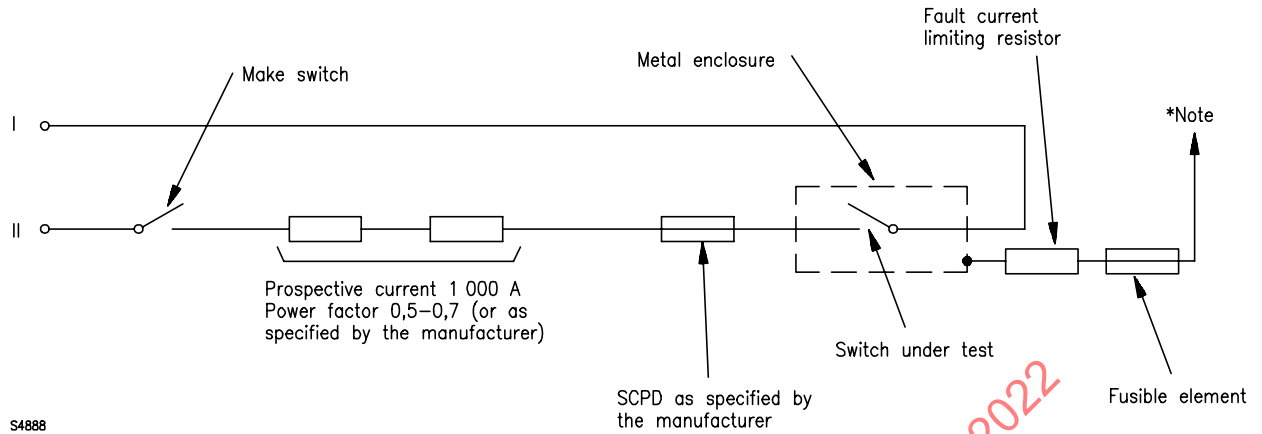


Figure 7

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](#))**



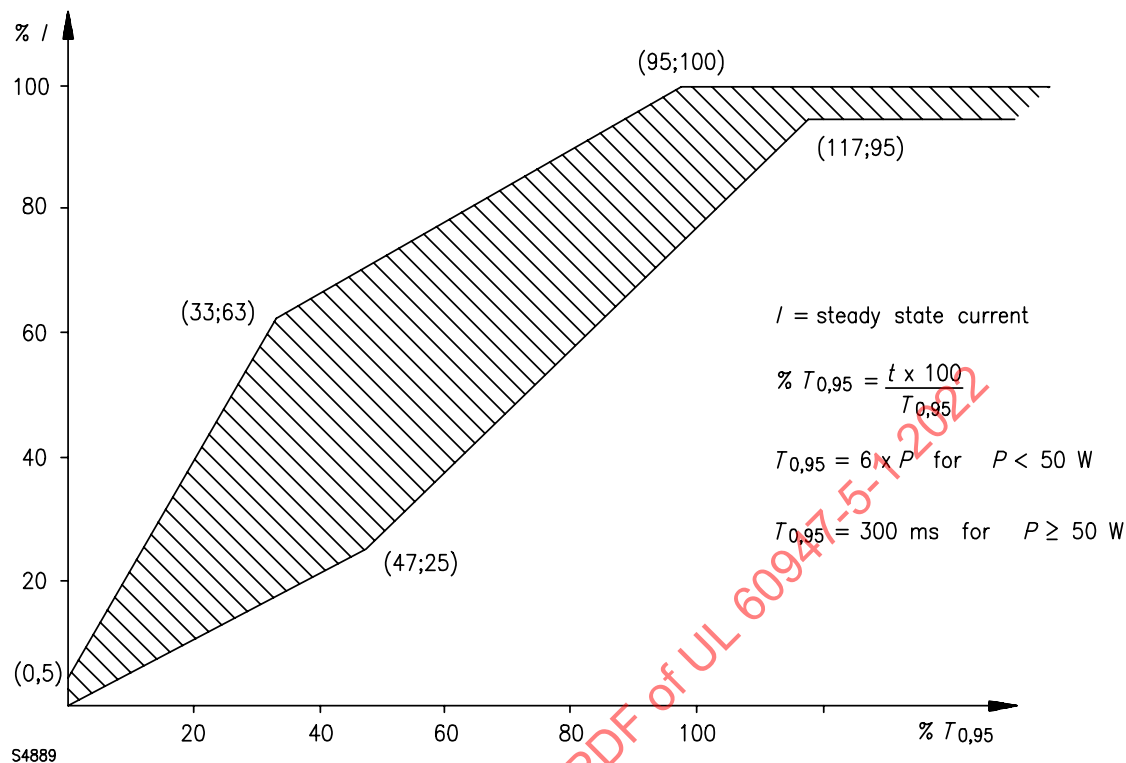


Figure 9  
Current/time limits for d.c. test loads (see 8.3.3.5.4)

