BS EN 61810-1:2015

BSI Standards Publication

Electromechanical elementary relays

Part 1: General and safety requirements

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National foreword

This British Standard is the UK implementation of EN 61810-1:2015. It is identical to IEC 61810-1:2015. It supersedes BS EN 61810-1:2008 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee EPL/94, General purpose relays and reed contact units.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of document 94/380/FDIS, future edition 4 of IEC 61810-1, prepared by IEC/TC 94 "All-ornothing electrical relays" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61810-1:2015.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2016-01-01
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2018-04-01

This document supersedes EN 61810-1:2008.

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Endorsement notice

The text of the International Standard IEC 61810-1:2015 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following note has to be added for the standard indicated :

IEC 60335-1:2010	NOTE	Harmonized as EN 60335-1:2012 (modified).
IEC 60664-1:1992	NOTE	Harmonized as EN 60664-1:2003 [1] (not modified).
IEC 60695-11-5:2004	NOTE	Harmonized as EN 60695-11-5:2005 (not modified).
IEC 60669-1	NOTE	Harmonized as EN 60669-1.
IEC 60730-1:2013	NOTE	Harmonized as EN 60730-1 [2] (modified).
IEC 60947-5-1:2003	NOTE	Harmonized as EN 60947-5-1:2004 (not modified).
IEC 60950-1:2005	NOTE	Harmonized as EN 60950-1:2006 (modified).
IEC 61140:2001	NOTE	Harmonized as EN 61140:2002 (not modified).
IEC 61508 Series	NOTE	Harmonized as EN 61508 Series.
IEC 61810-7:2006	NOTE	Harmonized as EN 61810-7:2006 (not modified).
ISO 14121-1	NOTE	Harmonized as EN ISO 14121-1 [3].
ISO 14971	NOTE	Harmonized as EN ISO 14971.

1) Superseded by EN 60664-1:2007 (IEC 60664-1:2007).

2) To be published.

3) Superseded by EN ISO 12100 (ISO 12100).

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu

Publication	Year	Title	EN/HD	Year
IEC 60038 (mod)	2009	IEC standard voltages	EN 60038	2011
IEC 60050	Series	International Electrotechnical Vocabulary (IEV)	-	-
IEC 60068-2-2	2007	Environmental testing - Part 2-2: Tests - Test B: Dry heat	EN 60068-2-2	2007
IEC 60068-2-17	1994	Basic environmental testing procedures - Part 2-17: Tests - Test Q: Sealing	EN 60068-2-17	1994
IEC 60068-2-20	2008	Environmental testing - Part 2-20: Tests - Test T: Test methods for solderability and resistance to soldering heat of devices with leads	EN 60068-2-20	2008
IEC 60079-15	2010	Explosive atmospheres - Part 15: Equipment protection by type of protection "n"	EN 60079-15	2010
IEC 60085	2007	Electrical insulation - Thermal evaluation and designation	EN 60085	2008
IEC 60099-1	-	Surge arresters - Part 1: Non-linear resistor type gapped surge arresters for a.c. systems	EN 60099-1	-
IEC 60112	2003	Method for the determination of the proof and the comparative tracking indices of solid insulating materials	EN 60112	2003
IEC 60364-4-44 (mod)	2007	Low-voltage electrical installations - Part 4-44: Protection for safety - Protection against voltage disturbances and electromagnetic disturbances	HD 60364-4-442	2012
IEC 60417-DB	-	Graphical symbols for use on equipment	-	-
IEC 60664-1	2007	Insulation coordination for equipment within low-voltage systems - Part 1: Principles, requirements and tests	EN 60664-1	2007

Publication	Year	Title	EN/HD	Year
IEC 60664-3	2003	Insulation coordination for equipment within low-voltage systems - Part 3: Use of coating, potting or moulding for protection against pollution	EN 60664-3	2003
IEC 60664-4	2005	Insulation coordination for equipment within low-voltage systems - Part 4: Consideration of high-frequency voltage stress	EN 60664-4 + corr. October	2006 2006
IEC 60664-5	2007	Insulation coordination for equipment within low-voltage systems - Part 5: Comprehensive method for determining clearances and creepage distances equal to or less than 2 mm	EN 60664-5	2007
IEC 60695-2-10	2013	Fire hazard testing - Part 2-10: Glowing/hot-wire based test methods - Glow-wire apparatus and common test procedure	EN 60695-2-10	2013
IEC 60695-2-11	2000	Fire hazard testing - Part 2-11: Glowing/hot-wire based test methods - Glow-wire flammability test method for end-products	EN 60695-2-11	2001 [1)]
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	EN 60695-2-12	2010
IEC 60695-2-13	2010	Fire hazard testing - Part 2-13: Glowing/hot-wire based test methods - Glow-wire ignition temperature (GWIT) test method for materials	EN 60695-2-13	2010
IEC 60695-10-2	2003	Fire hazard testing - Part 10-2: Abnormal heat - Ball pressure test	EN 60695-10-2	2003 [2)]
IEC 60721-3-3 +A1 +A2	1994 1995 1996	Classification of environmental conditions - - Part 3: Classification of groups of environmental parameters and their severities - Section 3: Stationary use at weatherprotected locations	EN 60721-3-3 - +A2	1995 - 1997
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 mm² up to 35 mm² (included)	EN 60999-1	2000

1) Superseded by EN 60695-2-11:2014 (IEC 60695-2-11:2014): dow = 2017-03-13.
2) Superseded by EN 60695-10-2:2014 (IEC 60695-10-2:2014): dow = 2017-03-26.

Publication	Year	Title	EN/HD	Year
IEC 61210 (mod)	2010	Connecting devices - Flat quick-connect terminations for electrical copper conductors - Safety requirements	EN 61210	2010
IEC 61760-1	2006	Surface mounting technology - Part 1: Standard method for the specification of surface mounting components (SMDs)	EN 61760-1	2006
IEC 61984	2008	Connectors - Safety requirements and tests	EN 61984	2009

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTROMECHANICAL ELEMENTARY RELAYS –

Part 1: General and safety requirements

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 61810-1 has been prepared by IEC technical committee 94: All-or-nothing electrical relays.

This fourth edition cancels and replaces the third edition published in 2008. This edition constitutes a technical revision.

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

– two main test procedures were introduced: procedure A, reflecting the procedure known from Edition 3 of this standard and procedure B, reflecting the assessment according to North American requirements;
– inclusion of dedicated device application tests especially relevant for applications in the North American Market (see Clause D.1);
– introduction of testing under single mounting condition;
– clarification of insulation requirements after endurance testing;

– inclusion of provisions for basic safety requirements;
– update of references.

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

FDIS	Report on voting
94/380/FDIS	94/384RVD

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

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

A list of all parts of IEC 61810 series, published under the general title *Electromechanical elementary relays* 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 web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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

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

ELECTROMECHANICAL ELEMENTARY RELAYS –

Part 1: General and safety requirements

1 Scope

This part of IEC 61810 applies to electromechanical elementary relays (non-specified time all-or-nothing relays) for incorporation into low voltage equipment (circuits up to 1 000 V alternate current or 1 500 V direct current). It defines the basic functional and safety requirements and safety-related aspects for applications in all areas of electrical engineering or electronics, such as:

- general industrial equipment,
- electrical facilities,
- electrical machines,
- electrical appliances for household and similar use,
- information technology and business equipment,
- building automation equipment,
- automation equipment,
- electrical installation equipment,
- medical equipment,
- control equipment,
- telecommunications,
- vehicles,
- transportation (e.g. railways).

Compliance with the requirements of this standard is verified by the type tests indicated.

In case the application of a relay determines additional requirements exceeding those specified in this standard, the relay should be assessed in line with this application in accordance with the relevant IEC standard(s) (e.g. IEC 60730-1, IEC 60335-1, IEC 60950-1).

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 60038:2009, *IEC standard voltages*

IEC 60050 (all parts), *International Electrotechnical Vocabulary* (available at http://www.electropedia.org)

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

IEC 60068-2-17:1994, *Basic environmental testing procedures – Part 2-17: Tests – Test Q: Sealing*

IEC 60068-2-20:2008, *Environmental testing – Part 2-20: Tests – Test T: Test methods for solderability and resistance to soldering heat of devices with leads*

IEC 60079-15:2010, *Explosive atmospheres – Part 15: Equipment protection by type of protection "n"*

IEC 60085:2007, *Electrical insulation – Thermal evaluation and designation*

IEC 60099-1, *Surge arresters – Part 1: Non-linear resistor type gapped surge arresters for a.c. systems*[1]

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

IEC 60364-4-44:2007, *Low voltage electrical installations – Part 4-44: Protection for safety – Protection against voltage disturbances and electromagnetic disturbances*

IEC 60417, *Graphical symbols for use on equipment* (available at http://www.graphical-symbols.info/equipment)

IEC 60664-1:2007, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

IEC 60664-3:2003, *Insulation coordination for equipment within low-voltage systems – Part 3: Use of coating, potting or moulding for protection against pollution*

IEC 60664-4:2005, *Insulation coordination for equipment within low-voltage systems – Part 4: Consideration of high-frequency voltage stress*

IEC 60664-5:2007, *Insulation coordination for equipment within low-voltage systems – Part 5: Comprehensive method for determining clearances and creepage distances equal to or less than 2 mm*

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 60695-2-11:2000, *Fire hazard testing – Part 2-11: Glowing/hot-wire based test methods – Glow-wire flammability test method for end-products*[2]

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 60695-2-13:2010, *Fire hazard testing – Part 2-13: Glowing/hot-wire based test methods – Glow-wire ignition temperature (GWIT) test method for materials*

IEC 60695-10-2:2003, *Fire hazard testing – Part 10-2: Abnormal heat – Ball pressure test*

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[1] Withdrawn.

[2] This first edition has been replaced in 2014 by a second edition 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 60721-3-3:1994, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 3: Stationary use at weatherprotected locations*
IEC 60721-3-3:1994/AMD 1:1995
IEC 60721-3-3:1994/AMD 2:1996

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

IEC 61210:2010, *Connecting devices – Flat quick-connect terminations for electrical copper conductors – Safety requirements*

IEC 61760-1:2006, *Surface mounting technology – Part 1: Standard method for the specification of surface mounting components (SMDs)*

IEC 61984:2008, *Connectors – Safety requirements and tests*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-444 and the following apply.

An alphabetical list of terms can be found at the end of this standard.

NOTE In the text of this standard, the term *relay* is used instead of *elementary relay* to improve the readability.

3.1 Terms and definitions related to general terms

3.1.1
marking
identification of a relay which, when completely given to the manufacturer of this relay, allows the unambiguous indication of its electrical, mechanical, dimensional and functional parameters

EXAMPLE Through the indication of the trade mark and the type designation on the relay, all relay-specific data can be derived from the type code.

3.1.2
intended use
use of a relay for the purpose for which it was made, and in the manner intended by the manufacturer

3.1.3
relay technology categories
categories of relays, based upon environmental protection

Note 1 to entry: Six categories are in use (RT 0 to RT V).

[SOURCE: IEC 60050-444:2002, 444-01-11]

3.1.4
pulse width modulation
PWM
pulse time modulation in which the pulse duration varies in accordance with a given function of the value of the modulating signal

[SOURCE: IEC 60050-702:1992, 702-06-57]

3.1.5
existing design
design which was already approved by the preceding Edition of this standard

3.1.6
hazard
potential source of harm

Note 1 to entry: Relevant hazards taken into account in this standard are heating, electrical shock, ignition and foreseeable misuse before the end of life.

3.1.7
type test
test of one or more devices made to a certain design to show that the design meets certain specifications

3.1.8
routine test
test to which each individual device is subjected during and/or after manufacture to ascertain whether it complies with certain criteria

3.1.9
sampling test
test on a number of devices taken at random from a batch

3.2 Terms and definitions of relay types

3.2.1
electrical relay
device designed to produce sudden and predetermined changes in one or more output circuits when certain conditions are fulfilled in the electric input circuits controlling the device

Note 1 to entry: For the purpose of this standard, output circuits are contact circuits.

Note 2 to entry: For the purpose of this standard, the term “coil” is used to denote “input circuit”, although other types of input circuits are possible.

[SOURCE: IEC 60050-444:2002, 444-01-01]

3.2.2
all-or-nothing relay
electrical relay, which is intended to be energized by a quantity, the value of which is either within its operative range or effectively zero

Note 1 to entry: "All-or-nothing relays" include both "elementary relays" and "time relays".

[SOURCE: IEC 60050-444:2002, 444-01-02]

3.2.3
elementary relay
all-or-nothing relay which operates and releases without any intentional time delay

[SOURCE: IEC 60050-444:2002, 444-01-03]

3.2.4
electromechanical relay
electrical relay in which the intended response results mainly from the movement of mechanical elements

[SOURCE: IEC 60050-444:2002, 444-01-04]

3.2.5
monostable relay
electrical relay which, having responded to an energizing quantity and having changed its condition, returns to its previous condition when that quantity is removed

[SOURCE: IEC 60050-444:2002, 444-01-07]

3.2.6
bistable relay
electrical relay which, having responded to an energizing quantity and having changed its condition, remains in that condition after the quantity has been removed; a further appropriate energization is required to make it change its condition

Note 1 to entry: Bistable relays are also called latching relays.

[SOURCE: IEC 60050-444:2002, 444-01-08]

3.3 Terms and definitions related to conditions and operations

3.3.1
release condition
for a monostable relay, specified condition of the relay when it is not energized; for a bistable relay, one of the specified conditions, as declared by the manufacturer

Note 1 to entry: See Figure A.1.

[SOURCE: IEC 60050-444:2002, 444-02-01]

3.3.2
operate condition
for a monostable relay, specified condition of the relay when it is energized by the specified energizing quantity and has responded to that quantity; for a bistable relay, the condition other than the release condition as declared by the manufacturer

Note 1 to entry: See Figure A.1.

[SOURCE: IEC 60050-444:2002, 444-02-02]

3.3.3
operate, verb
change from the release condition to the operate condition

Note 1 to entry: See Figure A.1.

[SOURCE: IEC 60050-444:2002, 444-02-04]

3.3.4
release, verb
for a monostable relay, change from the operate condition to the release condition

Note 1 to entry: See Figure A.1.

[SOURCE: IEC 60050-444:2002, 444-02-05]

3.3.5
reset, verb
for a bistable relay, change from the operate condition to the release condition

[SOURCE: IEC 60050-444:2002, 444-02-06]

3.3.6
cycle
operation and subsequent release/reset

[SOURCE: IEC 60050-444:2002, 444-02-11]

3.3.7
frequency of operation
number of cycles per unit of time

[SOURCE: IEC 60050-444:2002, 444-02-12]

3.3.8
continuous duty
duty in which the relay remains energized for a period long enough to reach thermal equilibrium

[SOURCE: IEC 60050-444:2002, 444-02-13]

3.3.9
intermittent duty
duty in which the relay performs a series of identical cycles, the durations in the energized and unenergized conditions being specified; the duration of energization of the relay is such as will not permit the relay to reach thermal equilibrium

[SOURCE: IEC 60050-444:2002, 444-02-14, modified – modification of the definition]

3.3.10
temporary duty
duty in which the relay remains energized for insufficient duration to reach thermal equilibrium, the time intervals of energization being separated by unenergized time intervals of duration sufficient to restore equality of temperature between the relay and the surrounding medium

[SOURCE: IEC 60050-444:2002, 444-02-16]

3.3.11
duty factor
ratio of the duration of energization to the total period in which intermittent or continuous or temporary duty takes place

Note 1 to entry: The duty factor can be expressed as a percentage of the total period.

[SOURCE: IEC 60050-444:2002, 444-02-15]

3.3.12
ambient temperature
temperature(s) prescribed for the air surrounding the relay under certain conditions, when the relay is mounted as indicated by the manufacturer

[SOURCE: IEC 60050-444:2002, 444-03-18, modified – modification of the definition and addition of a new note]

3.3.13
thermal equilibrium
variation of less than 1 K between any two out of three consecutive measurements made at an interval of 5 min

3.3.14
rated value
value of a quantity used for specification purposes, established for a specific set of operating conditions

[SOURCE: IEC 60050-444:2002, 444-02-18, modified – modification of the definition]

3.3.15
test value
value of a quantity for which the relay shall comply with a specified action during a test

[SOURCE: IEC 60050-444:2002, 444-02-20]

3.3.16
mechanical endurance
number of cycles under specified conditions with unloaded contact(s)

[SOURCE: IEC 60050-444:2002, 444-07-10, modified – modification of the definition]

3.4 Terms and definitions of operating values

3.4.1
energizing quantity
electrical quantity which, when applied to the coil(s) of a relay under specified conditions, enables it to fulfil its purpose

Note 1 to entry: For relays, the energizing quantity is usually a voltage. Therefore, the input voltage as energizing quantity is used in the definitions given in 3.4. Where a relay is energized by a given current instead, the respective terms and definitions apply with "current" used instead of "voltage".

[SOURCE: IEC 60050-444:2002, 444-03-01, modified – modification of the definition]

3.4.2
operate voltage
set voltage
value of the coil voltage at which a relay operates

Note 1 to entry: "Set voltage" applies to bistable relays only.

[SOURCE: IEC 60050-444:2002, 444-03-06, modified – modification of the term and the definition]

3.4.3
operate voltage
U_1
value of the coil voltage at which a relay operates, having previously been energized at that same voltage

Note 1 to entry: Thermal equilibrium has to be achieved.

3.4.4
limiting voltage
U_2
value of the coil voltage, taking into account the effect of heating due to the power dissipated by the coil(s), which when exceeded may result in a relay failure caused by thermal overload

Note 1 to entry: Thermal equilibrium has to be achieved.

3.4.5
operative range
range of values of coil voltage for which a relay is able to perform its specified function

[SOURCE: IEC 60050-444:2002, 444-03-05, modified – modification of the term and the definition]

3.4.6
release voltage
value of the coil voltage at which a monostable relay releases

[SOURCE: IEC 60050-444:2002, 444-03-08, modified – modification of the definition]

3.5 Terms and definitions related to contacts

For a.c., r.m.s. values for voltage and current are specified, unless otherwise indicated.

3.5.1
contact
arrangement of contact members, with their insulation, which close or open their contact circuit by their relative movement

Note 1 to entry: See Figure A.2.

[SOURCE: IEC 60050-444:2002, 444-04-03]

3.5.2
contact set
combination of contacts within a relay, separated by their insulation

Note 1 to entry: See Figure A.2.

[SOURCE: IEC 60050-444:2002, 444-04-04]

3.5.3
contact gap
gap between the contact points when the contact circuit is open

[SOURCE: IEC 60050-444:2002, 444-04-09]

3.5.4
make contact
contact which is closed when the relay is in its operate condition and which is open when the relay is in its release condition

[SOURCE: IEC 60050-444:2002, 444-04-17]

3.5.5
break contact
contact which is open when the relay is in its operate condition and which is closed when the relay is in its release condition

[SOURCE: IEC 60050-444:2002, 444-04-18]

3.5.6
change-over contact
combination of two contact circuits with three contact members, one of which is common to the two contact circuits; such that when one of these contact circuits is open, the other is closed

[SOURCE: IEC 60050-444:2002, 444-04-19]

3.5.7
switching voltage
voltage between the contact members before closing or after opening of a relay contact

Note 1 to entry: The term “contact voltage” (see IEC 60050-444:2002, 444-04-25) has been replaced by “switching voltage”. The definition remains unchanged, however.