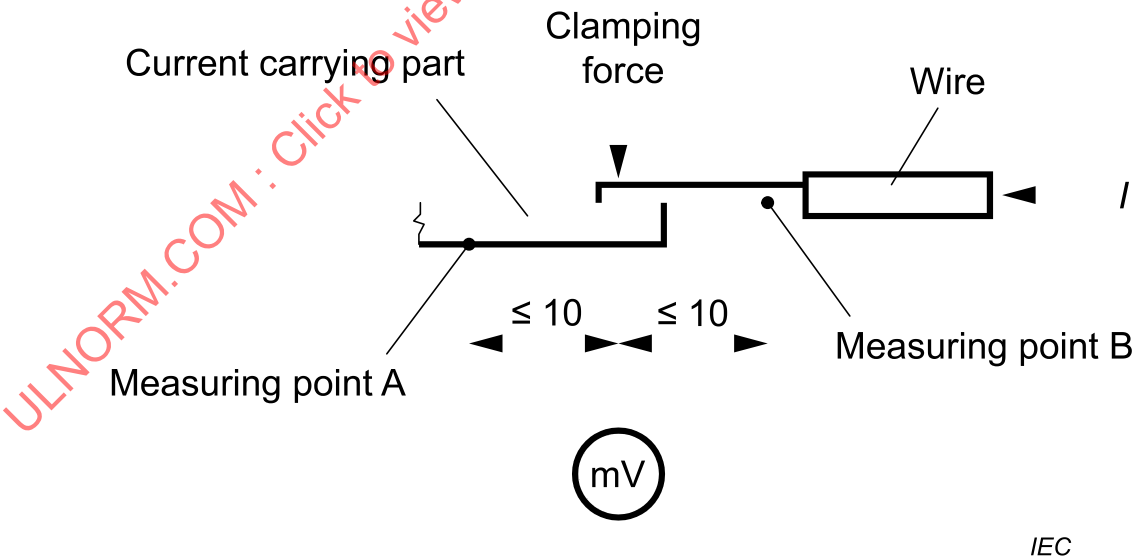


Figure 10  
Voltage drop measurement at contact point of the clamping unit or terminal

## Annex A (normative)

### Electrical ratings based on utilization categories

(see 3.1)

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

| Designation <sup>1)</sup> | Utilization category | Conventional enclosed thermal current<br>$I_{the}$<br>A                 | Rated operational current $I_e$ (A)<br>at rated operational voltage $U_e$ |       |       |       |       |       | VA rating <sup>2)</sup><br>VA |       |     |
|---------------------------|----------------------|-------------------------------------------------------------------------|---------------------------------------------------------------------------|-------|-------|-------|-------|-------|-------------------------------|-------|-----|
| Alternative current       |                      | 10<br>10<br>10<br>5<br>5<br>5<br>2,5<br>2,5<br>2,5<br>1,0<br>1,0<br>0,5 | 120 V                                                                     | 240 V | 380 V | 480 V | 500 V | 600 V | M                             | B     |     |
| A150                      | AC-15                |                                                                         | 6                                                                         | —     | —     | —     | —     | —     | 7 200                         | 720   |     |
| A300                      | AC-15                |                                                                         | 6                                                                         | 3     | —     | —     | —     | —     | 7 200                         | 720   |     |
| A600                      | AC-15                |                                                                         | 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            |                      |                                                                         | 10<br>10<br>10<br>5<br>5<br>5<br>2,5<br>2,5<br>2,5<br>1,0<br>1,0          | 125 V | 250 V |       | 400 V | 500 V | 600 V                         |       |     |
| N150                      | DC-13                | 2,2                                                                     |                                                                           | —     |       | —     | —     | —     | 275                           | 275   |     |
| N300                      | DC-13                | 2,2                                                                     |                                                                           | 1,1   |       | —     | —     | —     | 275                           | 275   |     |
| N600                      | DC-13                | 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<br>B = break         |       |     |

<sup>1)</sup> 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.

<sup>2)</sup> 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  $B = U_e \cdot I_e$ .

**Table A.2**  
Examples of semiconductors switching element ratings for 50 Hz and/or 60 Hz <sup>1)</sup>

| Switching element rating<br>Designation | Rated operational current $I_e$<br>A | Rated make current<br>A |      |      |      | Minimum operational current<br>A | Maximum OFF-state current<br>mA |
|-----------------------------------------|--------------------------------------|-------------------------|------|------|------|----------------------------------|---------------------------------|
|                                         |                                      | AC15                    | AC14 | AC13 | AC12 |                                  |                                 |
| 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                               |

<sup>1)</sup> The rated operational voltage shall be specified by the manufacturer.

**Table A.3**  
Examples of semiconductors switching element ratings for d.c. <sup>1)</sup>

| Switching element rating<br>Designation | Rated operational current $I_e$<br>A | Rated make current<br>A |      |      | Maximum OFF-state current<br>mA |
|-----------------------------------------|--------------------------------------|-------------------------|------|------|---------------------------------|
|                                         |                                      | DC14                    | DC13 | DC12 |                                 |
| 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                             |

<sup>1)</sup> The rated operational voltage shall be specified by the manufacturer.

**ADV D2 Modification to Annex A by adding ADV.1 to ADV.3 and Table A.4DV as follows:**

**ADV.1** In [Table A.1](#), the term “standard duty” can be used in lieu of contact rating codes B and P. The term “heavy duty” can be used in lieu of contact rating codes A and N.

**ADV.2** Equipment that complies with the requirements for across-the-line motor starting of an alternating-current motor shall be acceptable for alternating-current pilot duty without further tests, provided that the locked rotor current is at least 150% of the pilot-duty inrush current at the same voltage and the power factor is 0,5 or less.

**ADV.3** For contact rating codes A, B, and C ([Table A.1](#)) and for devices with ratings not expressed using codes, the pilot-duty inrush current (make) is ten times the steady state current value (break). For contact rating codes D and E ([Table A.1](#)), the pilot-duty inrush current (make) is six times the steady state current value (break). The relationship between horsepower ratings and equivalent control circuit contact ratings is shown in [Table A.4DV](#).