3.5.8
contact current
electric current which a relay contact carries before opening or after closing

[SOURCE: IEC 60050-444:2002, 444-04-26]

3.5.9
switching current
electric current which a relay contact makes and/or breaks

[SOURCE: IEC 60050-444:2002, 444-04-27]

3.5.10
limiting continuous current
greatest value of electric current which a closed contact is capable of carrying continuously under specified conditions

[SOURCE: IEC 60050-444:2002, 444-04-28, modified – modification of the term and the definition]

3.5.11
micro-interruption
interruption of a circuit by contact separation which does not provide full-disconnection or micro-disconnection

Note 1 to entry: There are no dielectric strength or dimensional requirements for the contact gap.

[SOURCE: IEC 60730-1:2013, 2.4.4, modified – modification of the definition]

3.5.12
micro-disconnection
adequate contact separation in at least one contact so as to provide functional security

Note 1 to entry: There is a requirement for the dielectric strength of the contact gap but no dimensional requirement.

[SOURCE: IEC 60730-1:2013, 2.4.3, modified – modification of the term and definition]

3.5.13
full-disconnection
contact separation for the disconnection of conductors so as to provide the equivalent of basic insulation between those parts intended to be disconnected

Note 1 to entry: There are dielectric strength and dimensional requirements.

[SOURCE: IEC 60730-1:2013, 2.4.2, modified – modification of the definition]

3.5.14
failure
termination of the ability of an item to perform a required function as defined in the failure criteria

Note 1 to entry: For the purpose of this standard, items are elementary relays.

[SOURCE: IEC 60050-191:1990, 191-04-01, modified – modification of the definition]

3.5.15
failure criteria
specified conditions to judge if a fault or malfunction is a failure

3.5.16
malfunction
event when an item does not perform an expected function

3.5.17
fault
deviation of the existing condition from the expected condition

3.5.18
contact failure
occurrence of break and/or make malfunctions of a contact under test, exceeding a specified number

3.5.19
failure to break
current flows although it should not

Note 1 to entry: This could be a contact welding/sticking as well as a delayed contact operate or release.

3.5.20
failure to make
no sufficient contact is ensured

Note 1 to entry: This could be a not acceptable or excessive contact resistance as well a bouncing of the contact due to the lost of overtravel.

3.5.21
electrical endurance
number of cycles without contact failure under specified conditions, with loaded contacts

3.5.22
end of life
the point at which the physical relay conditions for operate and release can no longer be ensured after an unspecified number of cycles.

Note 1 to entry: The intended use of electromechanical relays is to switch loads depending on the control circuit. The relay will follow this request until the mechanical and/or electrical breakdown of the relay (the relay is per definition a wear device).

Note 2 to entry: Using relays after end of life could cause hazards.

3.6 Terms and definitions related to accessories

3.6.1
manual operation
manual movement of the actuating member of the relay

3.6.2
actuating member
part which is pulled, pushed, turned or otherwise operated in order to initiate a function

3.7 Terms and definitions related to insulation

3.7.1
functional insulation
insulation between conductive parts which is necessary only for the proper functioning of the relay

[SOURCE: IEC 60664-1:1992, 1.3.17.1, modified – modification of the definition]

3.7.2
basic insulation
insulation of hazardous-live-parts which provides basic protection against electric shock

Note 1 to entry: Basic insulation does not necessarily include insulation used exclusively for functional purposes.

[SOURCE: IEC 60664-1:2002, 3.17.2, modified – modification of the definition]

3.7.3
supplementary insulation
independent insulation applied in addition to basic insulation, in order to provide protection against electric shock in the event of a failure of basic insulation

[SOURCE: IEC 61140:2001, 3.10.2, modified – modification of the definition]

3.7.4
double insulation
insulation comprising both basic insulation and supplementary insulation

[SOURCE: IEC 61140:2001, 3.10.3]

3.7.5
reinforced insulation
insulation of hazardous-live-parts which provides a degree of protection against electric shock equivalent to double insulation

[SOURCE: IEC 61140:2001, 3.10.4, modified – modification of the definition]

3.7.6
conductive part
part which is capable of conducting electric current, although it may not necessarily be used for this purpose

3.7.7
live part
conductor or conductive part intended to be energized in normal operation, including a neutral conductor, but by convention not a PEN conductor

Note 1 to entry: A PEN conductor combines the functions of both a protective earthing conductor and a neutral conductor.

[SOURCE: IEC 60050-195:1998, 195-02-19, modified – modification of the definition]

3.7.8
clearance
shortest distance in air between two conductive parts, or between a conductive part and the accessible surface of a relay

Note 1 to entry: An example for an accessible surface is the actuating member of a relay used for manual operation.

[SOURCE: IEC 60664-1:2007, 3.2, modified – modification of the definition]

3.7.9
solid insulation
solid insulating material interposed between two conductive parts

[SOURCE: IEC 60664-1:2007, 3.4]

3.7.10
creepage distance
shortest distance along the surface of the insulating material between two conductive parts

[SOURCE: IEC 60664-1:2007, 3.3, modified – modification of the definition]

3.7.11
tracking
progressive degradation of a solid insulating material by local discharges to form conducting or partially conducting paths

Note 1 to entry: Tracking usually occurs due to surface contamination.

[SOURCE: IEC 60050-212:2010, 212-11-56, modified – modification of the definition]

3.7.12
proof tracking index
PTI
numerical value of the proof voltage expressed in volts which a material can withstand without tracking under specified test conditions

[SOURCE: IEC 60050-212:2010, 212-11-60, modified – modification of the definition]

3.7.13
pollution
any addition of foreign matter, solid, liquid, or gaseous that can result in a reduction of electric strength or surface resistivity of the insulation

[SOURCE: IEC 60664-1:2007, 3.11]

3.7.14
pollution degree
numeral characterizing the expected pollution of the micro-environment

Note 1 to entry: Pollution degrees 1, 2 and 3 are used, see Annex H.

[SOURCE: IEC 60664-1:2007, 3.13]

3.7.15
micro-environment
immediate environment of the insulation which particularly influences the dimensioning of the creepage distances

[SOURCE: IEC 60664-1:2007, 3.12.2]

4 Influence quantities

The specified performance of a relay shall be given with respect to the reference conditions, i.e. the set of reference values of all influence quantities.

Unless otherwise explicitly stated by the manufacturer, the reference values and tolerance ranges listed in Table 1 apply.

Table 1 – Reference values of influence quantities

Influence quantity	Reference value	Tolerance range and conditions for testing[a]
Ambient temperature	23 °C	±5 K
Atmospheric pressure	96 kPa	86 kPa to 106 kPa
Relative humidity	50 %	25 % to 75 %
External magnetic induction	0	$0 \pm 5 \times 10^{-4}$ T in any direction
Position	As indicated by the manufacturer	According to 8.2 a)
Voltage/current (for coil and load)	As indicated by the manufacturer	±5 % for steady-state conditions
Frequency	16 $^{2}/_{3}$ Hz or 50 Hz or 60 Hz or 400 Hz	Same as reference value with tolerance ±2 %
Waveform	Sinusoidal	Sinusoidal; maximum distortion factor 5 % [b]
Alternating component in d.c. (ripple)	0	Maximum 6 % [c]
Direct component in a.c.	0	Maximum 2 % of peak value
Shock and vibration	0	Maximum 1 m/s^2
Industrial and other atmospheres	Clean air	Clean air (pollution not exceeding class 3C2 of IEC 60721-3-3)

[a] The test may be carried out with other values of the influence quantities, provided the quantitative relationship between one or more influence quantities and the value of the considered characteristic is known.

[b] Distortion factor: ratio of the harmonic content obtained by subtracting the fundamental wave from a non-sinusoidal harmonic quantity and the r.m.s. value of the non-sinusoidal quantity. It is usually expressed as a percentage.

[c] The alternating component (ripple content) of a d.c. supply, expressed as a percentage, is defined as follows:

$$\frac{\text{maximum value} - \text{minimum value}}{\text{d.c. component}} \times 100$$

5 Rated values

5.1 General

The recommended values listed below do not comprise all technical possibilities and other values may be adopted according to conditions of operation and use.

5.2 Rated coil voltage/rated coil voltage range

a) AC voltage, recommended r.m.s. values:

6 V; 12 V; 24 V; 48 V; $100/\sqrt{3}$ V; $110/\sqrt{3}$ V; $120/\sqrt{3}$ V; 100 V; 110 V; 115 V; 120 V; 127 V; 200 V; 220 V; 230 V; 240 V; 277 V; 400 V; 480 V; 500 V.

b) DC voltage, recommended values:

1,5 V; 3 V; 4,5 V; 5 V; 6 V; 9 V; 12 V; 24 V; 28 V; 48 V; 60 V; 100 V; 110 V; 125 V; 220 V; 250 V; 440 V; 500 V.

c) Rated voltage range (for example 220 V to 240 V) and corresponding frequencies (e.g. 50 Hz/60 Hz) shall be specified by the manufacturer.

5.3 Operative range

The operative range of a relay coil can be specified either according to 5.3.1 or 5.3.2 or 5.3.3.

5.3.1 The recommended operative range is to be specified according to one of two classes:

- Class 1: 80 % to 110 % of the rated coil voltage (or range).
- Class 2: 85 % to 110 % of the rated coil voltage (or range).

NOTE Where a rated coil voltage range applies, the operative range is from 80 % (or 85 %) of the lower limit to 110 % of the upper limit of the rated coil voltage range.

The above values apply over the full ambient temperature range as declared by the manufacturer.

Where the manufacturer deviates from the recommended classes, he shall specify both the rated coil voltage (or range) and the corresponding operative range, see Figure A.3.

5.3.2 As an alternative to the operative range specified in 5.3.1, the manufacturer may graphically represent the operative range against ambient temperature. This is achieved by describing the upper limit (U_2 = limiting coil voltage) and the lower limit (U_1 = operate voltage) of the operative range, as illustrated by Figure A.3.

5.3.3 Where relays are operated with pulse width modulation (PWM) and/or other methods of coil power reduction the coil energization shall be as stated by the manufacturer.

5.4 Release

The release values indicated below apply over the full ambient temperature range as declared by the manufacturer.

a) DC relay

Where the operative range is specified according to 5.3.1, the release voltage of monostable relays shall be not lower than 5 % of the rated coil voltage (or the upper limit of the rated coil voltage range), see Figure A.3.

Where the operative range is specified according to 5.3.2, the release voltage of monostable relays shall be not lower than 10 % of the lower limit U_1 of the operative range, see Figure A.3.

b) AC relay

The same conditions as for d.c. relays apply, except that a value of 15 % shall be used in place of 5 % or 10 %, respectively.

5.5 Reset

The recommended values shall be the same as those specified in 5.3, unless otherwise specified by the manufacturer (for instance for single coil bistable remanence relays).

5.6 Electrical endurance

Recommended number of cycles: 5 000; 6 000; 10 000; 20 000; 25 000; 30 000; 50 000; 100 000; 200 000; 300 000; 500 000; etc.

5.7 Frequency of operation

Recommended frequencies: 360/h; 720/h; 900/h and multiples thereof.

0,1 Hz; 0,2 Hz; 0,5 Hz and multiples thereof.

5.8 Contact loads

a) Resistive loads, recommended values

Current: 0,1 A; 0,5 A; 1 A; 2 A; 3 A; 5 A; 6 A; 8 A; 10 A; 12 A; 16 A; 20 A; 25 A; 30 A; 35 A; 60 A; 100 A.

Voltage: 4,5 V; 5 V; 12 V; 24 V; 36 V; 42 V; 48 V; 110 V; 125 V; 230 V; 250 V; 300 V; 400 V; 480 V; 500 V; 690 V; 1 000 V (AC/DC); 1 500 V DC.

b) Recommended inductive loads: see Annex B.

5.9 Ambient temperature

Unless otherwise stated, the preferred ambient temperature range is –10 °C to +55 °C for the operation of relays.

Other recommended values for the upper limit are:

+200 °C +175 °C +155 °C +125 °C +100 °C +85 °C
+70 °C +40 °C +30 °C

Other recommended values for the lower limit are:

–65 °C –55 °C –40 °C –25 °C –5 °C +5 °C

5.10 Categories of environmental protection

The relay technology categories describing the degree of sealing of the relay case or its contact unit are given in Table 2 below.

Table 2 – Categories of protection

Relay technology category		Protection
RT 0:	Unenclosed relay	Relay not provided with a protective case
RT I:	Dust protected relay	Relay provided with a case which protects its mechanism from dust
RT II:	Flux proof relay	Relay capable of being automatically soldered without allowing the migration of solder fluxes beyond the intended areas
RT III:	Wash tight relay	Relay capable of being automatically soldered and subsequently undergoing a washing process to remove flux residues without allowing the ingress of flux or washing solvents. NOTE In service, this type of relay is sometimes vented to the atmosphere after the soldering or washing process; in this case the requirements with respect to clearances and creepage distances can change.
RT IV:	Sealed relay	Relay provided with a case which has no venting to the outside atmosphere, and having a time constant better than 2×10^4 s in accordance with IEC 60068-2-17
RT V:	Hermetically sealed relay	Sealed relay having an enhanced level of sealing, assuring a time constant better than 2×10^6 s in accordance with IEC 60068-2-17

5.11 Duty factor

Recommended values:

10 %, 15 %; 25 %; 33 %; 40 %; 50 %; 60 %.

NOTE In addition, the frequency of operation stated by the manufacturer is to be maintained.

6 General provisions for testing

In the subsequent clauses, the requirements to be checked as well as the related tests are specified.

The tests according to this standard are type tests.

NOTE 1 Tests according to this standard can be applied to routine and sampling tests as appropriate. Preferred tests for routine testing are given in Table 4.

HAZARDS considered in this standard are hazards from heating, electrical shock, ignition and foreseeable misuse before the end of life.

HAZARDS shall not exceed a tolerable level. For the component, the compliance to the tests specified in Table 3 are considered to represent a tolerable level. For the application of the relay, a risk assessment shall be carried out according to Annex O.

NOTE 2 The risk evaluation for the component and for the application follows the same assessment rules for risk evaluation. For the component itself, the risk evaluation could be shown via this standard. However for the application this has to be done once more to determine the interaction of the single components and the foreseeable misuse, e.g. when various relays can be used in combination with a single socket.

The specimens shall be grouped in seven inspection lots, and the related tests shall be taken from Table 3.

The number of test specimen for each inspection lot shall be taken from Table 5 according to the test procedure specified.

For each inspection lot, the tests shall be carried out in the given order.

If one or more specimen(s) of an inspection lot do(es) not pass a test, this test as well as every other one that may have influenced the result of this test shall be repeated once with an additional set of specimens of the same design. In case the manufacturer modifies the relays, all tests technically influenced by this modification shall also be repeated.

Unless otherwise stated in this standard, the tests and measurements shall be carried out in accordance with the reference values and tolerance ranges of the influence quantities given in Table 1.

In special cases, the use of deviating values may be justified. These values shall be as given by the manufacturer and shall be indicated in the test report. The same applies to special test conditions deviating from the conditions specified in this standard (e.g. mounting position for heating tests).

Table 3 – Type testing

Inspection lot	Tests	Clause	Additional references
1	Marking and documentation	7	IEC 60417
1	Heating (all coil voltages)	8	IEC 60085
1	Basic operating function (all coil voltages)	9	
2	Dielectric strength	10	
3	Electrical endurance (per contact load and contact material)	11	
4	Mechanical endurance	12	
5	Clearances, creepage distances and distances through solid insulation	13	IEC 60664-1
6	Screw type terminals and screwless terminals (if applicable)	14.2	IEC 60999-1
6	Flat quick-connect terminations (if applicable)	14.3	IEC 61210
6	Solder terminals (if applicable)	14.4	IEC 60068-2-20
6	Sockets (if applicable)	14.5	IEC 61984
6	Alternative termination types (if applicable)	14.6	
6	Sealing (if applicable)	15	IEC 60068-2-17
7	Heat and fire resistance	16	IEC 60695-2-10
NOTE The number of coil voltages in inspection lot 1 to be tested can be reduced under certain conditions explained in Clauses 8 and 9.			

Table 4 – Routine tests

Inspection lot	Tests	Clause	Additional references
1	Marking and documentation	7	Table 6: 1a;1b;1c
2	Basic operating function	9	
3	Dielectric strength	10.2	
Dielectric test for routine test could be carried out for duration of 1s in accordance with IEC 61810-7:2006, 4.9. The test voltage shall not have any negative impact on the insulation (further use).			

Table 5 – Number of test samples

Kind of testing	Test procedure	Number of samples	Mounting conditions
Type test	A[a]	3	Group mounting
	B	1	Single mounting
Sampling test	n.a.	3	n.a.
NOTE For routine tests by definition all products are tested. For routine tests and sampling tests no test procedure or mounting condition can be specified.			
[a] See also Annex E.			

7 Documentation and marking

7.1 Data

The manufacturer shall make the following data available (with indication of the units):

Table 6 – Required relay data *(1 of 2)*

N°	Data	Notes	Place of indication
1 Identification data			
1a	Manufacturer's name, identification code or trade mark		Relay
1b	Type designation	It shall be unambiguous and ensure identification of the product by respective documentation	Relay
1c	Date of manufacture	May be coded if specified in the documentation	Relay (preferred) or package
2 Coil data			
2a	Rated coil voltage, or rated coil voltage range, or operative range of the coil voltage	Values of the limits or class (see 5.3), including coil power reduction	Relay or catalogue or instruction sheet
2b	Frequency for a.c.		Relay or catalogue or instruction sheet
2c	Coil resistance(s)		Relay or catalogue or instruction sheet
3 Contact data			
3a	Contact load(s)	Type – current – voltage – schematics (see Table 16 for examples)	Relay or catalogue or instruction sheet
3b	Number of cycles for electrical endurance		Catalogue or instruction sheet
3c	Frequency of operation		Catalogue or instruction sheet
3d	Duty factor		Catalogue or instruction sheet
3e	Number of cycles for mechanical endurance		Catalogue or instruction sheet
3f	Contact material(s)		Catalogue or instruction sheet
3g	Type of interruption	Micro-interruption, micro-disconnection, full disconnection	Catalogue or instruction sheet
4 Insulation data			
4a	Type of insulation (depending on the application of the relay)	Functional, basic, reinforced, double insulation	Catalogue or instruction sheet
4b	Deviation from standard dimensioning	According to options a) to c) of 13.1	Catalogue or instruction sheet
4c	Pollution degree	Of relay environment	Catalogue or instruction sheet
4d	Impulse withstand voltage(s)	For all circuits	Catalogue or instruction sheet
4e	Rated insulation voltage(s)	For all circuits	Catalogue or instruction sheet

Table 6 *(2 of 2)*

N°	Data	Notes	Place of indication
5 General data			
5a	Test procedure	A (Group mounting) or B (Single mounting)	Catalogue or instruction sheet
5b	Ambient temperature range		Catalogue or instruction sheet
5c	Categories of environmental protection (RT)		Catalogue or instruction sheet
5d	Mounting position	If applicable	Catalogue or instruction sheet
5e	Data to permit suitable connection of the relay	Including polarity	Catalogue or instruction sheet
5f	Accessories	If essential to the relay performance	Catalogue or instruction sheet
5g	Data concerning earthing or grounding of metal parts	If applicable	Catalogue or instruction sheet
5h	Duty restrictions	If any	Catalogue or instruction sheet
5i	Mounting distance	See Annex E	Catalogue or instruction sheet
5j	Maximum permissible steady-state temperature of the terminals (if applicable), and/or material combination for flat quick-connect terminations	Applies also to the combination of relay and mating socket	Manufacturer documentation
5k	Resistance to soldering heat	Including reference to the test procedure	Manufacturer documentation

7.2 Additional data

Manufacturers of elementary relays provided with an actuating member for manual operation in order to facilitate the test of the equipment in which the relay is incorporated shall specify any special operating requirements.

EXAMPLE When operating the actuating member (e.g. push-button) for manual operation, the action from OFF-state to ON-state (or vice versa) is operated as quickly as possible.

7.3 Marking

The data of 1a) and 1b) of Table 6 shall be marked on the relay so that they are legible and durable.

The test indicated below is carried out when only additional material(s) are used for marking (e.g. inkjet or pad printing).

Compliance with the durability requirements for the marking is checked by inspection and by rubbing the marking by hand as follows:

a) 15 back-and-forth movements in about 15 s with a piece of cloth soaked with distilled water, followed by

b) 15 back-and-forth movements in about 15 s with a piece of cloth soaked with petroleum spirit.

During the tests, the soaked piece of cloth shall be pressed on the marking with a pressure of about 2 N/cm^2.

After these tests, the marking shall still be legible.

NOTE The petroleum spirit used is defined as an aliphatic solvent hexane with a content of aromatics of maximum 0,1 volume %, a kauributanol-value of 29, initial boiling point approximately 65 °C, dry point approximately 69 °C and specific gravity of 0,68 g/cm^3.

7.4 Symbols

When symbols are used, they shall be in line with those given in Table 7.

Rated values of switching voltage and switching current may be indicated as given in Table 8.

Table 7 – Symbols

Volt	V
Ampere	A
Frequency of the supply	Hz
Volt-ampere	VA
Watt	W
Direct current ((IEC 60417-5031) (2002-10))	⎓ or DC
Alternating current (single-phase) ((IEC 60417-5032) (2002-10))	∼ or AC
Alternating current (two-phase)	2 ∼
Alternating current (two-phase with neutral)	2N ∼
Alternating current (three-phase)	3 ∼
Alternating current (three-phase with neutral)	3N ∼
Alternating/direct current ((IEC 60417-5033) (2002-10))	≂ or DC/AC
Protective earth ((IEC 60417-5019) (2006-08))	⏚
Make contact (normally open contact)	NO
Break contact (normally closed contact)	NC
Change-over contact	CO

Table 8 – Examples for indication of rated values

10 A 250 V ∼ or 10 A 250 V AC or 10 A 250 V ∼ cos φ 0,4	16 A 230 V ∼ or 16 / 230 ∼ or $\frac{16}{230}$ ∼

8 Heating

8.1 Requirements

Relays shall be constructed so that they do not attain excessive temperatures in normal use. The relay manufacturer shall either

– select the thermal classification of materials in accordance with Table 9 and indicate this classification for the respective tests, or

– specify the maximum temperature and verify the suitability of the material in accordance with the ball pressure test of Clause 16.

Table 9 – Thermal classification

Thermal classification (coil insulation system)	Maximum temperature	Maximum temperature for existing designs
Y	90 °C	-
A	105 °C	120 °C
E	120 °C	135 °C
B	130 °C	145 °C
F	155 °C	155 °C
H	180 °C	175 °C
200 (N)	200 °C	195 °C
220 (R)	220 °C	215 °C
250 (C)	250 °C	-

This Table 9 is valid for change of resistance method. When the coil temperature is measured by the thermocouple method, the values for maximum temperature shall be reduced by 20 K.

For relays of the same construction, the test can be reduced from all coil voltages to the coil voltage with the maximum coil power consumption.

NOTE The thermal classification is in accordance with IEC 60085.

Actuating members for manual operation which are touched for a short time only in normal use shall comply with the following limiting temperatures:

- Metal 60 °C
- Ceramics or vitreous material 70 °C
- Plastics, rubber or moulded material 85 °C

If the temperature surpasses the given limit during the test of 8.2, a respective warning shall be included in the documentation established for the user of the relay.

8.2 Test set-up

a) Test procedure A – Group mounting: The test is carried out with three relays mounted side by side in the same direction, see Table 5 – test procedure A and Annex E.

Test procedure B – Single mounting: The test is carried out with one relay (see Table 5 – test procedure B).

Unless specifically designed otherwise, the specimens are tested in the horizontal position with the terminals pointing downwards. The mounting distance shall be stated by the manufacturer.

b) Terminal screws and/or nuts are tightened with a torque equal to two-thirds of that specified in IEC 60999-1.

c) In case of screwless terminals, care is to be taken to ensure that the conductors are correctly fitted to the terminals in accordance with IEC 60999-1.

d) The relays shall be mounted in a sufficiently large heat chamber without forced convection. When an air circulating test chamber is used for testing, baffles shall be provided within the test chamber, unless all other conditions in this clause are met.

e) The specimen shall be protected from air draughts, solar influences and the like and it is not allowed to be subjected to any artificial cooling.

f) During the test, the predetermined ambient temperature of the heat chamber shall not be influenced by the relay.

g) The ambient temperature shall be constantly at room temperature or alternatively equal to the upper limit of the operating temperature range.

h) When thermocouples are used for measuring the temperatures of a coil, at least two thermocouples are to be used. The thermocouples are to be placed on the surface of the magnet wire which is the upper surface based on the orientation during testing.

8.3 Test procedure

After thermal equilibrium is achieved, the values of t_1 and R_1 are measured (see formula below). After that, all contacts shall be loaded with the limiting continuous current as specified by the manufacturer.

- For relays with make contacts, the coil(s) shall be energized with 1,1 times the rated coil voltage or nominal coil voltage as stated by the manufacturer, or with 1,1 times the upper limit of the rated coil voltage range, or with U_2, until thermal equilibrium is reached. Then the values of t_2 and R_2 are measured.
- For relays with break contacts, the heating test shall be done in two steps. First the coil is energized as stated before for make contact relays (no contact load) and the temperature rise of the coil itself. And secondly the coil is unenergized and the NC contact(s) loaded, until thermal equilibrium is reached. Then the values of t_2 and R_2 are measured.
- For relays operated with pulse width modulation (PWM) and/or other methods of coil power reduction or for bistable relays, the coil energization shall be as stated by the manufacturer.

The temperature(s) of the coil(s) shall be determined by the resistance method and the temperature rise calculated according to the following formula:

$$\Delta t = \frac{R_2 - R_1}{R_1}(234{,}5 + t_1) - (t_2 - t_1)$$

where

Δt is the temperature rise;

R_1 is the resistance at the beginning of the test (chamber temperature) or at room temperature;

R_2 is the resistance at the end of the test;

t_1 is the ambient temperature at the beginning of the test (chamber temperature) or room temperature;

t_2 is the ambient temperature at the end of the test.

The value of 234,5 applies to electrolytic copper (EC58). For other materials, the respective values have to be used instead and indicated by the manufacturer, e.g. 225,0 for aluminium.

The temperature limits of all used materials may not be exceeded when the relay is operated at the upper limit of the operating temperature range.

8.4 Terminals

8.4.1 General

Temperature at the terminals is determined by means of fine wire thermocouples which are positioned so that they have negligible effect on the temperature being determined. The measuring points are positioned on the terminals as close as possible to the body of the relay. If the thermocouples cannot be positioned directly on the terminals, the thermocouples may be fixed on the conductors as close as possible to the relay, see Annex E.

Temperature sensors other than thermocouples are permitted, provided they show equivalent test results.

The maximum permissible steady-state temperature of the terminals as indicated by the manufacturer (see item 5j of Table 6) shall not be exceeded.

8.4.2 Solder terminals

The electrical interconnections between the relays are made with bare rigid conductors with a cross-sectional area according to Table 10. The connections of the relay to the voltage or current source(s) are realized with flexible conductors according to Table 10.

Table 10 – Cross-sectional areas and lengths of conductors dependent on the current carried by the terminal

Current carried by the terminal A		Cross-sectional area of conductors		Minimum conductor length for testing
Above	**Up to and including**	mm^2	AWG	mm
-	3	0,5	20	500
3	6	0,75	18	500
6	10	1,0	18	500
10	16	1,5	16	500
16	25	2,5	14	500
25	32	4,0	12	500
32	40	6,0	10	1 200
40	50	10,0	8	1 200
50	65	16	6	1 200
65	85	25	4	1 200
85	100	35	3	1 200
100	115	35	2	1 200
115	130	50	1	1 200
130	150	50	0	1 200
150	175	70	00	1 200
175	200	95	000	1 200
200	225	95	0000	1 200
225	250	120	250	1 200
250	275	150	300	1 200
275	300	185	350	1 200
300	350	185	400	1 200
350	400	240	500	1 400
When a dimension of a wire is not available, the next smallest available standard wire size shall be used.				

8.4.3 Flat quick-connect terminations

The electrical interconnections between the relays are made with bare rigid conductors with a cross-sectional area according to Table 10. The connections of the relay to the voltage or current source(s) are realized with flexible conductors according to Table 10. The electrical interconnections between the relays as well as to the voltage or current source(s) shall be made using connectors according to IEC 61210.

NOTE 1 When the connectors are soldered in the crimping area, the determination of the flat quick-connect termination of the relay without significant influence from either the connector or the quality of the crimping can be realised.

For each test, new connectors shall be used.

The determined absolute temperature shall not exceed the lowest permissible value for flat quick-connect terminations given in Annex A of IEC 61210:2010, unless the manufacturer specifies the appropriate material combination(s).

The temperature rise at the flat quick-connect terminations shall not exceed 45 K. This may be verified without the temperature rise influence of the relay contacts and the coil (e.g. bridged or short circuited or soldered relay contacts).

NOTE 2 The following nominal dimensions of quick-connect terminations are commonly used:

Connector size	Maximum steady-state current
2,8 mm	6 A
4,8 mm	16 A
6,3 mm	25 A
9,5 mm	32 A

8.4.4 Screw and screwless type terminals

The electrical interconnections between the relays are made with bare rigid conductors according to Table 10. The connections of the relay to the voltage or current source(s) are realized with flexible conductors according to Table 10.

The temperature rise at the terminals shall not exceed 45 K. This may be verified without the temperature rise influence of the relay contacts and the coil (e.g. bridged or short-circuited or soldered relay contacts).

8.4.5 Alternative termination types

The electrical interconnections between the relays are made with bare rigid conductors according to Table 10. The connections of the relay to the voltage or current source(s) are realized with flexible conductors according to Table 10.

The temperature rise at the terminals shall not exceed 45 K. This may be verified without the temperature rise influence of the relay contacts and the coil (e.g. bridged or short-circuited or soldered relay contacts).

8.4.6 Sockets

The maximum steady-state temperature limits permissible for the connections between relay and socket as well as for the insulating materials of both relay and socket adjacent to the connection shall not be exceeded.

The electrical interconnections between the sockets are made with conductors according to Table 10. The connections of the sockets to the voltage or current source(s) are realized with flexible conductors according to Table 10.

The mounting distance between sockets shall be specified by the manufacturer.

9 Basic operating function

9.1 General test conditions

Prior to the tests, the relays are subjected to the specified atmospheric test conditions so that they are in thermal equilibrium.

For relays of the same construction, the test can be reduced from all coil voltages to the two coil voltages with minimum and maximum magnetomotive force (or ampereturns respectively).

9.2 Operate (monostable relays)

9.2.1 Operate with (constant) coil voltage

This test is carried out using at least one of the following five test modes as indicated in Table 11, depending on the values for the operative range as specified by the manufacturer (see 5.3.1 for Test mode I, II and III or 5.3.2 for Test mode IV and V) and the specified Test procedure.

Table 11 – Operate and release with constant coil voltages

Test mode	Mode I	Mode II	Mode III	Mode IV	Mode V
Test procedure[a]	B (single mounting)		A[b] (group mounting)		B (single mounting)
Mounting conditions	Not specified	The test is carried out and assembled depending on the test procedure of Table 5. The specimen(s) shall be tested in the horizontal position with the terminals pointing downwards, unless otherwise prescribed by the manufacturer. If applicable, the mounting distance shall be stated by the manufacturer.			
Operate – Preconditioning – General	The relay shall be preconditioned at the maximum permissible ambient temperature specified by the manufacturer by applying – as indicated by the manufacturer with the contacts (contact set) loaded with the maximum continuous current(s) specified by the manufacturer for this test until thermal equilibrium is reached.				
Operate – Preconditioning – Coil voltage	Rated coil voltage	Rated coil voltage, or the upper limit of the rated coil voltage range (see 5.3.1 and Figure A.4)		The maximum value of the lower limit of the operative range of the coil (U_1 = operate voltage at this temperature, see 5.3.2 and Figure A.5)	
Operate – Operating function	Immediately after removal of the coil voltage and related arrival at the release condition, the relay shall operate again when energized at the lower limit of the operative range. Afterwards the coil voltage shall be increased up to 110 % of the nominal coil voltage until thermal equilibrium is reached. Immediately after removal of the coil voltage and related arrival at the release condition, the relay shall operate again when energized with the nominal coil voltage.	Immediately after removal of the coil voltage and related arrival at the release condition, the relay shall operate again when energized at the lower limit of the operative range.		Immediately after removal of the coil voltage, and related arrival at the release condition, the relay shall operate again when re-energized at U1.	
Release – Preconditioning	The relays shall reach thermal equilibrium at the minimum permissible ambient temperature.				
Release – Releasing function	[c]	After a short application of the operate voltage to establish the operate condition, the coil voltage shall be immediately reduced to the relevant value specified in 5.4. When this occurs, the relay shall release.			

NOTE Mode III represents the method 1 of IEC 61810-1:2008 and Mode IV represents the method 2 of IEC 61810-1:2008.

[a] See Table 5

[b] See also Annex E.

[c] For existing designs, it may happen that the value for the release voltage is not given. In such cases, the release voltage has to be defined by the manufacturer without any reconfirmation or shall be 0 V.

9.2.2 Operate with PWM and/or other operating methods

This test is carried out in accordance with the specified test procedure and with the appropriate test mode indicated in Table 12 if the operative range according to 5.3.3 is specified by the manufacturer.

Table 12 – Operate and release with PWM and/or other operating methods

<table>
<tr><th colspan="3">Test mode</th><th>Mode II</th><th>Mode III</th></tr>
<tr><td colspan="3">Test procedure</td><td>B (single mounting)</td><td>A (group mounting)</td></tr>
<tr><td colspan="3">Mounting conditions</td><td colspan="2">The test is carried out and assembled depending on the test procedure of Table 5. The specimen(s) shall be tested in the horizontal position with the terminals pointing downwards, unless otherwise prescribed by the manufacturer. If applicable, the mounting distance shall be stated by the manufacturer.</td></tr>
<tr><td rowspan="3">Operate</td><td rowspan="2">Preconditioning</td><td>General</td><td colspan="2">The relay shall be preconditioned at the maximum permissible ambient temperature specified by the manufacturer by applying – as indicated by the manufacturer with the contacts (contact set) loaded with the maximum continuous current(s) specified by the manufacturer for this test until thermal equilibrium is reached.</td></tr>
<tr><td>Coil voltage</td><td colspan="2">Steady state coil voltage as specified by the manufacturer</td></tr>
<tr><td colspan="2">Operating function</td><td colspan="2">Immediately after removal of the coil voltage and related arrival at the release condition, the relay shall operate again when energized at the lower limit of the operative range or under the condition specified by the manufacturer.

Afterwards the coil voltage shall be increased up to 110 % of the steady state coil voltage until thermal equilibrium is reached. Immediately after removal of the coil voltage and related arrival at the release condition, the relay shall operate again when energized with the nominal coil voltage.

In case the relay coil is defined by the applied current, the test above is carried out the same way but voltages shall be replaced by currents.</td></tr>
<tr><td rowspan="2">Release</td><td colspan="2">Preconditioning</td><td colspan="2">The relays shall reach thermal equilibrium at the minimum permissible ambient temperature.</td></tr>
<tr><td colspan="2">Releasing function</td><td colspan="2">After a short application of the operate voltage to establish the operate condition, the coil voltage shall be immediately reduced to the relevant value specified in 5.4.

When this occurs, the relay shall release.</td></tr>
</table>

9.3 Operate/reset (bistable relays)

The relays shall be preconditioned at the maximum permissible ambient temperature with the contacts (contact set) loaded with the maximum continuous current specified by the manufacturer until thermal equilibrium is reached.

The relay shall operate when energized with the specified operate voltage according to 5.3.

Under the same conditions the relay shall be tested to verify that it properly resets.

10 Dielectric strength

10.1 Preconditioning

The tests of 10.2 shall be started immediately after the preconditioning and finished without unnecessary delay. The time to complete the test shall be indicated in the test report.

The preconditioning comprises the dry heat and damp heat tests.

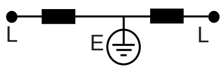
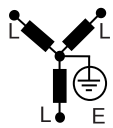
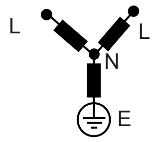
The dry heat test is carried out in a heat chamber. The air temperature is maintained at 55 °C with an accuracy of ±2 K in the area where the specimens are mounted. The specimens are kept in the chamber for 48 h.

The damp heat test is carried out in a climatic test cabinet at a relative humidity between 91 % and 95 %. The air temperature shall be maintained at 25 °C with an accuracy of ±5 K in the area where the specimens are mounted. The specimens are kept in the chamber for 48 h. There shall be no condensation.

10.2 Dielectric strength

In case of an a.c. voltage for the circuit under consideration, the insulation is subjected to a voltage of substantially sine wave form, having a frequency of 50 Hz or 60 Hz. For d.c. circuits a d.c. test voltage is applied. The test voltage shall be raised uniformly from 0 V to the value prescribed in Table 13 or Table 14 within not more than 5 s and held at that value for 60 s without flashover. A current of not more than 3 mA is permitted.

Table 13 – Dielectric strength – AC

Insulation or disconnection to be tested[g]	Test voltage[a b] depending on the rated voltage of the circuit (r.m.s. values)							
	[c] Up to and including 50 V	50 V to 120 V	100 V to 200 V 120 V to 240 V 125 V to 250 V		230 V / 400 V 277 V / 480 V[k]		400 V / 400/ $\sqrt{3}$ V 480 V / 480/ $\sqrt{3}$ V	
			[d] 		[e] 		[f] 	
	L – E	L – E	L – E	L – L	L – E	L – L	L – E	L – L
	V	V	V		V		V	
Functional insulation[h]	500	1 300	1 300	1 500	1 500	1 700	1 700	1 700
Basic insulation[i]	500	1 300	1 300	---	1 500	---	1 700	---
Basic insulation (Test procedure B)	500	1 000 + 2 times rated voltage						
Supplementary insulation[i]	---	1 300	1 300	---	1 500	---	1 700	---
Reinforced or double insulation[i]	500	2 600	2 600	---	3 000	---	3 400	---
Micro-disconnection[j]	400	400	400	500	500	700	700	700
Full-disconnection	500	1 300	1 300	1 500	1 500	1 700	1 700	1 700

[a] The high-voltage transformer used for the test shall be designed so that, when the output terminals are short-circuited after the output voltage has been adjusted to the test voltage, the output current is at least 200 mA. The overcurrent relay shall not trip when the output current is less than 3 mA. Care shall be taken that the r.m.s. value of the test voltage is measured within ±3 %.