**Table A.4DV**  
**Horsepower-rated switches used in control circuits**

| Switch rating, single-phase,<br>horsepower | Maximum rating of coil,<br>VA | Equivalent control circuit contact<br>rating code |
|--------------------------------------------|-------------------------------|---------------------------------------------------|
| 1                                          | 720                           | A150, A300, A600                                  |
| 1/2                                        | 360                           | B150, B300, B600                                  |
| 1/8                                        | 180                           | C150, C300                                        |
| 1/10                                       | 72                            | D150, D300                                        |

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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.

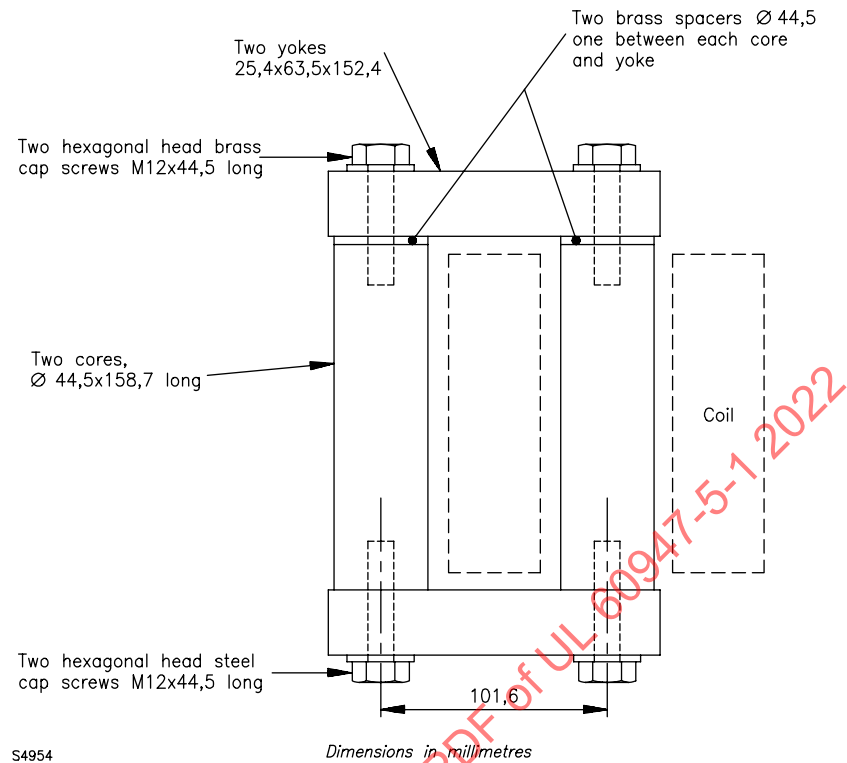
#### B.2 Construction

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  $\mu\Omega/\text{cm}$ . (Cold-finished low carbon steels such as AISI 1010, 1015, 1018 or 116 equivalent meet this requirement.) At one end of each core, a nonmagnetic 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.



**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 <sup>2</sup> | 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                     |

## 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.

##### 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.

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

| Kind of current                                                                                                                                                                                                                                                                                                                                                        | Utilization category | Make     |       |                                                                            | Break |       |                   |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|----------|-------|----------------------------------------------------------------------------|-------|-------|-------------------|
| Alternating                                                                                                                                                                                                                                                                                                                                                            | AC-15                | $I$      | $U$   | $\cos \varphi$                                                             | $I$   | $U$   | $\cos \varphi$    |
|                                                                                                                                                                                                                                                                                                                                                                        |                      | $10 I_e$ | $U_e$ | $0,7^{1)}$                                                                 | $I_e$ | $U_e$ | $0,4^{1)}$        |
| Direct <sup>2)</sup>                                                                                                                                                                                                                                                                                                                                                   | DC-13                | $I$      | $U$   | $T_{0,95}$                                                                 | $I$   | $U$   | $T_{0,95}$        |
|                                                                                                                                                                                                                                                                                                                                                                        |                      | $I_e$    | $U_e$ | $6 \times P^{3)}$                                                          | $I_e$ | $U_e$ | $6 \times P^{3)}$ |
| $I_e$ 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 |       |       |                   |
| <sup>1)</sup> 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. |                      |          |       |                                                                            |       |       |                   |

**Table C.1 Continued on Next Page**



Table C.1 Continued

| Kind of current                                                                                                                                                                                                                                                                                                                                             | Utilization category | Make | Break |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|------|-------|
| <sup>2)</sup> 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.                                                                                                                                             |                      |      |       |
| <sup>3)</sup> 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<sub>e</sub>;
- 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<sub>e</sub>, 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

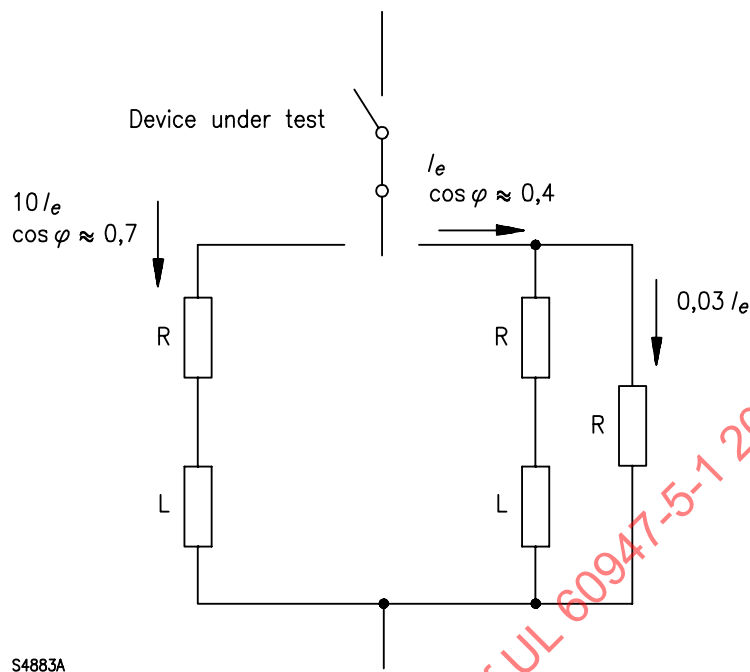
Circuits to be used shall consist of:

- 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,

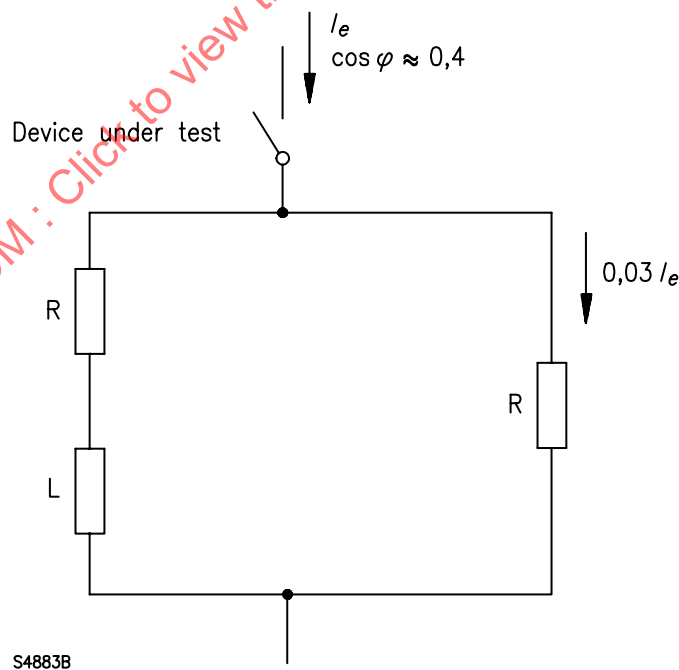
- b) an iron-cored inductor, in series with a resistor, if required, to obtain a duration T<sub>0,95</sub> as indicated in [Table C.1](#).

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 %.



**Figure C.1**  
**Normal circuit**

(see [C.3.2.2](#))



**Figure C.2**  
**Simplified circuit**

(see [C.3.2.2](#))

## Annex D

### Vacant

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## Annex E (normative)

### Items subject to agreement between manufacturer and user

#### Annex EDV D2 *Modification of Annex E as follows:*

#### Annex E is informative.

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

## **Annex F (normative)**

### **Class II control circuit devices insulated by encapsulation Requirements and tests**

**Annex FDV D2 Modification of Annex F by replacing it with the following:**

**Annex F does not apply.**

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

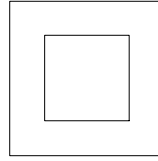
##### **F.2.3**

##### **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.

## F.7 Instructional and functional requirements

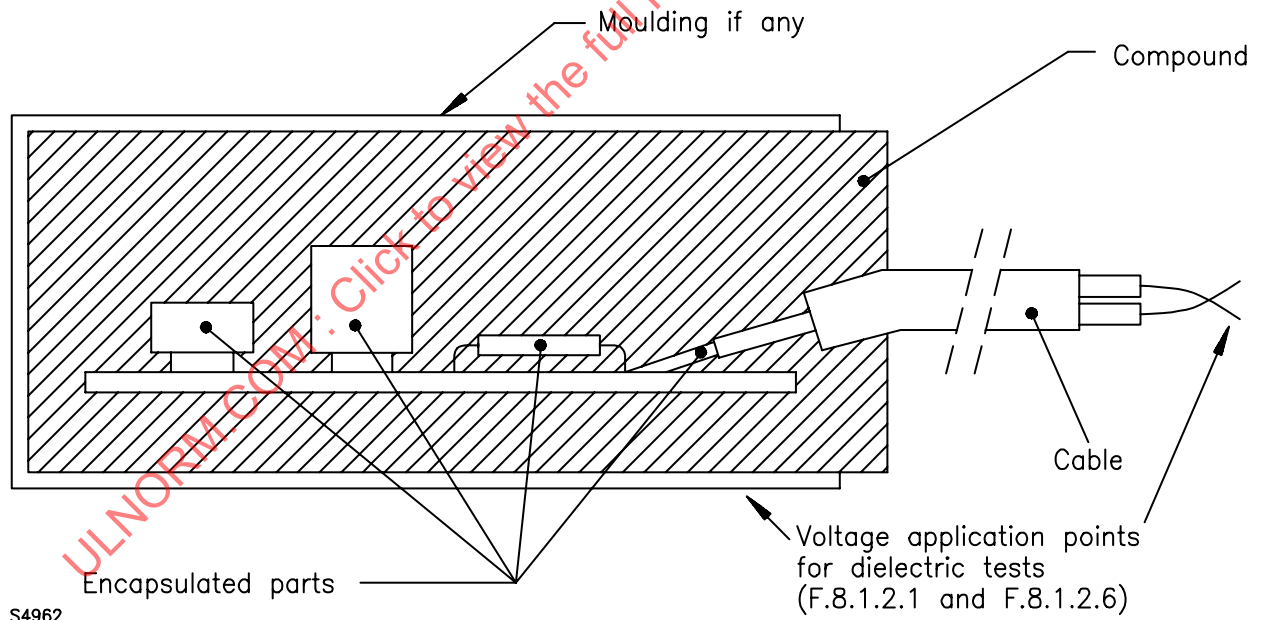
### F.7.1 Choice of compound

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**

### 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  $U_{\text{imp}}$  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<sup>3</sup>