[b] For functional, basic and supplementary insulation as well as for full disconnection, the values are derived from the formula U_n + 1 200 V (rounded).

For micro-disconnection, the values are derived from the formula U_n + 250 V (rounded), with U_n being the nominal voltage of the supply system.

[c] Up to and including 50 V: not to be connected direct to the supply mains. No temporary overvoltages according to IEC 60364-4-44 are expected to occur.

[d] Single-phase system, mid-point earthed.

[e] Three-phase system, mid-point earthed.

[f] Three-phase system, one phase earthed.

[g] Special components which might render the test impractical such as light emitting diodes, free-running diodes, varistors are disconnected at one pole, or bridged, or removed, as appropriate to the insulation being tested.

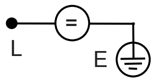
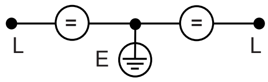
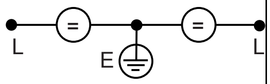
[h] An example is the insulation between contacts necessary for proper function only.

[i] For the test of basic, supplementary and reinforced insulation, all live parts are connected together and care shall be taken to ensure that all moving parts are in the most onerous position.

[j] Contact gap ensuring proper function of the contact (covers also micro-interruption).

[k] For higher voltage systems, e.g. 400 V/690 V, the values should be derived using the respective "Maximum value of rated operational voltage to earth" from Table G.1 and the formulas in footnote b.

Table 14 – Dielectric strength – DC

Insulation or disconnection to be tested [d]	Test voltage[a b] depending on the rated voltage of the circuit					
	[c] Up to and including 50 V	50 V to 120 V	120 V to 250 V 125 V to 250 V		240 V to 480 V [k]	
						
	L – E	L – E	L – E	L – L	L – E	L – L
	V		V		V	
Functional insulation[e]	500	1 300	1 300	1 500	1 500	1 700
Basic insulation[f]	500	1 300	1 300	---	1 500	---
Basic insulation (Test procedure B)	500	1 000 + 2 times rated voltage				
Supplementary insulation[f]	---	1 300	1 300	---	1 500	---
Reinforced or double insulation[f]	500	2 600	2 600	---	3 000	---
Micro-disconnection[g]	400	400	400	500	500	700
Full-disconnection	500	1 300	1 300	1 500	1 500	1 700

[a] The high-voltage transformer used for the test shall be designed so that, when the output terminals are short-circuited after the output voltage has been adjusted to the test voltage, the output current is at least 200 mA. The overcurrent relay shall not trip when the output current is less than 3 mA. Care shall be taken that the value of the test voltage is measured within ±3 %.

[b] For functional, basic and supplementary insulation, as well as for full disconnection, the values are derived from the formula U_n + 1 200 V (rounded).

For micro-disconnection, the values are derived from the formula U_n + 250 V (rounded), with U_n being the nominal voltage of the supply system.

[c] Up to and including 50 V: Not to be connected direct to the supply mains. No temporary overvoltages according to IEC 60364-4-44 are expected to occur.

[d] Special components which might render the test impractical such as light emitting diodes, free-running diodes, varistors are disconnected at one pole, or bridged, or removed, as appropriate to the insulation being tested.

[e] An example is the insulation between contacts necessary for proper function only.

[f] For the test of basic, supplementary and reinforced insulation, all live parts are connected together and care shall be taken to ensure that all moving parts are in the most onerous position.

[g] Contact gap ensuring proper function of the contact (covers also micro-interruption).

[k] For higher voltage systems the testing voltage should be derived by using the formulas in footnote b.

10.3 Special cases for test procedure B

In special cases (particularly for existing designs) the test potential shall be for basic insulation the following values for alternating-current, or 1,414 (√2) times the following values for direct-current:

a) 500 V – For relays rated not more than 50 V;

b) 1 000 V plus twice the rated voltage – For relays rated 51 V to 600 V:

c) 1 000 V – For relays rated 51 V to 250 V and intended for use in a pollution degree 2 location; or

d) 2 000 V plus 2,25 times maximum rated voltage – rated 601 V to 1 500 V.

These values are valid for / between:

a) uninsulated live parts and the enclosure with the contacts open and closed;
b) terminals of opposite polarity with the contacts closed; and
c) uninsulated live parts of different circuits.

11 Electrical endurance

11.1 General

The test is performed according to Table 15 on each contact load and each contact material as specified by the manufacturer.

The number of test samples shall be in compliance with the specified test procedure from Table 5.

The test set-up described in Annex C shall be used.

Unless otherwise explicitly stated by the manufacturer, this test is carried out at the upper limit of the ambient temperature range, and the relay coil(s) shall be energized with rated voltage or an appropriate value within the rated coil voltage range or operative range.

The contacts shall be monitored to detect break and/or make malfunctions as well as unintended bridging.

The preferred arrangement of the relays is group mounted under the mounting conditions of Annex E for the heating test unless otherwise prescribed by the manufacturer. For PCB relays it is permitted to use a PCB for connecting the relays with the wires and ensure the minimum mounting distances. However the dimensions of the connecting wires shall be according to Table 10.

The contacts are connected to the load(s) in accordance with Table 16 as specified and indicated by the manufacturer. If not otherwise specified by the manufacturer, the load shall be applied to both the make and break side of a change-over contact.

Relays provided with an additional actuating member for manual operation (for example, push-button) shall be tested respectively to verify that the relay is capable of properly switching on and off its maximum rated contact current at related voltage at least 100 times at ambient temperature in accordance with Table 2.

Table 15 – Electrical endurance test procedures

Procedure	Test procedure [a]		
	A (Group mounting)	**B (Single mounting)**	**B (Single mounting) and Clause D.1 [d]**
Test sequence	Overload test (optional, see 11.2)	Overload test (optional, see 11.2)	Overload test [c] Parameter given in Clause D.1, Tables D.1, D.2 and D.3
	Electrical endurance		Electrical endurance Parameter given in Clause D.1, Tables D.2 and D.3
	Dielectric strength test		
	Heating test [b] (optional)		n.a.

[a] See also Table 5.

[b] For application standards e.g. IEC 60730-1 or IEC 60669-1 the heating test after the electrical endurance is requested.

[c] For electronic ballast: overload test is not requested.

[d] Following exactly the requirements in accordance with Clause D.1.

11.2 Overload and endurance test

An overload test shall be performed if the manufacturer specifies value(s) for the limiting making and/or breaking capacity higher than the rated switching current (see Table 15). The overload test consists of 50 cycles switching the specified higher values. The overload test on a CO contact could be done sequentially – NO and NC contact side separately. There shall be no malfunction.

Following the overload test, the endurance test shall be performed on the same samples, under the same test conditions and at the rated switching current.

For inductive loads, see Annex B.

Dedicated device application tests and their test sequences as well test circuits for special loads (e.g. lamp loads, cable loads) are compiled in Annex D.

11.3 Failure and malfunction criteria

During the electrical endurance test, not more than 5 temporary malfunctions per relay are permitted. A temporary malfunction is an event that will self-correct, so that it does not repeat over the following test cycle. The occurrence of two or more successive temporary malfunctions is regarded as a failure, as is more than 5 temporary malfunctions per relay, over the duration of the test. One or more relay failures result in failure of the endurance test. If one or more specimen (only for test procedure A) fail(s), the test may be repeated once with three additional specimens. All three additional specimens shall pass the test.

For test in accordance with Clause D.1, at least one sample shall be tested and the first malfunction is regarded as a failure.

11.4 Final dielectric test

Immediately after the electrical endurance test, the relay shall pass a dielectric test according to 10.2 with 75 % of the value indicated in Table 13 or Table 14 for functional isolation.

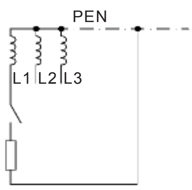
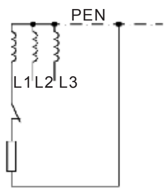
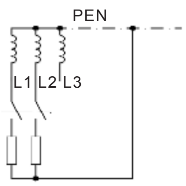
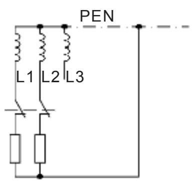
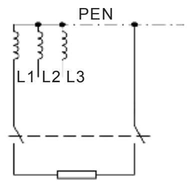
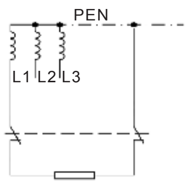
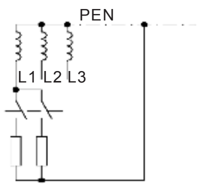
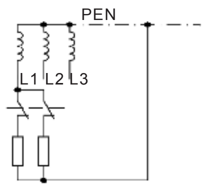
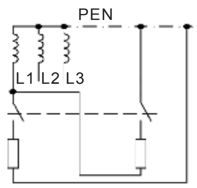
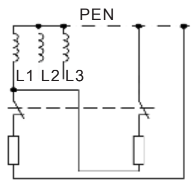
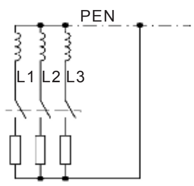
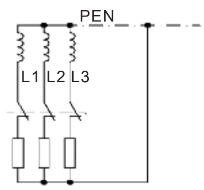
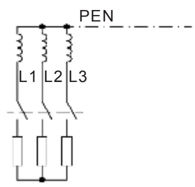
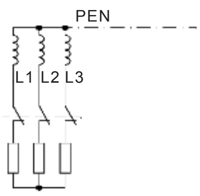
For relays designed for basic, reinforced or supplementary insulation systems, immediately after the electrical endurance test the integrity of the insulation system shall be verified by dielectric test according to 10.2 under basic insulation requirements indicated in Table 13 or Table 14. This test is not applicable for existing designs.

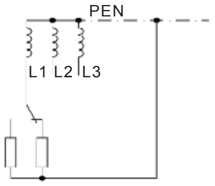
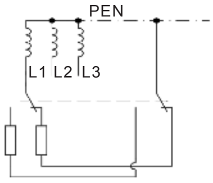
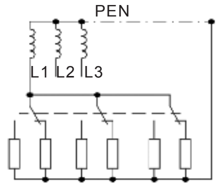
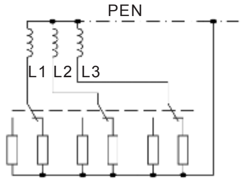
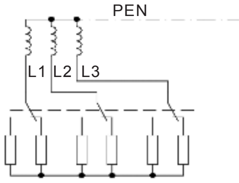
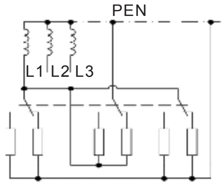
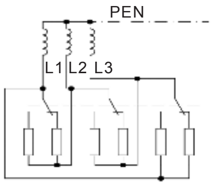
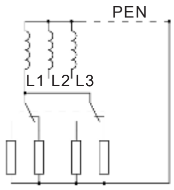
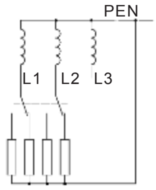
NOTE For existing designs the 75 % of the initial values are still remaining as defined within the IEC 61810-1:2008.

For test in accordance with Clause D.1, the dielectric test in accordance with the requirement of basic insulation, test procedure B in Tables 11 and 12 is applicable.

If required by the application, a heating test can be performed after the dielectric test.

Table 16 – Schematics for contact loading

Single-pole contact	a 	b 	
Double-pole contact	c 	d 	e 
	f 	g 	h 
	i 	j 	
Multi-pole contact	k 	l 	m 
	n 		

<table>
<tr><td rowspan="3">Change-over contact</td><td>o </td><td>p </td><td>q </td></tr>
<tr><td>r </td><td>s </td><td>t </td></tr>
<tr><td>u </td><td>v </td><td>w </td></tr>
<tr><td colspan="4">If none of the schematics apply, the manufacturer should indicate an appropriate one.</td></tr>
</table>

12 Mechanical endurance

The test of the mechanical endurance is intended to verify whether a relay functions properly after the number of cycles stated by the manufacturer.

The test conditions are as follows:

a) the relays are mounted according to item a) of 8.2 and Table 5;

b) the coil voltage equals the rated value, or an appropriate value within the rated coil voltage range or operative range;

c) influence quantities according to Clause 4;

d) frequency of operation as stated by the manufacturer; the relay shall however, attain both the operate and release/reset condition within one cycle.

In order to monitor the cycles, the contacts of each relay are connected to contact loads as specified by the manufacturer. Contacts of multi-pole relays may be connected in parallel. The contact load chosen shall ensure reliable monitoring of the performed cycles, whilst not causing a level of wear of the contact points that might devalue the test. If during this test the difference between the number of detected cycles and the number of energization cycles exceeds 0,1 % of the specified mechanical endurance, the respective relay has not passed the test.

The integrity of the insulation system for basic, reinforced or supplementary insulation systems shall be verified immediately after the mechanical endurance test by dielectric test according to 10.2 indicated in Table 13 or Table 14. This test is not applicable for existing designs.

Subsequently for all relays a visual inspection shall verify the mechanical integrity of the relays. For this purpose, it may be necessary to open the relays. Parts which are necessary for the proper function of the relay, or any safety related parts, which are loose and/or broken shall be considered a failure.

NOTE Safety related are defined as parts to ensure creepages and clearances as well protection against electrical shock and requirement on solid insulation.

If one or more (only for test procedure A) fail(s), the test may be repeated once with three additional specimens. All three additional specimens shall pass the test.

In any case, the verification of the mechanical endurance is given by the electrical endurance test up to the number of cycles of the electrical endurance.

13 Clearances, creepage distances and solid insulation

13.1 General provisions

The requirements and tests indicated in this clause are based on IEC 60664-1.

This standard does not deal with distances through liquid insulation, gases other than air, and compressed air.

NOTE 1 In case some other insulation material with better characteristics than air is used, reduced clearances and creepage distances can be applicable when verified for the entire lifetime of the relay.

Based on other parts of the IEC 60664 series of basic safety standards in the field of low-voltage insulation coordination, the relay manufacturer may select to apply one or more of the following options a) to c):

a) When all the conditions of IEC 60664-5 are fulfilled, the dimensioning of clearances and creepage distances for spacings up to 2 mm as given in that standard may be applied instead. However, the provisions for solid insulation (see 13.3) remain unchanged.

   NOTE 2 IEC 60664-5 applies in the case of printed wiring boards and similar constructions where the clearances and creepage distances are identical and along the surface of solid insulation (see examples 1, 5 and 11 shown in Annex F). Smaller dimensioning than that based on IEC 60664-1 can be achieved dependent on the water absorption characteristics of the solid insulating material. According to IEC 60664-5, the dimensions for reinforced or double insulation can exceed 2 mm.

b) For constructions in accordance with IEC 60664-3, where protection against pollution is achieved by using adequate bonding, coating, potting or moulding, the reduced clearances and creepage distances as specified in IEC 60664-3 may be used. All the requirements and tests of IEC 60664-3 shall be fulfilled. The following items apply:
   - value for lower temperature under 5.7.1 of IEC 60664-3:2003, −10 °C;
   - temperature cycle under 5.7.3 of IEC 60664-3:2003, Severity 1;
   - the partial discharge test under 5.8.5 of IEC 60664-3:2003 is not required;
   - none of the additional tests under 5.9 of IEC 60664-3:2003 is required.

   The temperature for preconditioning 5.7.2 of IEC 60664-3:2003 and upper temperature, 5.7.3 of IEC 60664-3:2003 shall be determined during a heating test on a single relay under nominal conditions and maximum ambient temperature. The thermocouple has to be placed next to interested area under consideration. In accordance with IEC 60079-15:2010, 22.5 the measured temperature shall be increased by 10 °C. It is permitted to reduce the test duration of the dry heat test by using the following formula:

$$\text{Duration}[h] = 2\ 685 \times 10^{-0{,}069\ 3 \times (T_2 - T_1)}$$

   where

   T_2 is the chosen test temperature, under consideration of all material temperature limits in the investigated area;

   T_1 is the measured temperature + 10 °C.

   NOTE 3 The functional, mechanical and electrical properties of the involved materials can be considered.

   The provisions for solid insulation (see 13.3) remain unchanged.

   NOTE 4 In Annex F, examples 5b, 6b, 7b, and 8b show the determination of clearance and creepage distances in this case.

c) In the case of relays to be used for frequencies of the working voltage above 30 kHz, it is strongly recommended to apply the provisions for insulation coordination as given in IEC 60664-4.

13.2 Clearances and creepage distances

Clearances and creepage distances shall be dimensioned according to the criteria given in Table 17.

Table 17 – Provisions for the dimensioning of clearances and creepage distances

Characteristics to be tested	**Clearances**	**Creepage distances**
	Clearances shall be so dimensioned that they comply with the requirements of Table 18 depending on the impulse withstand voltage stated by the manufacturer, eventually taking into account the overvoltage category as given in Annex G and the pollution degree according to Annex H. Details regarding the measurement of clearances are described in Annex F.	Creepage distances shall be dimensioned as given in Table 20 for the highest voltage that can occur in the circuit(s) in normal use, whereby the pollution degree according to Annex H and the material group taken from Table 19 shall be considered. A creepage distance shall not be less than the associated clearance. Details regarding the measurement of creepage distances are described in Annex F.
Functional insulation [f]	There are no requirements for the clearances.	There are no requirements for the creepage distances.
Basic insulation [e]	Rated values according to Table 18 apply to all relevant parts of the relay. Inside the relay case the rated values shall be chosen considering the pollution degree according to Annex H.	Rated values according to Table 20 apply to all relevant parts of the relay. Inside the relay case, the rated values shall be chosen considering the pollution degree according to Annex H.
Supplementary insulation	Equal to basic insulation.	Equal to basic insulation.
Double insulation	Comprises basic and supplementary insulation.	Comprises basic and supplementary insulation.
Reinforced insulation [c]	Equal to basic insulation, however one step higher in the preferred series of rated values of the impulse voltage, or 160 % of the rated impulse voltage for basic insulation.[a b]	Twice the value for basic insulation.
Across open contact for micro-disconnection [d]	Inside the relay case, there are no requirements concerning clearances. Distances between the contact members and other conducting parts of the contact down to its fixation within the relay shall not be smaller than the contact gap.	Inside the relay case, there are no requirements concerning creepage distances. Distances between the contact members and other conducting parts of the contact down to its fixation within the relay shall not be smaller than the contact gap.
Across open contact for full-disconnection	Rated value as for basic insulation in accordance with Table 18. Distances between the contact members and other conducting parts of the contact down to its fixing within the relay shall not be smaller than the contact gap.	Rated value as for basic insulation in accordance with Table 20. Distances between the contact members and other conducting parts of the contact down to its fixing within the relay shall not be smaller than the contact gap.

NOTE The properties of the functional insulation are evaluated with the type tests of this standard. Requirements for the functional insulation may be given by the application and the relevant application standards.

[a] Clearances for reinforced insulation shall be dimensioned using one of the values for the rated impulse voltage taken from Table 18 by the manufacturer, if necessary taking into account the overvoltage category as given in Annex G and the pollution degree according to Annex H, but one step higher in the preferred series of values given in Table 18 than that specified for basic insulation. If the impulse withstand voltage required for basic insulation is other than a value from the preferred series, reinforced insulation shall be dimensioned to withstand 160 % of the impulse withstand voltage required for basic insulation.

[b] In case of relays provided with double insulation, where basic and supplementary insulation cannot be

tested separately, the insulation system is considered as reinforced insulation.

[c] In case of a foreseeable single failure condition – e.g. broken wire or loosened coil windings- the requirements for basic insulation shall remain fulfilled by design.

[d] The requirements for micro-disconnection also include those for micro-interruption.

[e] At least basic insulation shall be given between terminals of opposite polarity (all possibilities):

- between uninsulated live parts and the relay housing with the contacts open and closed;

- between terminals of opposite polarity with the contacts closed;

- between uninsulated live parts of different circuits.

[f] Between terminals of relay coils, functional insulation applies. Not required for existing designs.

Table 18 – Minimum clearances in air for insulation coordination

Impulse withstand voltage [a]	**Minimum clearances up to 2 000 m above sea level** [c d]		
	Pollution degree [e]		
	1	2	3
kV	mm	mm	mm
0,33 [b]	0,01	0,2 [c]	0,8
0,40	0,02	0,2 [c]	0,8
0,50 [b]	0,04	0,2 [c]	0,8
0,60	0,06	0,2	0,8
0,80 [b]	0,10	0,2	0,8
1,0	0,15	0,2	0,8
1,2	0,25		0,8
1,5 [b]	0,5		0,8
2,0	1,0		
2,5 [b]	1,5		
3,0	2,0		
4,0 [b]	3,0		
5,0	4,0		
6,0 [b]	5,5		
8,0 [b]	8,0		
10	11		
12 [b]	14		

[a] This voltage is

- for basic insulation directly exposed to or significantly influenced by transient overvoltages from the low-voltage mains: the rated impulse voltage of the equipment;
- for other basic insulation: the highest impulse voltage that can occur in the circuit;
- for reinforced insulation, see notes a and b of Table 14.

In special cases (particularly for existing designs) intermediate values derived by interpolation may be used for the dimensioning of clearances.

[b] Preferred values for relating to the overvoltage category (see Annex G).

[c] For printed wiring material, the values for pollution degree 1 apply except that the value shall not be less than 0,04 mm, as specified in Table 20.

[d] As the dimensions in Table 18 are valid for altitudes up to and including 2 000 m above sea level, clearances for altitudes above 2 000 m are to be multiplied by the altitude correction factor specified in Table A.2 of IEC 60664-1:2007.

[e] Details regarding pollution degrees are specified in Annex H.

The relationship between the material group and the proof tracking index (PTI) is given in Table 19.

Table 19 – Material groups

Material group I	600 ≤ PTI
Material group II	400 ≤ PTI < 600
Material group IIIa	175 ≤ PTI < 400
Material group IIIb (for existing designs only)	100 ≤ PTI < 175

The PTI values are derived from the tracking test indicated in Annex I.

Table 20 – Minimum creepage distances for equipment subject to long-term stresses

Voltage r.m.s. [a] [e]	Creepage distances								
	Pollution degree [d]								
	Printed wiring material (PCB)		Other materials						
	1	2	1	2			3		
				Material group			Material group		
	[b]	[c]	[b]	I	II	IIIa	I	II	IIIa
V	mm	mm	mm	mm	mm	mm	mm	mm	mm
10	0,025	0,04	0,08	0,4			1		
12,5	0,025	0,04	0,09	0,42			1,05		
16	0,025	0,04	0,1	0,45			1,1		
20	0,025	0,04	0,11	0,48			1,2		
25	0,025	0,04	0,125	0,5			1,25		
32	0,025	0,04	0,14	0,53			1,3		
40	0,025	0,04	0,16	0,56	0,8	1,1	1,4	1,6	1,8
50	0,025	0,04	0,18	0,6	0,85	1,2	1,5	1,7	1,9
63	0,04	0,063	0,2	0,63	0,9	1,25	1,6	1,8	2
80	0,063	0,1	0,22	0,67	0,95	1,3	1,7	1,9	2,1
100	0,1	0,16	0,25	0,71	1	1,4	1,8	2	2,2
125	0,16	0,25	0,28	0,75	1,05	1,5	1,9	2,1	2,4
160	0,25	0,4	0,32	0,8	1,1	1,6	2	2,2	2,5
200	0,4	0,63	0,42	1	1,4	2	2,5	2,8	3,2
250	0,56	1	0,56	1,25	1,8	2,5	3,2	3,6	4
320	0,75	1,6	0,75	1,6	2,2	3,2	4	4,5	5
400	1	2	1	2	2,8	4	5	5,6	6,3
500	1,3	2,5	1,3	2,5	3,6	5	6,3	7,1	8
630	1,8	3,2	1,8	3,2	4,5	6,3	8	9	10
800	2,4	4	2,4	4	5,6	8	10	11	12,5
1 000	3,2	5	3,2	5	7,1	10	12,5	14	16
1 250			4,2	6,3	9	12,5	16	18	20
1 600			5,6	8	11	16	20	22	25

[a] This voltage is

- for basic and supplementary insulation of a circuit energized directly from the low-voltage mains: the rated voltage, or the rated insulation voltage;
- for basic and supplementary insulation of a circuit not energized directly from the low-voltage mains: the highest r.m.s. voltage which can occur in the equipment or internal circuit when supplied at rated voltage and under the most onerous combination of conditions of operation within equipment rating.

[b] Material groups I, II, IIIa, and IIIb (see Table 19).

[c] Material groups I, II, and IIIa (see Table 19).

[d] Details regarding pollution degrees are specified in Annex H.

[e] In special cases, intermediate values derived by interpolation may be used for the dimensioning of creepage distances.

The relationship between rated insulation voltage and supply system voltage is given in Table 21.

Table 21 – Rated insulation voltage according to supply system voltage

					Rated voltage of the supply system [a] V (AC r.m.s., or DC)										
	12,5	**24**	30	**42**	**60**	**100**	**150**	208	220	**277**	380	440	575	1 000	1 500 [b]
		25		**48**		110			**230**	300	**400**	**480**	600		
				50		**120**			**240**			500			
						125			**250**						
						127									
Rated insulation voltage V	**12,5**	**25**	**32**	**50**	**63**	**125**	**160**	**200**	**250**	**320**	**400**	**500**	**630**	**1 000**	**1 500**

[a] The rated voltage can be L-E (line to earth) or L-L (line to line).

[b] Only DC.

13.3 Solid insulation

Solid insulation shall be capable of durably withstanding electrical and mechanical stresses as well as thermal and environmental influences which may occur during the anticipated life of the relay.

The qualification of the solid insulation shall be verified by dielectric tests according to 10.2 immediately after the preconditioning of 10.1.

There is no dimensional requirement for the thickness of functional and basic insulation.

The basic insulation is always directly adjacent to the hazardous potential.

The distances through insulation for supplementary and reinforced insulation shall not be smaller than 1,0 mm.

NOTE The distance through insulation can however be reduced when the relevant IEC standard for specific equipment into which the relay is to be incorporated allows this.

The requirement indicated above does not mean that the specified distance through insulation has to be achieved only by solid insulation. The insulation may comprise solid material and one or more air gaps.

This requirement, however, is not applicable where the insulation consists of thin layers, except for mica and similar scaling material, and if

- for supplementary insulation, the insulation consists of at least two layers, provided that each of the layers withstands the dielectric strength test of 10.2 for supplementary insulation;
- for reinforced insulation, the insulation consists of at least three layers, provided that any two layers withstands the dielectric strength test of 10.2 for reinforced insulation.

13.4 Accessible surfaces

Relay surfaces intended to be touched (e.g. actuating members) shall meet the requirements for basic insulation.

NOTE Since only relays as components for incorporation into equipment are covered by this standard, it is assumed that only skilled or instructed persons have access to the relay. Such persons are aware that the relay surfaces shall not be touched without precautions against the hazards of electric shock. In particular, they use appropriate (insulated) tools to operate actuating members.

13.5 Solid insulation in the coil assembly as part of the insulation coordination

If the coil bobbin (or any other part of the coil assembly) provides at least basic insulation and its thickness is less than 0,33 mm, it shall be subjected to the tests described in a) to d). There shall be no breakdown of the coil assembly during these tests.

a) Three separate samples of the assembly of coil and frame shall be subjected to this test after constant temperatures have been reached as the result of operation under the conditions specified in 8.2 and 8.3. While heated from the normal temperature test, the coil terminals are to be connected to an alternating current source of twice the normal rated voltage at any frequency up to 400 Hz.
b) The required test voltage specified in a) is to be obtained by starting at one-quarter or less of the full rated value and increasing to twice full rated value in not more than 15 s. After being held for 7 200 electrical cycles or for 60 s, whichever is less, the voltage is to be reduced within 5 s to one-quarter or less of the maximum rated value and the circuit is to be opened.
c) While heated following operation at 110 % of its rated voltage, each of the three samples are to be subjected to the test described in a) and b), except that the test voltage is to be 130 % of the temperature test voltage.
d) If the temperature that a coil winding reaches in the tests described in a) and c) is known, an oven that can be set at the required temperature may be used to condition the sample to that temperature before conducting the test.

14 Terminations

14.1 General

An overview on termination types is given in Annex J.

14.2 Screw terminals and screwless terminals

Screw terminals and screwless terminals shall comply with the requirements and tests of IEC 60999-1. The test current shall be the rated current for the relay (not that of the terminal, which might be higher) as specified by the manufacturer.

14.3 Flat quick-connect terminations

Flat quick-connect terminations shall comply with the requirements and tests of IEC 61210 as regards dimension, temperature rise (see 8.4.3) and mechanical force. Deviating dimensions of a male tab are permitted provided the connection to a standard female connector ensures the insertion and withdrawal forces as specified in IEC 61210.

Male tabs shall have sufficient distance between one another to ensure the required clearances and creepage distances when non-isolated female connectors are mounted; in case these requirements can only be fulfilled with isolated female connectors, this shall be explicitly stated in the manufacturer's documentation.

14.4 Solder terminals

14.4.1 Resistance to soldering heat

Solder terminals and their supports shall have a sufficient resistance to soldering heat.

After the test of the resistance to soldering heat and subsequent cooling to room temperature, the relays shall comply with the requirements of Clause 9 (operate and release) at room temperature. The solder terminals shall not have worked loose nor have been displaced in a manner impairing their further use, and they shall still comply with the requirements (distances) of Clause 13.

14.4.2 Solder pins

The test is carried out according to test Tb of IEC 60068-2-20 as given in Table 22 for method 1A.

Terminals for mounting on printed circuit boards shall be fitted with a thermal screen (simulating a printed board) of (1,5 ± 0,1) mm thickness. During the test, immersion shall be effectuated only up to the lower surface of this screen.

Table 22 – Test conditions for test Tb

Subclauses of IEC 60068-2-20:2008	Conditions
5.1.2	No initial measurement
5.2.4	Method 1A: solder bath at 260 °C
5.2.4	Duration of immersion: (5 ± 1) s
5.3.3	Method 2: soldering iron at 350 °C
5.3.1	Soldering iron of size ‘B’
5.3.3	No cooling device
5.3.3	Duration of application of the soldering iron: (10 ± 1) s

14.4.3 Terminals for surface mounting (SMD)

This test shall be carried out according to the procedure of 7.2 of IEC 61760-1:2006 as stated by the manufacturer.

14.4.4 Other solder terminations (e.g. soldering lugs)

This test shall be carried out as indicated by the manufacturer in accordance with test Tb of IEC 60068-2-20 as given in Table 22.

14.5 Sockets

Sockets shall comply with the requirements and tests of IEC 61984.

However, the corrosion test of IEC 61984 is replaced by a dry heat steady state test in accordance with IEC 60068-2-2, Test Bb at 70 °C for 240 h.

NOTE 1 This ageing test is intended to ensure the mechanical and electrical properties of the combination of relay and socket.

For the measurement of the resistance across relay and socket terminations it is permissible to use a relay dummy (e.g. with short-circuited relay contacts).

The tests shall be made with the sockets specified by the manufacturer and stated in the documentation of the relay.

NOTE 2 Within the scope of this standard, the combination only of a relay and mating socket can be assessed.

14.6 Alternative termination types

Other termination types are permitted to the extent that they are not in conflict with this standard and comply with their relevant IEC standard (if any).

15 Sealing

The specified sealing of the relay case or the contact unit shall be verified.

The applicable sealing test as indicated below shall be conducted to show compliance with the specified relay technology category (see 5.10), following the applicable tests of Clause 14, dependent of the termination technology.

For RT III, the sealing test shall be made by immersion in a liquid at a temperature equal to the upper limit of the operating temperature range of the relay (with a tolerance of –0 K/+5 K), in accordance with test Qc, Method 2 of IEC 60068-2-17, unless otherwise prescribed by the manufacturer. Within this test procedure immersion times shorter than 10 min may be specified.

Any deviation from the standard test condition shall be documented together with Clause 7 requirements.

For RT IV and RT V relays, an appropriate test of IEC 60068-2-17 shall be selected by the manufacturer.

16 Heat and fire resistance

In order to verify that the requirements regarding resistance of solid insulating materials to heat and fire are met, the following tests shall be carried out by the relay manufacturer:

- Glow-wire test according to Annex K.
- Ball pressure test according to Annex L.

As an alternative, the relay manufacturer may provide test reports for the materials.

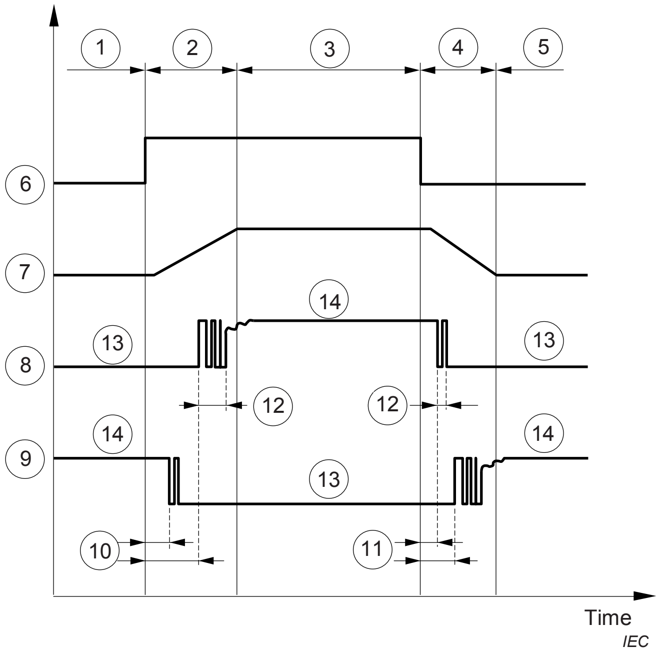
Sealing and potting materials are not considered unless their total external surface exceeds an area equivalent to the largest face of the relay.

For special applications (e.g. for relays used in telecom equipment) the needle flame test of Annex M may be carried out in place of the glow-wire test. This shall be stated by the manufacturer.

NOTE For some applications of relays (particularly for household appliances, information and office equipment) the needle flame test can be performed as an option.

Annex A
(normative)

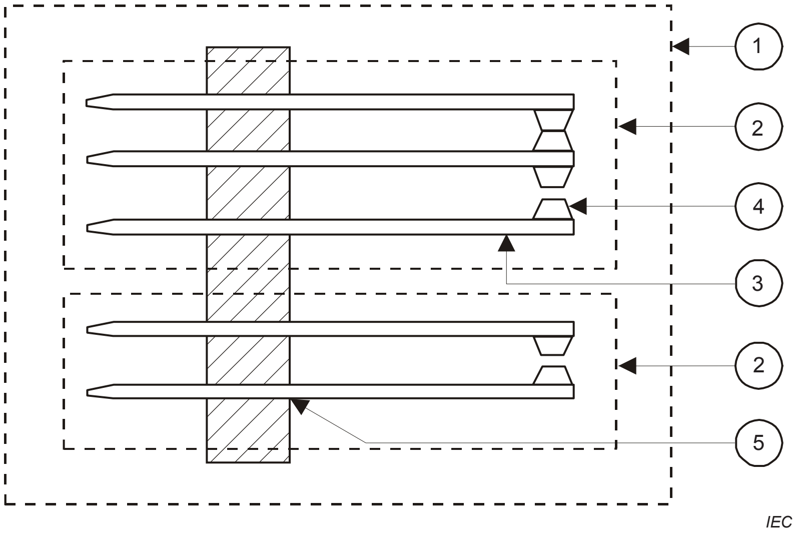
Explanations regarding relays



Key

1	release condition
2	operate
3	operate condition
4	release
5	release condition
6	coil voltage
7	change in position of movable parts
8	voltage at make contact
9	voltage at break contact
10	operate time
11	release time
12	bounce time
13	open
14	closed

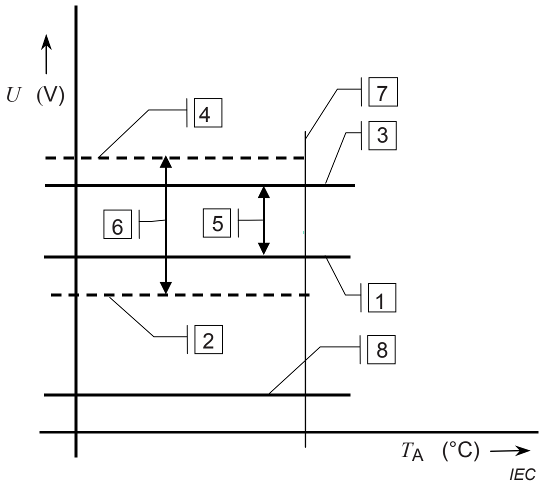
Figure A.1 – Diagram explaining terms related to monostable relays