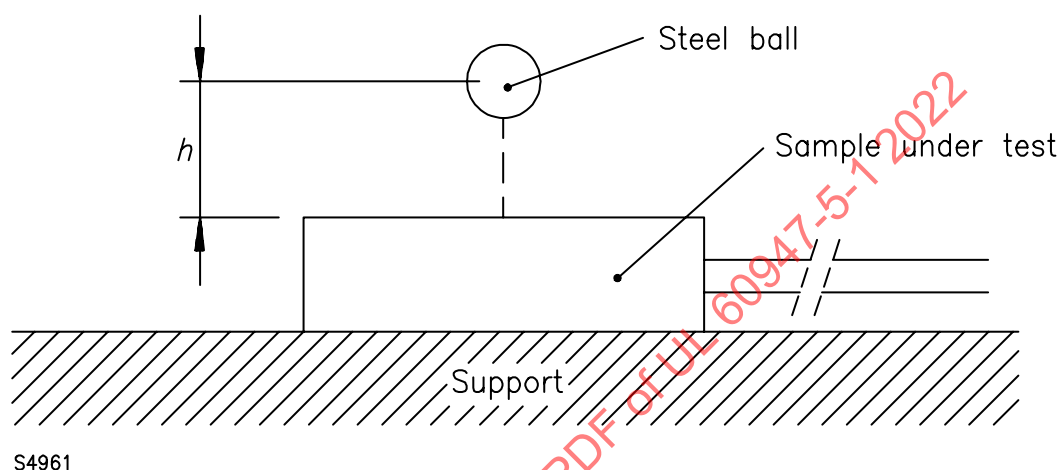
<sup>3</sup> Small cracks of the moulding compounds, if any (see [Figure F.1](#)) are acceptable after tests [F.8.1.2.3](#), [F.8.1.2.4](#) and [F.8.1.2.5](#). They shall not impair the results of the final test of [F.8.1.2.6](#).

#### 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<sup>4</sup>.

<sup>4</sup> 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](#).

#### 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<sup>5</sup>.

<sup>5</sup> 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](#).



#### 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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## 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.7.1.1DV D2 Modification of G.7.1.1 by adding G.7.1.1DV.1 to G.7.1.1DV.6 and Table G.7.1.1DV.3 as follows:**

##### **G.7.1.1DV.1 General**

Control circuit devices with integrally connected cables shall comply with the requirements in [G.7.1.1DV.1.1](#) through [G.7.1.1DV.1.3](#).

**G.7.1.1DV.1.1** A cable with a jacket type other than hard service (S) or junior hard service (SJ) shall be tested as described in [G.7.1.1DV.2](#) and [G.7.1.1DV.3](#). The tensile strength and

elongation shall be a minimum of 10,3 MN/m<sup>2</sup> (1500 psi) and 100 percent, respectively, on unconditioned samples of the insulation on the individual conductors or on the outer jacket of the cable. After the oven conditioning, the tensile strength shall be at least 70 percent of the value obtained on the unconditioned samples, and the elongation shall be at least 65 percent of the value obtained on the unconditioned samples.

**G.7.1.1DV.1.2** Control circuit devices with a Type 12, 12K, or 13 enclosure rating and an integrally connected cable without an oil resistant rating shall be tested as described in [G.7.1.1DV.2](#) and [G.7.1.1DV.4](#). After the oil conditioning, the tensile strength and elongation of the insulation on the individual conductors or of the outer jacket of the cable shall be at least 50 percent of the values obtained on unconditioned samples

**G.7.1.1DV.1.3** Control circuit devices intended for outdoor use and provided with an integrally connected cable without an outdoor use rating shall be tested as described in [G.7.1.1DV.2](#), [G.7.1.1DV.5](#), and [G.7.1.1DV.6](#). After five samples are subjected to the ultraviolet light (UV) conditioning as specified in [G.7.1.1DV.5](#), the average tensile strength and ultimate elongation of the insulation on the individual conductors or of the outer jacket of the cable shall be at least 80 percent of the average values obtained on five unconditioned samples.

#### **G.7.1.1DV.2 Tensile strength and elongation tests**

The number of samples to be tested, the methods of selection and preparation of the samples, the testing of the samples, the making of the measurements, and the calculations for ultimate elongation and tensile strength shall be as specified in the test method for physical properties tests of insulation and jacket in CSA C22.2 No. 2556/UL 2556.

#### **G.7.1.1DV.3 Oven conditioning**

Samples of the insulation on the individual conductors or the outer jacket of a cable shall be conditioned in a full draft circulating air oven. The duration of conditioning and the oven temperature shall be as specified in [Table G.7.1.1DV.3](#).

**Table G.7.1.1DV.3**  
**Oven conditioning**

| Temperature rating of conductor insulation or outer jacket |     | Oven time, hours | Oven temperature |        |
|------------------------------------------------------------|-----|------------------|------------------|--------|
| °C                                                         | °F  |                  | °C               | °F     |
| 60                                                         | 140 | 168              | 100 ±1           | 212 ±2 |
| 75                                                         | 167 | 240              | 100 ±1           | 212 ±2 |
| 90                                                         | 194 | 168              | 121 ±1           | 250 ±2 |
| 105                                                        | 221 | 168              | 136 ±1           | 277 ±2 |

#### **G.7.1.1DV.4 Oil conditioning**

Samples of the insulation on the individual conductors or the outer jacket of the cable shall be conditioned by immersion in IRM immersion oil No. 902 for 168 hours at a temperature at least equivalent to the intended rating of the insulation.

#### **G.7.1.1DV.5 Ultraviolet light (UV) conditioning**

Samples of the insulation on the individual conductors or the outer jacket of a cable intended for outdoor use shall be tested as specified in the Sunlight Resistance evaluation in CSA C22.2 No. 2556/UL 2556, for 720 hours of exposure.

### G.7.1.1DV.6 Cold bend test

The jacket on an outdoor-use cable shall not crack on its inner or outer surface while specimens of the complete finished cable that have been cooled for 4 hours in air at a temperature of minus 35 when tested according to the Cold Bend evaluation in CSA C22.2 No. 2556/UL 2556. The diameter of the mandrel shall be as specified in CAN/CSA-C22.2 No. 49/UL 62.

### 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.

### 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

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 mm<sup>2</sup>. 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.8.2.2DV D2** *Modification of G.8.2.2 by replacing the second and third paragraphs as well as the “Example” with G.8.2.2DV.1 and G.8.2.2DV.2 and Tables G.8.2.2DV.1 to G.8.2.2DV.3:*

**G.8.2.2DV.1** The tensile force applied shall be the corresponding minimum value of [Table G.8.2.2DV.3](#) based on the wire cross-section and the number of conductors in the cable.

**G.8.2.2DV.2** Typical material characteristics are given in [Table G.8.2.2DV.1](#). [Table G.8.2.2DV.2](#) gives some examples of usual cross-section and outside diameter values.

NOTE: The force values for the pull-out test are based on the industrial copper requirements by acceptable elongation of 1% and a tensile strength of 100N/m<sup>2</sup> as stated in [Table G.8.2.2DV.1](#).

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**Table G.8.2.2DV.1**  
**Material characteristics (informative)**

|                                  |                                  |                                   |
|----------------------------------|----------------------------------|-----------------------------------|
| Copper (soft / unalloyed)        | Tensile strength                 | 200 – 250 N/mm <sup>2</sup> (MPa) |
|                                  | Yield strength                   | 40 – 80 N/mm <sup>2</sup>         |
|                                  | Elongation at break              | > 40%                             |
| Copper (at cold deformation)     | Tensile strength                 | min. 350 N/mm <sup>2</sup>        |
|                                  | Yield strength                   | min. 320 N/mm <sup>2</sup>        |
|                                  | Elongation at break              | < 5%                              |
| Pure copper (electrolytic 99,9%) | Tensile strength                 | 220 N/mm <sup>2</sup>             |
| Copper (industrial)              | Tensile strength (1% elongation) | 120 – 180 N/mm <sup>2</sup>       |
| ETP1 Copper (usual in cable)     | Tensile strength                 | 240 N/mm <sup>2</sup>             |
| Aluminium                        | Tensile strength                 | 45 N/mm <sup>2</sup>              |
| Commercial steel                 | Tensile strength                 | 880 N/mm <sup>2</sup>             |

**Table G.8.2.2DV.2**  
**Examples of standard cable types (informative)**

| No. of terminals | Cross section, mm <sup>2</sup> | Outside diameter, mm |
|------------------|--------------------------------|----------------------|
| 2                | 0,09                           | 1,9                  |
| 3                | 0,09                           | 2,2                  |
| 2                | 0,09                           | 2,2                  |
| 4                | 0,08                           | 2,6                  |
| 3                | 0,14                           | 2,9                  |
| 3                | 0,25                           | 3,7                  |
| 2                | 0,25                           | 3,7                  |
| 3                | 0,25                           | 4,5                  |

**Table G.8.2.2DV.3**  
**Tensile forces**

| No. of terminals | Single cross section [mm <sup>2</sup> ] | Total cross section [mm <sup>2</sup> ] | Limit value CU [N/mm <sup>2</sup> ] | Tensile force calc. [N] | CSA C22.2 No. 60947-1 / UL 60947-1 [N] | CSA C22.2 No. 60947-5-1 / UL 60947-5-1 [N] | Minimum value [N]      |
|------------------|-----------------------------------------|----------------------------------------|-------------------------------------|-------------------------|----------------------------------------|--------------------------------------------|------------------------|
| 2                | 0,08                                    | 0,16                                   | 100                                 | 16 <sup>1)</sup>        | 20                                     | 44 <sup>2)</sup>                           | 16 <sup>1)</sup>       |
| 3                |                                         | 0,24                                   |                                     | 24 <sup>1)</sup>        | 30                                     | 44 <sup>2)</sup>                           | 24 <sup>1)</sup>       |
| 4                |                                         | 0,32                                   |                                     | 32 <sup>1)</sup>        | 40                                     | 52 <sup>2)</sup>                           | 32 <sup>1)</sup>       |
| 2                | 0,14                                    | 0,28                                   | 100                                 | 28                      | 20                                     |                                            | 28                     |
| 3                |                                         | 0,42                                   |                                     | 42                      | 30                                     | 60                                         | 42                     |
| 4                |                                         | 0,56                                   |                                     | 56                      | 40                                     |                                            | 56                     |
| 12               |                                         | 1,68                                   |                                     | 168                     | 120                                    | 160 <sup>3)</sup>                          | 90 <sup>4)</sup> / 160 |
| 2                | 0,18                                    | 0,36                                   | 100                                 | 36                      | 20                                     |                                            | 36                     |
| 3                |                                         | 0,54                                   |                                     | 54                      | 30                                     |                                            | 54                     |
| 4                |                                         | 0,72                                   |                                     | 72                      | 40                                     |                                            | 72                     |
| 8                |                                         | 1,44                                   |                                     | 144                     | 80                                     |                                            | 90 <sup>4)</sup> / 144 |