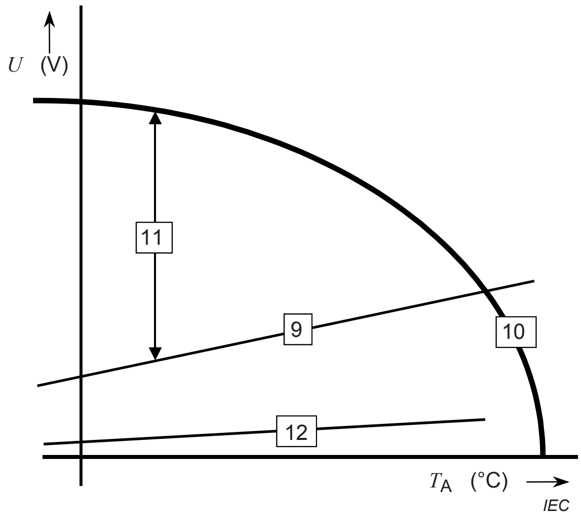
Key

1	contact set	2	contact	3	contact member
4	contact point	5	fixing		

Figure A.2 – Example explaining terms relating to contacts



a) Operative range according to 5.3.1



b) Operative range according to 5.3.2

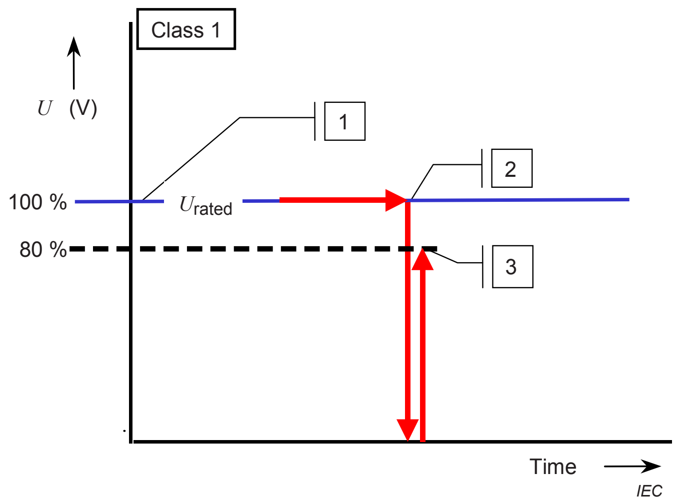
Key

U coil voltage

T_A ambient temperature

1	rated coil voltage, or lower limit of the rated coil voltage range	7	maximum permissible ambient temperature for the rated coil voltage or the rated coil voltage range
2	lower limit of the operative range of the coil voltage EXAMPLE 80 % of 1 (for class 1)	8	release voltage, ≥ 5 % (DC coil) / 15 % (AC coil) of 3
3	rated coil voltage, or upper limit of the rated coil voltage range	9	lower limit U_1 of the operative range of the coil voltage
4	upper limit of the operative range of the coil voltage EXAMPLE 110 % of 3 (for class 1)	10	upper limit U_2 of the operative range of the coil voltage (limiting voltage)
5	rated coil voltage range	11	operative range of the coil voltage
6	operative range of the coil voltage	12	release voltage, ≥ 10 % (DC coil) / 15 % (AC coil) of 9

Figure A.3 – Explanations regarding the operative range of the coil voltage



Key

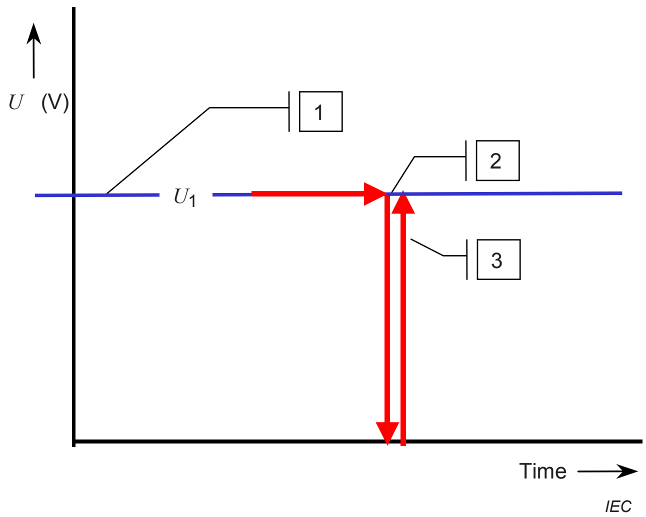
1 energization with rated coil voltage (or upper limit of rated coil voltage range) until thermal equilibrium is reached

2 removal of voltage

3 immediately after the removal of the coil voltage, energization with 80 % of the rated coil voltage (or lower limit of rated coil voltage range)

Requirement: the relay shall operate

Figure A.4 – Explanation regarding the preconditioning and testing of the operate voltage according to 5.3.1 (Class 1) and 9.2



Key

1 energization with the maximum value of the lower limit U_1 of the operative range of the coil voltage until thermal equilibrium is reached

2 removal of voltage

3 immediately after the removal of the coil voltage, re-energization with U_1

Requirement: the relay shall operate

Figure A.5 – Explanation regarding the preconditioning and testing of the operate voltage according to 5.3.2 and 9.2

Annex B
(informative)

Inductive contact loads

In this annex, provisions for the testing of relays with respect to making and breaking capacity and electrical endurance for inductive contact loads are specified. Other loads and tests may be specified by the manufacturer.

Unless otherwise specified the testing is carried out at ambient temperature.

Separate samples may be used for the different tests of Tables B.1 to B.3.

The sample lot shall be chosen in accordance with Table 5, test procedure B for Table B.1 and Table B.2 and for Table B.3 test procedure A only.

It is up to the discretion of the manufacturer to choose one or more of the tests described in Table B.1, Table B.2 and Table B.3, respectively. However, when the test according to Table B.1 is performed, also the test of Table B.2 applies.

The performed test(s) are to be indicated in the test report.

NOTE 1 In the following tables, a classification of loads is given, related to utilization categories (AC 15 and DC 13) defined in IEC 60947-5-1.

For the electrical endurance test, the duty factor shall be not more than 50 % but not less than 10 % and the 10 times making current shall not overheat the test device.

The test circuit shall be in accordance with Clause C.1. In addition a resistor shall be in parallel to the breaking load carrying 3 % (for AC and 1 % for DC) of the breaking current. The inductance shall be provided by air core reactors or alternatively with iron core reactors (with a maximum distortion factor of 5 % for AC). If the contact bouncing is less than 3 ms, it is permitted to carry out the electrical endurance only with the breaking load (without the higher inrush load).

NOTE 2 Provisions for measuring the contact bounce time can be found in IEC 61810-7.

Table B.1 – Verification of the making and breaking capacity (abnormal conditions)

Classifica-tion	**Making**			**Breaking**			**Number of cycles and frequency**		
	I/I_e	U/U_e	cos φ	I/I_e	U/U_e	cos φ	Number of cycles	Frequency in cycles per minute	Duration of energization s
AC inductive load (contactor coil, solenoid valve)	10	1,1	0,3	10	1,1	0,3	10	6	0,04
	Total number of cycles						10		
	I/I_e	U/U_e	$T_{0,95}$	I/I_e	U/U_e	$T_{0,95}$	Number of cycles	Frequency in cycles per minute	Duration of energization
DC inductive load (contactor coil, solenoid valve)	1,1	1,1	$6 \times P$ [a]	1,1	1,1	$6 \times P$ [a]	10	6	$T_{0,95}$
	Total number of cycles						10		

I_e	Rated operating current	I	Switching current
U_e	Rated operating voltage	U	Switching voltage
$P = U_e \times I_e$	Steady-state power in W	$T_{0,95}$	Time to reach 95 % of the steady-state current in ms

[a] The value "$6 \times P$" is derived from an empirical relation appropriate for most of the d.c. inductive loads up to P = 50 W, where $6 \times P$ = 300 ms. Loads with a rated power above 50 W comprise small loads in parallel. Therefore, 300 ms is an upper limit independent of the power value.

Table B.2 – Verification of the making and breaking capacity (normal conditions)

Classification	Making			Breaking			Number of cycles and frequency		
	I/I_e	U/U_e	cos φ	I/I_e	U/U_e	cos φ	Number of cycles	Frequency in cycles per minute	Duration of energization s
AC inductive load (contactor coil, solenoid valve)	10	[c]	0,3	1	[c]	0,3	50	6	0,05
	10	1	0,3	1	1	0,3	10	> 60 [b]	0,05
	10	1	0,3	1	1	0,3	990	60	0,05
	10	1	0,3	1	1	0,3	5 000	6	0,05
	Total number of cycles						6 050		
	I/I_e	U/U_e	$T_{0,95}$	I/I_e	U/U_e	$T_{0,95}$	Number of cycles	Frequency in cycles per minute	Duration of energization
DC inductive load (contactor coil, solenoid valve)	1	[c]	$6 \times P$ [a]	1	[c]	$6 \times P$ [a]	50	6	$T_{0,95}$
	1	1	$6 \times P$ [a]	1	1	$6 \times P$ [a]	10	> 60 [b]	$T_{0,95}$
	1	1	$6 \times P$ [a]	1	1	$6 \times P$ [a]	990	60	$T_{0,95}$
	1	1	$6 \times P$ [a]	1	1	$6 \times P$ [a]	5 000	6	$T_{0,95}$
	Total number of cycles						6 050		
I_e	Rated operating current						I	Switching current	
U_e	Rated operating voltage						U	Switching voltage	
$P = U_e \times I_e$	Steady-state power in W						$T_{0,95}$	Time to reach 95 % of the steady-state current in ms	

[a] The value "$6 \times P$" is derived from an empirical relation appropriate for most of the d.c. inductive loads up to P = 50 W, where $6 \times P$ = 300 ms. Loads with a rated power above 50 W comprise small loads in parallel. Therefore, 300 ms is an upper limit independent of the power value.

[b] With maximum permissible frequency (ensuring reliable making and breaking of the contacts).

[c] The test is carried out at a voltage of $U_e \times 1{,}1$, with the test current I_e adjusted at U_e.

Table B.3 – Electrical endurance test

Current	Classification	Making			Breaking		
AC	inductive load (contactor coil, solenoid valve)	I	U	cos φ	I	U	cos φ
		$10\ I_e$	U_e	0,7 [a]	I_e	U_e	0,4 [a]
DC [b]	inductive load (contactor coil, solenoid valve)	I	U	$T_{0,95}$	I	U	$T_{0,95}$
		I_e	U_e	$6 \times P$ [c]	I_e	U_e	$6 \times P$ [c]
I_e	Rated operating current			I	Switching current		
U_e	Rated operating voltage			U	Switching voltage		
$P = U_e \times I_e$	Steady-state power in W			$T_{0,95}$	Time to reach 95 % of the steady-state current in ms		

[a] The power factors indicated are conventional values and appear only in test circuits in which electrical characteristics of coils are simulated. Reference is made to the fact that for circuits with a power factor of 0,4 shunt resistors are used to simulate the damping effect due to eddy current losses.

[b] For d.c. inductive loads provided with a switching device to operate an economy resistor, the rated operating current shall be equal to at least the highest making current.

[c] The value "$6 \times P$" is derived from an empirical relation appropriate for most of the d.c. inductive loads up to P = 50 W, where $6 \times P$ = 300 ms. Loads with a rated power above 50 W comprise small loads in parallel. Therefore, 300 ms is an upper limit independent of the power value.

Table B.4 – Contact rating designations and equivalency to utilization categories

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

a 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.

b The rated operational current I_e (A), the rated operational voltage U_e (V) and the break apparent power B (V.A) are correlated by the formula B = $U_e \times I_e$.

Annex C
(normative)

Test set-up

C.1 Test circuit

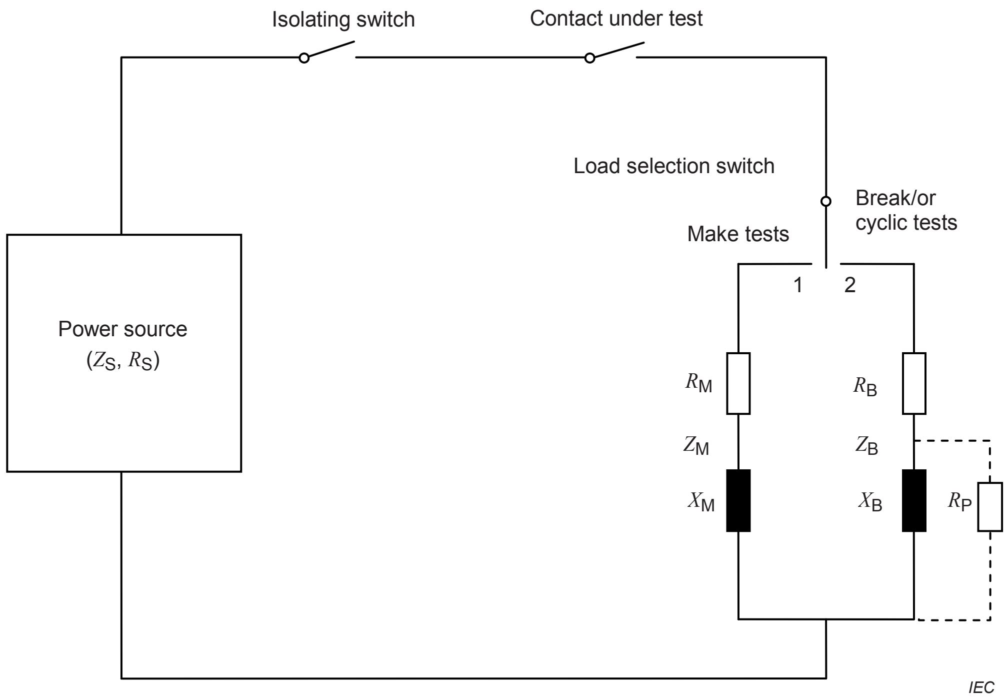
A generalized test circuit is given in Figure C.1 and a functional block diagram in Figure C.2.

The isolating switch, the load selection switch and the contact under test shall be sequenced appropriate to the test conditions specified.

The characteristics indicated in Tables C.1 and C.2 apply, unless otherwise specified.

The test conditions given in Clause 11 apply. All relevant details (e.g. number of cycles, frequency of operation, duration of energization) have to be specified by the manufacturer.

The declared value of the current shall be expressed in terms of the steady state (r.m.s. if a.c.) value of current in the contact circuit.



Contact categories 0 and 1	Contact category 2
$Z_s < 0{,}02\ Z_{M,B}$ (a.c.)	$Z_s < 0{,}05\ Z_{M,B}$ (a.c.)
$R_s < 0{,}02\ R_{M,B}$ (d.c.)	$R_s < 0{,}05\ R_{M,B}$ (d.c.)

For standard load values and tolerances for L/R and cos φ: see Table C.2.

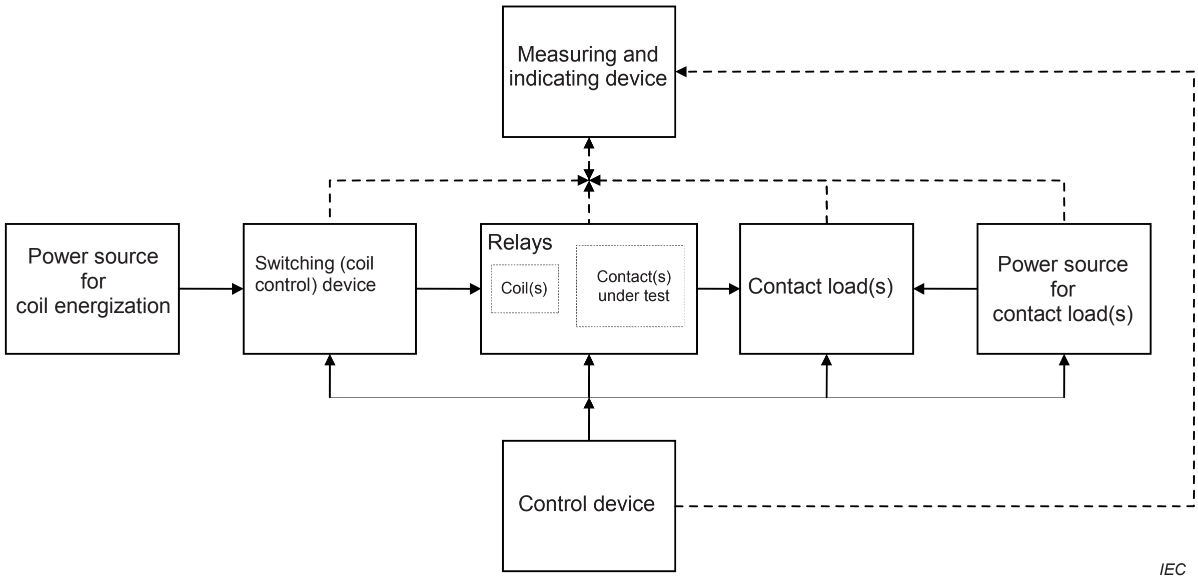
Load selection switch, position 1: Make test when different load (inrush current) is used.

Load selection switch, position 2: Make and break (or cyclic) tests with same load.

Isolating switch: Used to connect/disconnect the load circuit, independent of the contact under test.

Formula for R_P: $R_P = 33{,}3\times (1 / \cos \varphi - \cos \varphi)\times U / I_e$

Figure C.1 – Standard test circuit



NOTE The relays under test include any suppression and/or indicating device.

Figure C.2 – Functional block diagram

Table C.1 – Characteristics of power sources for contact loads

Characteristic	Standard values – Power supply	Contact load categories (see Clause C.4)	Tolerances	Notes
Voltage	Preferred and other specified values	CC 0 and CC 1	± 2 %	Voltage across the load including the closed contact
		CC 2	± 5 %	
Current	Preferred and other specified values	CC 0 and CC 1	± 5 %	
		CC 2	Minimum: rated test current	Transient currents as required for the test shall be properly provided
Frequency	Standard rated values	CC 0... CC 2	± 2 %	See Table 1
Waveform	Sinusoidal	CC 0... CC 2	Maximum distortion factor: 5 %	See Table 1
Alternating component in d.c. (ripple)	0	CC 0... CC 2	Maximum: 6 %	See Table 1
Direct component in a.c.	0	CC 0... CC 2	Maximum 2 % of peak value	See Table 1

Table C.2 – Standard contact load characteristics

Load characteristics	Standard values		Contact load categories (see Clause C.4)	Tolerances	Notes
	DC supply	AC supply			
CC 0 load (≤ 30 mV / ≤10 mA)	$L/R \leq 10^{-7}$ s	cos φ ≥ 0,95	CC 0… CC 2		L is the unavoidable inherent circuit inductance
Resistive load	$L/R \leq 10^{-7}$ s		CC 0 and CC 1		
	$L/R \leq 10^{-6}$ s		CC 2		
		cos φ ≥ 0,95	CC 0… CC 2		
Inductive load	L/R = 0,005 s		CC 0 and CC 1	± 15 %	
	L/R = 0,040 s		CC 2		
		cosφ = 0,4	CC 0… CC 2	± 0,1	
For inductive loads, values other than the standard values can be used if declared by the manufacturer. However, the tolerances should be as indicated in this table.					

C.2 Description and requirements

C.2.1 Power source for coil energization

The power source for the energization of the relay coil(s) comprises the power supply including provisions for stabilization within given voltage limits and given impedances including safety arrangements, for example, fuses.

The source shall deliver the rated values of the coil voltage with a tolerance of ± 5 % for steady-state conditions. The input voltage envelope shall be rectangular.

The source and, when necessary, its polarity shall be able to be controlled externally.

C.2.2 Switching (coil control) device

This is circuitry to effect the various switching actions required during a cycle of testing, including the connections to the relays under test and having the ability to change the polarity of the connections to bistable relays.

This device shall be capable of handling the rated values of the coil voltage without affecting the stated tolerances.

C.2.3 Power source for contact loads

The power source supplying the load circuit(s) comprises the power supply including provisions for stabilization within given voltage and impedance limits including safety arrangements, for example fuses.