Table G.8.2.2DV.3 Continued on Next Page

Table G.8.2.2DV.3 Continued

|   |      |      |     |     |     |                   |                        |
|---|------|------|-----|-----|-----|-------------------|------------------------|
| 2 | 0,20 | 0,40 | 100 | 40  | 20  |                   | 40                     |
| 3 |      | 0,60 |     | 60  | 30  |                   | 60                     |
| 4 |      | 0,80 |     | 80  | 40  |                   | 80                     |
| 3 | 0,25 | 0,75 | 100 | 75  | 45  | 74                | 75                     |
| 4 |      | 1,00 |     | 100 | 60  | 90                | 90 <sup>4)</sup> / 100 |
| 5 |      | 1,25 |     | 125 | 75  |                   | 90 <sup>4)</sup> / 125 |
| 7 |      | 1,75 |     | 175 | 105 | 160 <sup>3)</sup> | 90 <sup>4)</sup> / 160 |
| 8 |      | 2,00 |     | 200 | 120 | 160 <sup>3)</sup> | 90 <sup>4)</sup> / 160 |
| 3 | 0,34 | 1,02 | 100 | 102 | 45  |                   | 90 <sup>4)</sup> / 102 |
| 4 |      | 1,36 |     | 136 | 60  |                   | 90 <sup>4)</sup> / 136 |
| 5 |      | 1,70 |     | 170 | 75  | 160 <sup>3)</sup> | 90 <sup>4)</sup> / 160 |
| 8 |      | 2,72 |     | 272 | 120 | 160 <sup>3)</sup> | 90 <sup>4)</sup> / 160 |
| 2 | 0,50 | 1,00 | 100 | 100 | 40  |                   | 90 <sup>4)</sup> / 100 |
| 3 |      | 1,50 |     | 150 | 60  |                   | 90 <sup>4)</sup> / 150 |
| 4 |      | 2,00 |     | 200 | 80  | 160 <sup>3)</sup> | 90 <sup>4)</sup> / 160 |
| 5 |      | 2,50 |     | 250 | 10  | 160 <sup>3)</sup> | 90 <sup>4)</sup> / 160 |

<sup>1)</sup> The smaller values for a single cross section of 0,08 mm<sup>2</sup> are only applicable for devices intended for use with safety extra low voltage (SELV) or Class 2 circuits. For other voltage ranges, the tensile forces according to the generic rules of CSA C22.2 No. 60947-1 / UL 60947-1 shall be considered.

<sup>2)</sup> The listed tensile forces are approximate values; hence, the cable diameter and the corresponding copper cross sections in relation to the single cross section and the number of terminals of the different cable types can vary strongly. It is only possible to compare them in simple ways.

<sup>3)</sup> Tensile force limitation:  $F = 160 \text{ N}$ .

<sup>4)</sup> Only for devices with safety extra low voltage (SELV).

**Notes:**

a) These values are valid for an industrial environment.

b) Shielded cable: A shield shall be considered as an additional terminal with a similar single cross section in the calculation according to Table G.8.2.2DV.3 tensile forces, in case the shield is fixed with the enclosures and possesses strain relief properties.

### 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.

### 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.

#### **G.8.3DV D2 Modification of G.8.3 by adding the following:**

**Compliance with stated enclosure Type ratings shall be verified in accordance with CSA C22.2 No 94.1, CSA C22.2 No. 94.2, UL 50, and UL 50E.**

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## Annex H (normative)

### Additional requirements for semiconductor switching elements for control circuit devices

**Annex HDV D2 Modification of Annex H by replacing “normative” with “informative”:**

**Annex H is informative.**

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

Semiconductor 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

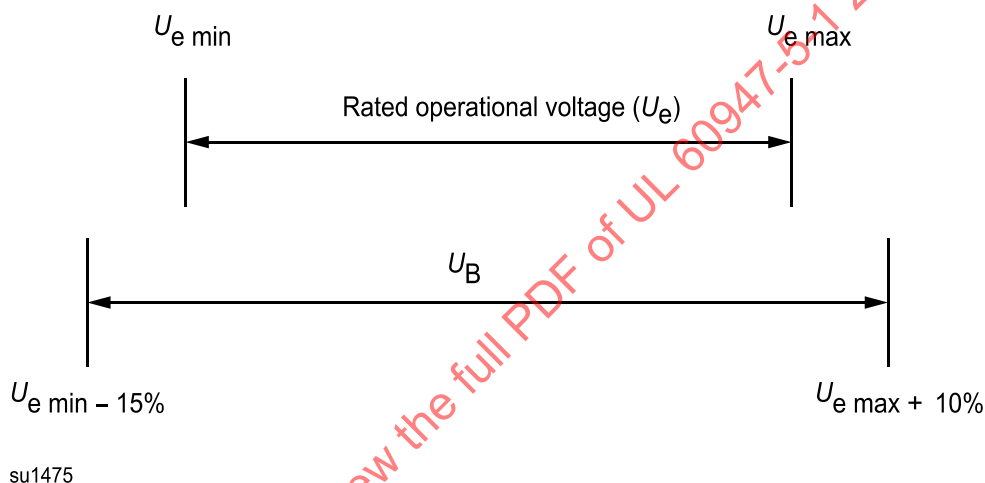
### H.4.1 Rated voltage

#### 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*

- Voltage drop (see H.7.1.1)
- Minimum operational current (see H.7.1.2)
- OFF-state current (see H.7.1.3)
- 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](#).