The requirements for source impedance and resistance are given in Figure C.1. The tolerance of the power supply shall be in accordance with Table C.1.

C.2.4 Control device

This equipment generates the commands to run a specified test sequence controlling synchronization and the flow of orders (e.g. starts, measurements, stops).

C.2.5 Measuring and indicating device

This device facilitates detection of the making and breaking of the relay contacts over every cycle, compared with the waveform generated by the control device. Any failure to perform the intended function shall be indicated and recorded. This device shall not have any significant influence on the outcome of the test.

C.3 Test schematic

Test schematics shall be selected from those shown in Table 16, unless otherwise specified.

C.4 Contact load categories (CC)

For the purpose of selecting details for test circuits (see Tables C.1 and C.2), the manufacturer shall declare the appropriate contact load category(ies) for the contact under test.

Contact load category 0 (CC 0)

A load characterized by a maximum switching voltage of 30 mV and a maximum switching current of 10 mA.

Contact load category 1 (CC 1)

A low load without contact arcing.

NOTE Arcing with a duration of up to 1 ms is disregarded.

Contact load category 2 (CC 2)

A high load where contact arcing can occur (see Figure C.3).

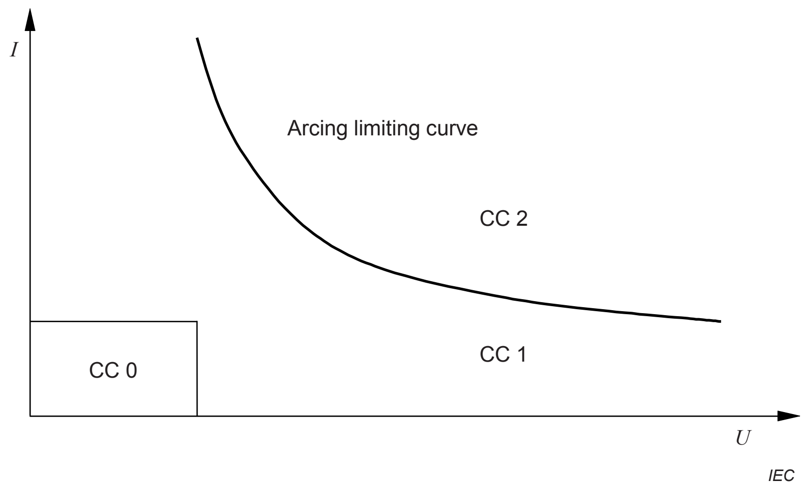


Figure C.3 – Contact load categories

C.5 Special loads

Recommended test circuits for special applications are given in Annex D.

Annex D
(informative)

Special loads

D.1 Dedicated device application tests and test sequences

For relays intended or dedicated device applications, the overload and endurance tests shall be conducted in accordance with the test parameters defined in Tables D.1, D.2 and D.5.

Table D.1 – Overload test values

Intended device application	Current A	Power factor
Across-the-line AC motor starting, single phase	6 times device full-load current [a]	0,40 – 0,50
Across-the-line DC motor starting	10 times device full-load current [b]	DC [c]
DC General use	1,5 times device rated value	DC [c]
AC General use	1,5 times device rated value	0,75 – 0,80
DC Resistance	1,5 times device rated value	DC [a]
AC Resistance	1,5 times device rated value	1,0
AC Resistance air heating	1,5 times device rated value	1,0
DC Resistance air heating	1,5 times device rated value	DC [c]
AC Incandescent lamps (Tungsten)	1,5 times device rated value	0,75 – 0,80
DC Incandescent lamps (Tungsten)	1,5 times device rated value	DC
AC Electrical discharge lamps (Ballast)	3,0 times device rated value	0,40 – 0,50

[a] See Table D.3 for AC full load currents.

[b] See Table D.4 for DC full load currents.

[c] Load is a noninductive resistive load.

Following the overload test, the endurance test shall be performed on the same samples (for change over contacts it is permitted to test both contact sides separately), under the same test conditions and at the rated switching current as stated by the manufacturer or in accordance with Table D.2.

The overload test shall consist of 50 cycles switching load conditions representing maximum interrupting values of voltage, current, and power. During the overload test, there shall be no electrical or mechanical breakdown of the equipment, no undue burning or pitting of the contacts and no welding of the contacts. The fuse specified below shall not open.

The sample shall be connected to the rated load using the same size conductors from the heating test, alternate single mounting path. The enclosure or wire mesh shall be connected through a 30 A, non-time delay fuse connected to the portion of the test circuit considered least likely to strike ground.

The cycle time shall be 1 s on and 9 s off. If it can be determined that for a duration less than one second, the device conducts the test current without interrupting the circuit or being adversely affected by heat and the device contacts are properly sealed before the break is initiated as confirmed by oscilloscopic or oscillographic measurements, the on time may be reduced to that duration. The closed test circuit voltage is to be 100 % to 110 % of the overload test voltage specified in Table D.1.

Table D.2 – Endurance test values

Intended device application	Test current A	Power factor	Number of cycles	Test cycle time	
				On	Off
Across-the-line AC motor starting	Twice full-load current [a]	0,40 – 0,50	1 000 [c]	1/2	1/2
Across-the-line DC motor starting	Twice full-load current [b]	DC [h]	1 000 [c]	1/2	1/2
DC General use	Rated current	DC [h]	6 000	1 [e]	9 [e]
AC General use	Rated current	0,75 – 0,80 [d]	6 000	1 [e]	9 [e]
DC Resistance	Rated current	DC [h]	6 000	1 [e]	9 [e]
AC Resistance	Rated current	1,0	6 000	1 [e]	9 [e]
DC Resistance air heating [i]	Rated current	DC [h]	100 000	1 [e]	9 [e]
AC Resistance air heating [i]	Rated current	1,0	100 000	1 [e]	9 [e]
AC Incandescent lamps (Tungsten)	Rated current	1,0	6 000 [g]	1 [f]	59 [f]
DC Incandescent lamps (Tungsten)	Rated current	DC	6 000 [g]	1 [f]	59 [f]
AC Electrical discharge lamps (Standard ballast)	Twice rated current	0,40 – 0,50	6 000	1	9
AC Electrical discharge lamps (Electronic ballast)	[i]	[i]	6 000	1	9

[a] See Table D.3 for AC full load currents.

[b] See Table D.4 for DC full load currents.

[c] These devices are to be subjected to at least 6 000 mechanical cycles at any convenient rate.

[d] If the device is marked "resistance only", the test may be conducted using a noninductive resistance load. This "resistance only" rating is different than a resistance heating rating or a resistance air heating rating.

[e] The cycle times are to be shown or as described in the overload test.

[f] A control may be operated faster than 1 cycle per minute if synthetic loads are used or if a sufficient number of banks of lamps controlled by a commutator are employed so that each bank will cool for at least 59 s between successive applications.

[g] For a magnetic relay intended to turn a television receiver on and off, the number of test cycles is to be 25 000, and the relay shall be marked "TV-X," where "TV" signifies the television and "X" is the steady-state current rating of the relay to be replaced by the actual ampere value (such as TV-5 or TV-3).

[h] Load is a noninductive resistive load.

[i] Devices rated 120 V AC and 277 V AC, intended to control electronic fluorescent ballast loads up to 16 A of steady state current shall be endurance tested using the load in accordance with the text. Alternately, they may be tested on the specific model electronic ballast(s) they are intended to control and marked as noted in this standard.

Table D.3 – Horsepower-rated equipment full-load currents (AC)

Horse power	110 V – 120 V	200 V	208 V	220 V – 240 V[a]	380 V – 415 V	440 V – 480 V	550 V – 600 V
1/10	3	–	–	1,5	1,0	–	–
1/8	3,8	–	–	1,9	1,2	–	–
1/6	4,4	2,5	2,4	2,2	1,4	–	–
1/4	5,8	3,3	3,2	2,9	1,8	–	–
1/3	7,2	4,1	4	3,6	2,3	–	–
1/2	9,8	5,6	5,4	4,9	3,2	2,5	2,0
3/4	13,8	7,9	7,6	6,9	4,5	3,5	2,8
1	16	9,2	8,8	8	5,1	4,0	3,2
1 1/2	20	11,5	11	10	–	–	–
2	24	13,8	13,2	12	–	–	–

[a] To obtain full-load currents for 265 V and 277 V motors, decrease corresponding 220 V – 240 V ratings by 13 % and 17 %, respectively.

Table D.4 – Horsepower-rated equipment currents (DC)

Horsepower	90 V	110 V – 120 V	180 V	220 V – 240 V	550 V – 600 V
1/10	–	2	–	1	–
1/8	–	2,2	–	1,1	–
1/6	–	2,4	–	1,2	–
1/4	4	3,1	2	1,6	–
1/3	5,2	4,1	2,6	2	–
1/2	6,8	5,4	3,4	2,7	–
3/4	9,6	7,6	4,8	3,8	1,6
1	12,2	9,5	6,1	4,7	2,0
1 1/2	–	13,2	8,3	6,6	–
2	–	17	10,8	8,5	–

Table D.5 – Overload and endurance test voltages

	Voltage rating of relay[a] V					
	110 – 120	220 – 240	254 – 277	380 – 415	440 – 480	560 – 600
Test voltage	120	240	277	415	480	600

[a] If the rating does not fall within any of the indicated voltage ranges, it is to be tested at its rated voltage.

To obtain the reactive power factor specified in Tables D.1 and D.2, the inductance shall be provided by air core reactors or alternatively with iron core reactors (with a maximum distortion factor of 5 % for AC). Reactors may be connected in parallel. No reactor is to be connected in parallel with a resistor.

Exception: An air-core reactor in any phase may be connected in parallel with a resistor (RSH) if the resistor power consumption is approximately 1 % of the total power consumption in that phase calculated in accordance with the following formula:

$$RSH = [100(1/PF - PF)]U/I_e$$

where

PF is the power factor;

U is the closed-circuit phase voltage; and

I_e is the phase current.

The closed test circuit voltage is to be 100 % to 110 % of the overload test voltage specified in Table D.5.

A device having two or more poles is to be tested with opposite polarity between two adjacent poles, unless the device is marked “same polarity” or equivalent.

During tests on multipole devices for use in opposite-polarity applications, all unused poles are to be connected electrically to the enclosure. Following the overload test, the endurance test shall be performed on the same samples (for change over contacts it is permitted to test both contact sides separately), under the same test conditions and at the rated switching current as stated by the manufacturer or in accordance with Table D.2.

During the endurance test, there shall be no electrical or mechanical breakdown of the device, welding, undue burning or pitting of the contacts. The fuse specified for the overload test shall not open. After the test, the device shall comply with the requirements of the dielectric strength test in Clause 10.

The conditions for the endurance test shall be the same as the conditions for the overload test except as described in this clause.

The equipment is to close and open a test circuit having the applicable current and power factor specified in Table D.2. The number of test cycles and the test cycle times are to be as specified in Table D.2.

The closed circuit test voltage is to be 100 % to 110 % of the endurance test voltage specified in Table D.5.

If tungsten-filament lamps are used as the load, the load is to be made up of the smallest possible number of 500 W lamps, or of larger lamps if agreeable to those concerned; except that one or two lamps smaller than the 500 W size may be used if necessary to make up the required load.

The circuit is to be such that the peak value of the inrush current will be reached in 1/240 of a second after the circuit is closed.

A synthetic load may be used in place of tungsten-filament lamps if it is equivalent to a tungsten-filament lamp load on the test circuit in question, and the inrush current is at least ten times the normal current.

A synthetic load used in place of tungsten-filament lamps may consist of noninductive resistors if they are connected and controlled so that a portion of the resistance is shunted during the closing of the switch under test. A synthetic load may also consist of a noninductive resistor or resistors that are connected in parallel with a capacitor.

A relay with a rated current (steady state current) and rated voltage in accordance with Tables D.6 or D.7 shall be tested as follows to determine if the relay is compatible with an electronic fluorescent ballast that operates within the parameters defined by Tables D.6 or D.7.

Exception – If testing is conducted using a specific electronic ballast, the ballast manufacturer's name and model number shall be identified in the enclosed instructions.

Table D.6 – Bulk energy capacitances

System (VAC)	Bulk energy capacitance: µF per Ampere of steady state current
120	175
277	125

The test circuit, as shown in Figure D.1, shall provide the inrush characteristics meeting or exceeding those characteristics defined in Table D.7 in parallel with an AC resistive load based on the steady state current rating of the relay.

The series coil values shall be adjusted based on the input line characteristics of the test laboratory to achieve the peak currents listed in Table D.7. The series coil shall be sized such that it does not saturate during testing and shall be able to handle the resulting power dissipation with less than 10 °C temperature rise. Peak current and pulse width are illustrated in Figure D.2.

The circuit shall provide a method to discharge the capacitor bank in between test cycles without influencing the performance of the device under test. This is accomplished by S2 and R2 in Figure D.1. S2 should be switched alternately with S1 and R2 should be sized to allow for complete discharge of C during the period that S1 is open.

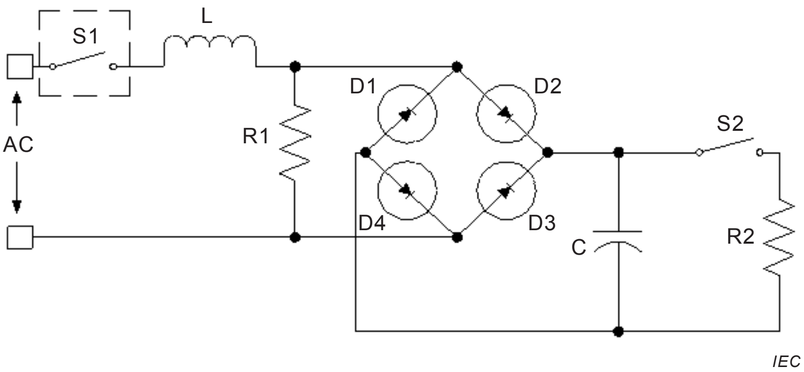
Relays rated 20 A for use on 20 A branch circuits shall be tested with a 16 A load representing 80 % of the branch circuit rating. Since all other devices can be installed on 20 A branch circuits, they shall be tested with full rated load.

Table D.7 – Peak current requirements

Steady state current (A)	Peak current (A), 120 VAC	Pulse width 120 VAC (ms) (See Note 2)	I^2t (A^2s) 120 VAC (See Note 1)	Peak current (A), 277 VAC	Pulse width 277 VAC (ms) (See Note 2)	I^2t(A^2s) 277 VAC (See Note 1)
0,5	75	0,34	11	77	0,07	11
1	107	0,48	24	131	0,71	27
2	144	0,70	41	205	0,85	76
3	166	0,89	51	258	0,98	111
5	192	1,20	74	320	1,20	205
8	221	1,25	98	370	1,25	274
10	230	1,50	106	430	1,50	370
12	235	1,80	110	440	1,80	387
15	239	2,00	114	458	2,00	420
16	242	2,10	117	480	2,10	461

NOTE 1 The values used to calculate I^2t are the peak current shown in Table D.7 and a pulse duration of 2 ms (t).

NOTE 2 Pulse widths shown in the Table D.7 will provide adequate performance with electronic ballasts having pulse widths up to 2 ms.



Reference	Description
AC	Test voltage is either 277 VAC or 120 VAC
S1	Device under test
L	Series inductor, its value of inductance (L) and resistance (R) are selected. When combined with the AC line source impedance it provides the specified reference waveforms
R1	AC synthetic load resistor, value to provide desired continuous current. (e.g., 5 A, 8 A, 16 A)
D1 to D4	Bridge rectifier
C	Capacitor load bank, design value to provide 125 µF for each continuous amp of load current at a test voltage of 277 VAC, and 175 µF for each continuous amp of load current at a test voltage of 120 VAC.
S2	Capacitor discharge switch
R2	Bleeder resistor, value to provide appropriate capacitor load bank discharge rate

Figure D.1 – Typical test circuit diagram

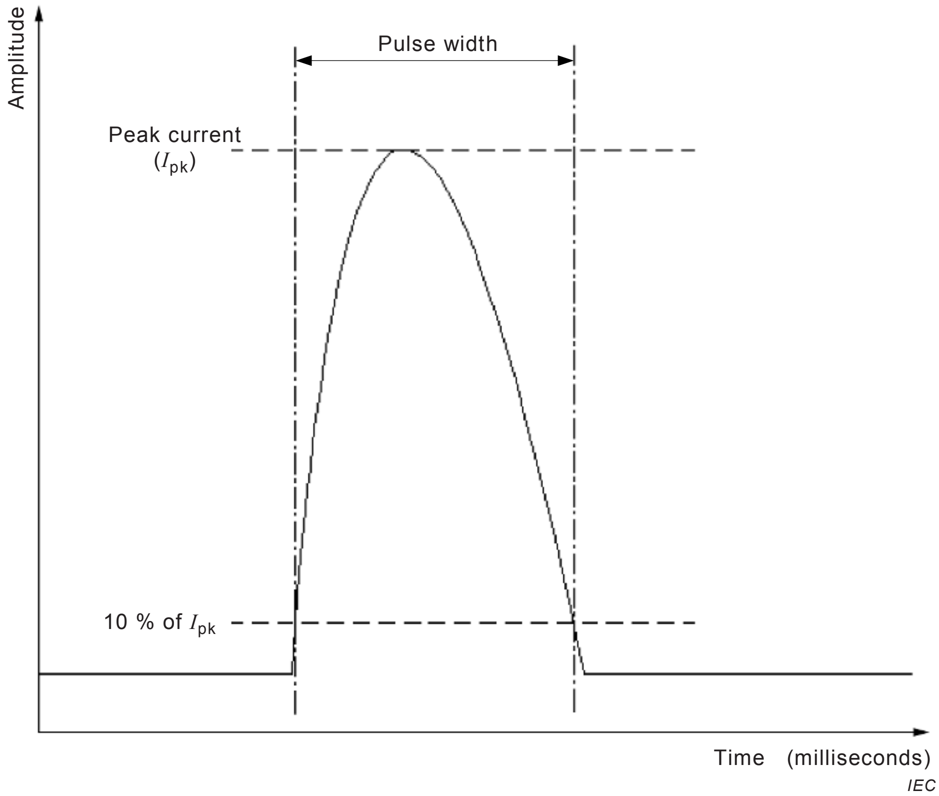


Figure D.2 – Waveform per synthetic measurement of pulse width and peak current

D.2 Special loads for telecom and signal relays

For relays intended to be used in telecom and signalling applications, a cable load test may be applicable when specified by the manufacturer.

The load circuit should be in accordance with Figure D.3.

Test details (in particular the cable characteristics) shall be as specified by the manufacturer.

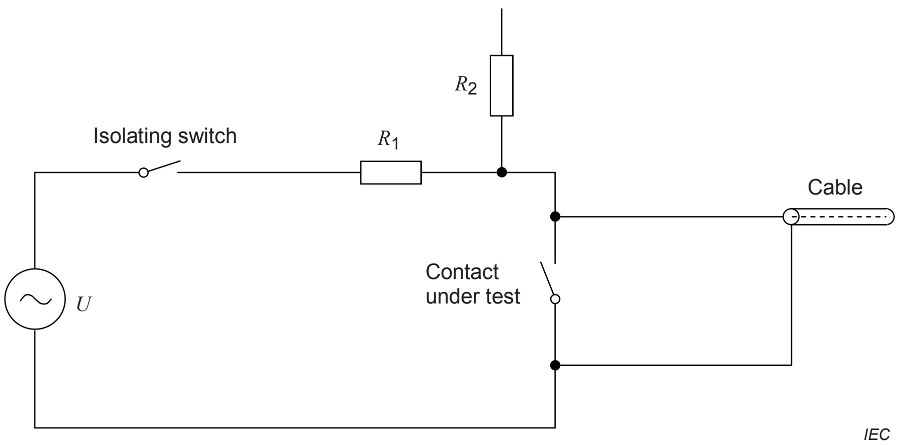


Figure D.3 – Circuit for cable load

D.3 Special loads with inrush current

For relays intended to be used in applications with inrush currents, a respective test may be applicable when specified by the manufacturer.

The load circuit should be in accordance with Figures D.4, D.6 or D.7 as appropriate, unless otherwise specified. However, the manufacturer is permitted to specify and declare a time constant other than 2,5 ms (standard value for tungsten filament lamps) for the cases described in Figures D.4 and D.6. The time periods for the open and closed contact should be no less than 4 times the time constant $C \times R_3$ and $C \times R_2$, respectively.

Special contact ratings for inrush current loads established by tests in accordance with Figures D.4 and D.6 are described in the following format:

Steady state current / Peak inrush current / Voltage / Time constant

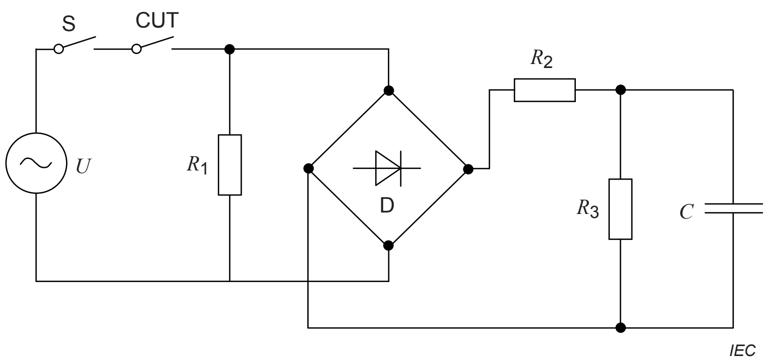
The steady state current represents the rated current for special inrush loads.

See Figure D.5 with an example for the testing of relays rated 10/100 A/250 V~/2,5 ms.

In case of contact ratings established in accordance with Figure D.7 for inrush current loads with power-factor correction the following is used:

Steady state current / Voltage / Current limiting resistance (R_2) / Capacitance (C_F)

The values of the current limiting resistance and the capacitance need to be indicated only when deviating from the values indicated in Figure D.7.

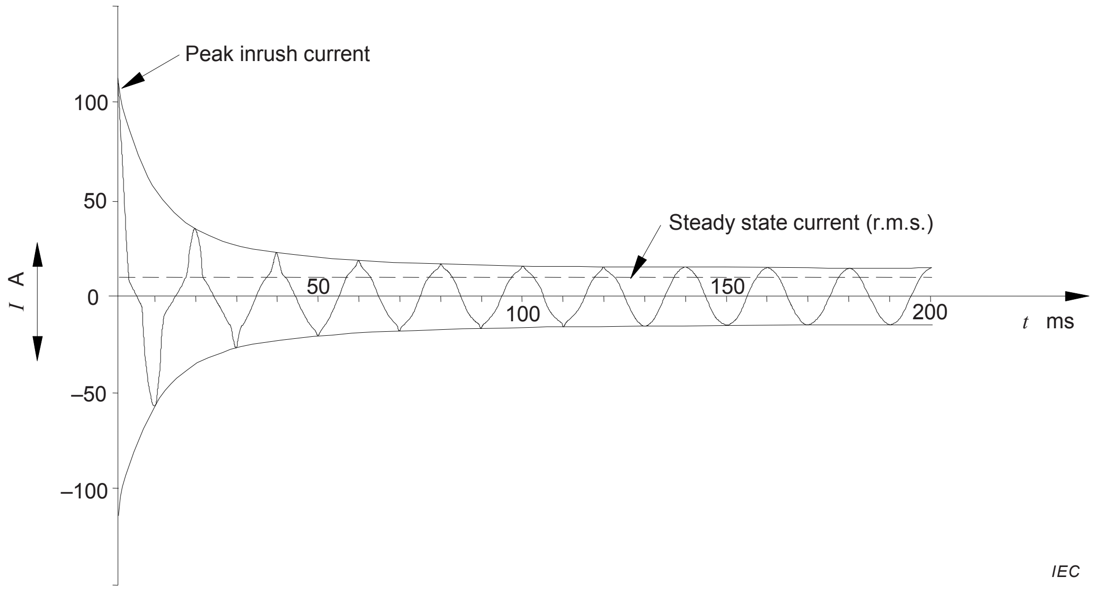


Components

$R_1 = U / I$	where U is the rated voltage and I is the steady state current of the load;
$R_2 = R_1 \times 1{,}414 / (X - 1)$	where X is the ratio between the peak inrush current and the steady state current;
$R_3 = (800/X) \times R_1$	
$C \times R_2 = 2\,500\ \mu s$	standard value for lamp load, other values are permitted
D	rectifier-bridge
S	isolating switch
CUT	contact under test

The circuit elements and the source impedance are chosen so as to ensure a 10 % accuracy of the peak inrush current, and the steady state current.

Figure D.4 – Test circuit for inrush current loads (e.g. capacitive loads and simulated tungsten filament lamp loads) – AC circuits



Values calculated from Figure D.4

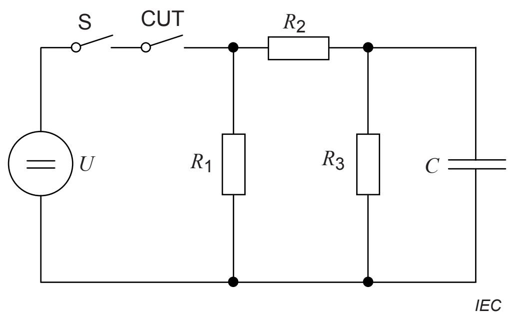
R_1 = 25 Ω

R_2 = 3,93 Ω

R_3 = 2 000 Ω

C = 636 μF

Figure D.5 – Example for a tungsten filament lamp test for relays rated 10/100 A/250 V~/2,5 ms

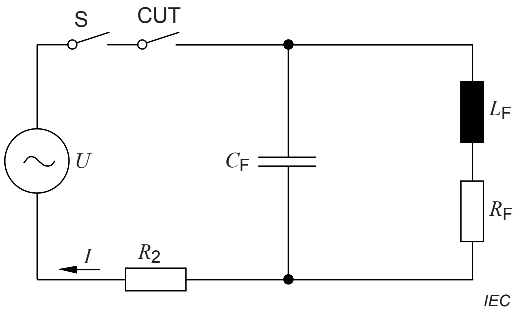


Components

$R_1 = U/I$	where U is the rated voltage and I is the steady state current;
$R_2 = R_1 / (X - 1)$	where X is the ratio between the peak inrush current and the steady state current;
$R_3 = (800/X) \times R_1$	
$C \times R_2$ = 2 500 μs	standard value for lamp load, other values are permitted
CUT	contact under test
S	isolating switch

The circuit elements and the source impedance are chosen so as to ensure a 10 % accuracy of the peak inrush current, and the steady state current.

Figure D.6 – Test circuit for inrush current loads (e.g. capacitive loads and simulated lamp loads) – DC circuits



Components

CUT contact under test
S isolating switch

C_F = 70 μF ± 10 % ($I \leq 6$ A), where I is the steady state current,
= 140 μF ± 10 % (6 A < $I \leq 20$ A), where I is the steady state current unless otherwise specified and declared by the manufacturer

L_F and R_F adjusted to have I = steady state current and 0,9 (lagging) power factor

R_2 (including wire resistance) = 0,25 Ω unless otherwise specified and declared by the manufacturer

The source impedance and the circuit elements are chosen so as to ensure

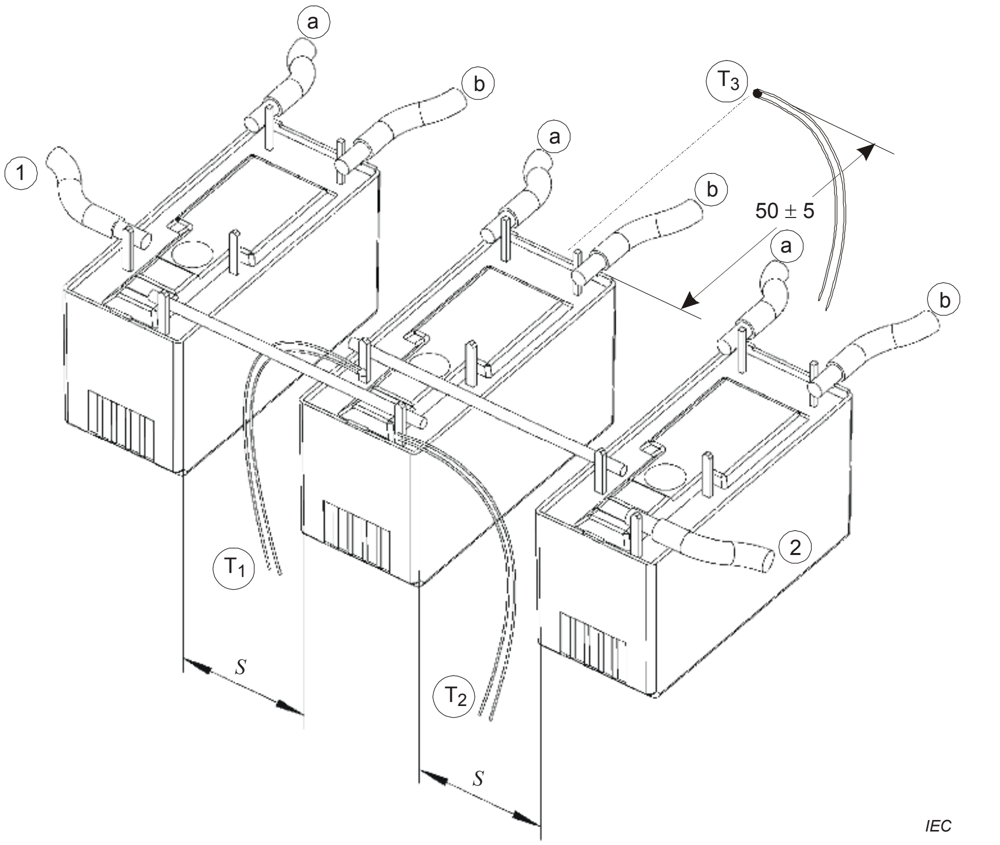
– a prospective short-circuit current of the supply of 3 kA to 4 kA;
– an accuracy of ± 5 % of the rated voltage U;
– an accuracy of the steady state current I of $^{-0}_{+5}$ %;
– an accuracy of the power factor of ± 0,05.

Figure D.7 – Test circuit for inrush current loads (e.g. simulated fluorescent lamp loads) with power-factor correction

Annex E
(normative)

Heating test arrangement

Dimensions in millimetres



Key

1, 2	contact terminals	a, b	coil terminals	*S*	mounting distance
T_i ,T_2	thermocouples	The test point for measuring the ambient temperature shall be in that horizontal plane defined by the axis of the centre relay. The distance from the coil side of the relay shall be (50 ± 5) mm.			

Figure E.1 – Test arrangement

The test shall be made as indicated in Figure E.1 with the terminals pointing downward and on an insulating plate. The connections between any adjacent relays shall be made with bare rigid conductors that are as short as possible.

In particular cases, the manufacturer may submit the relays mounted on pc board as in actual use. All relevant details of the test arrangement (e.g. material and thickness of the pc board, width and thickness of the conductors on the board, plating or coating (if applicable), length and cross-sectional area of external conductors) are to be indicated in the test report.

NOTE Soldering is carried out with adequate tools and care.

Annex F
(normative)

Measurement of clearances and creepage distances

The width X specified in Examples 1 to 11 apply to all examples as a function of the pollution degree as follows:

Pollution degree	Width X
1	≥0,25 mm
2	≥1,0 mm
3	≥1,5 mm

If the associated clearance is less than 3 mm, the minimum width X may be reduced to one-third of this clearance.

The methods of measuring creepage distances and clearances are indicated in the following Examples 1 to 11. These cases do not differentiate between gaps and grooves or between types of insulation.

The following assumptions are made:

– any recess is assumed to be bridged with an insulating link having a length equal to the specified width X and being placed in the most unfavourable position (see Example 3);

– where the distance across a groove is equal to or larger than the specified width X, the creepage distance is measured along the contours of the groove (see Example 2);

– creepage distances and clearances measured between parts which can assume different positions in relation to each other are measured when these parts are in their most unfavourable position.

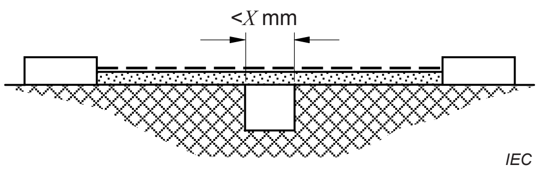


Figure F.1 – Example 1

Condition: Path under consideration includes a parallel- or converging-sided groove of any depth with a width less than "X" mm.

Rule: Creepage distance and clearance are measured directly across the groove as shown.

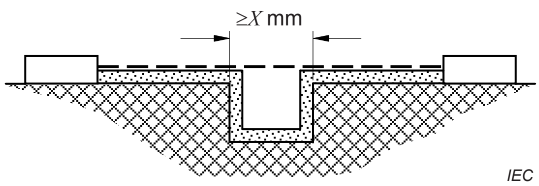


Figure F.2 – Example 2

Condition: Path under consideration includes a parallel-sided groove of any depth and with a width equal to or more than "X" mm.

Rule: Clearance is the "line-of-sight" distance. Creepage path follows the contour of the groove.

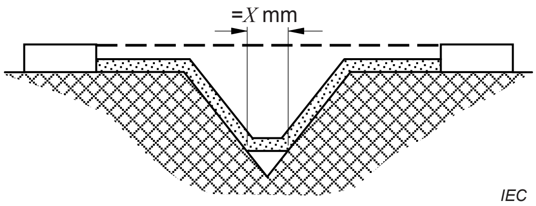


Figure F.3 – Example 3

Condition: Path under consideration includes a V-shaped groove with a width greater than "X" mm.

Rule: Clearance is the "line-of-sight" distance. Creepage path follows the contour of the groove but "short-circuits" the bottom of the groove by an "X" mm link.

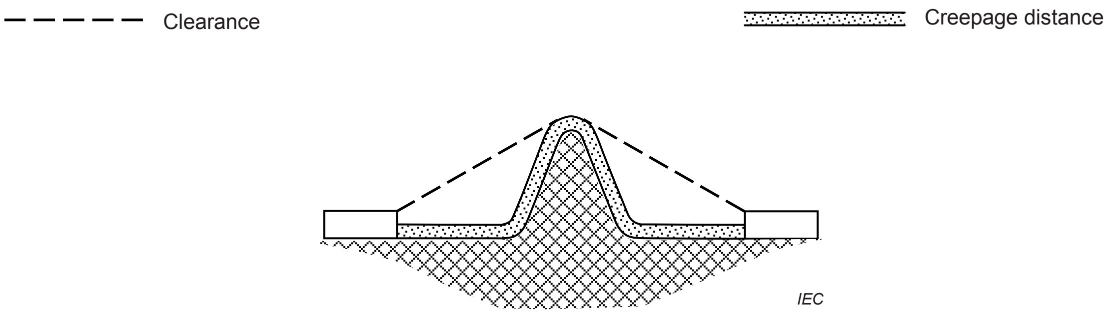


Figure F.4 – Example 4

Condition: Path under consideration includes a rib.

Rule: Clearance is the shortest direct air path over the top of the rib. Creepage path follows the contour of the rib.

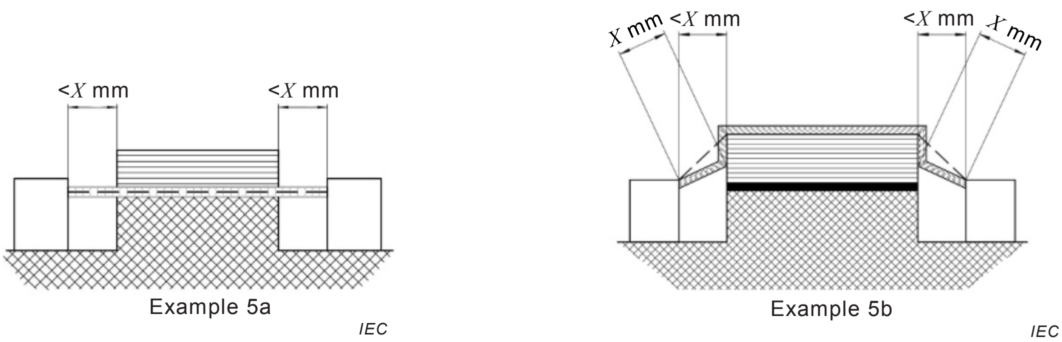


Figure F.5 – Example 5a and 5b

Condition: Path under consideration includes an uncemented/cemented (5a/5b) joint with grooves less than “X” mm wide on each side.

Rule Ex. 5a: Creepage and clearance path is the “line-of-sight” distance shown.

Rule Ex. 5b: Clearance is the shortest direct air path over the top of the joint. Creepage path follows the contour of the joint.

Clearance e.g. bonding Creepage distance

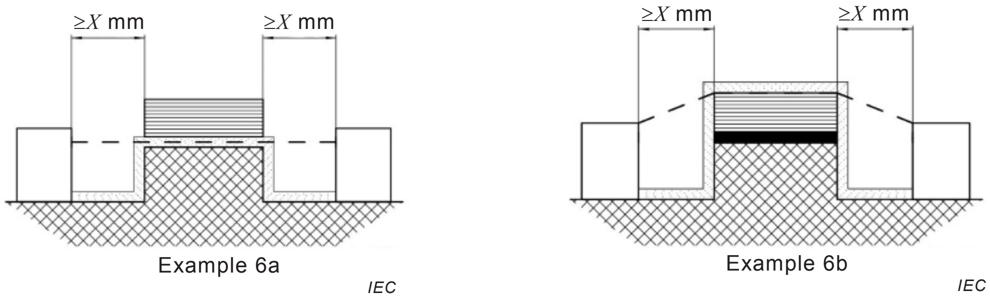


Figure F.6 – Example 6a and 6b

Condition: Path under consideration includes an uncemented/cemented (6a/6b) joint with grooves equal to or more than "*X*" mm wide on each side.

Rule Ex. 6a: Clearance is the "line-of-sight" distance. Creepage path follows the contour of the grooves.

Rule Ex. 6b: Clearance is the shortest direct air path over the top of the joint. Creepage path follows the contour of the grooves and the joint.

Clearance e.g. bonding Creepage distance