NOTE In [Table A.2](#) and [Table 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 [Table A.2](#) and [Table 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](#))

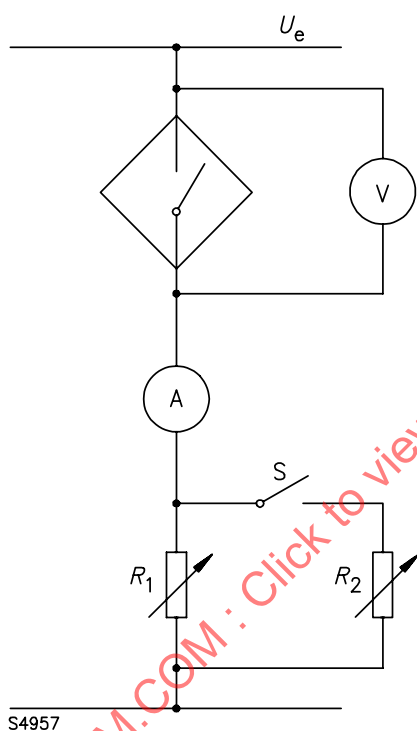
e) Verification of electromagnetic compatibility (see [H.8.7](#))

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  $23\text{ °C} \pm 5\text{ °C}$  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](#).



$R_1$  = Resistive load

$R_2$  = Resistive load

V = High impedance voltmeter,  $0,2\text{M}\Omega/\text{V}$

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.

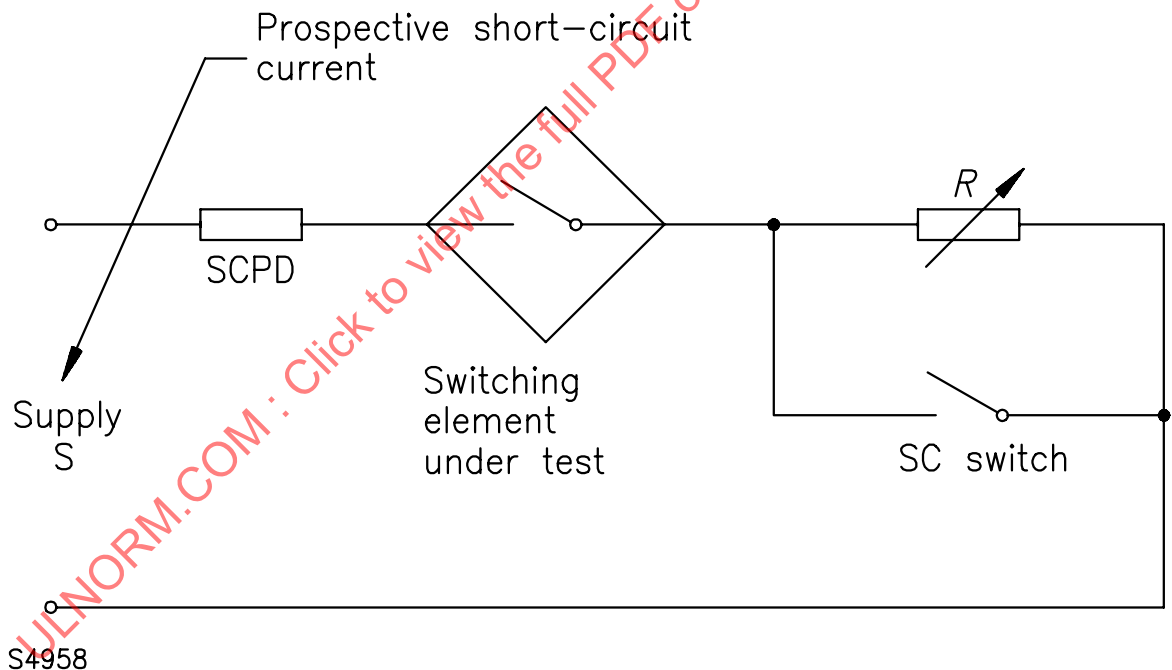
### H.8.6 Performance under short-circuit current conditions

#### 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 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.

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.

## Annex J (normative)

### Special requirements for indicator lights and indicating towers

**Annex JDV** *Modification of Annex J by replacing “normative” with “informative”:*

**Annex J is informative.**

#### 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.

#### 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:

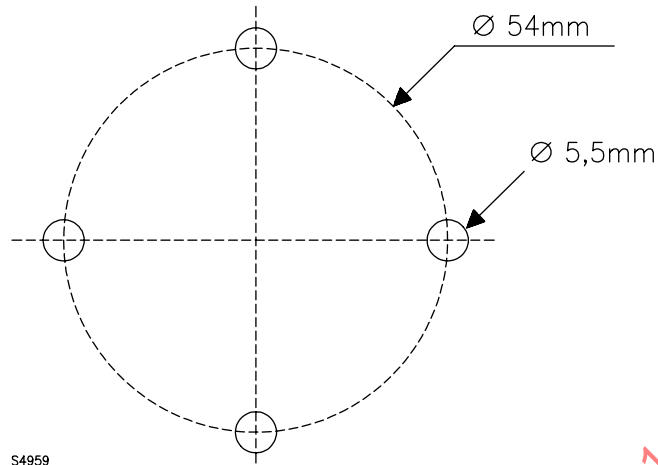
- 1) rated voltage of the indicator light;
- 2) rated voltage of the lamp (if different from the rated voltage of the indicator light).
- 3) rated power of the lamp or its type designation, or rated current for a LED.

## **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](#)).





**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: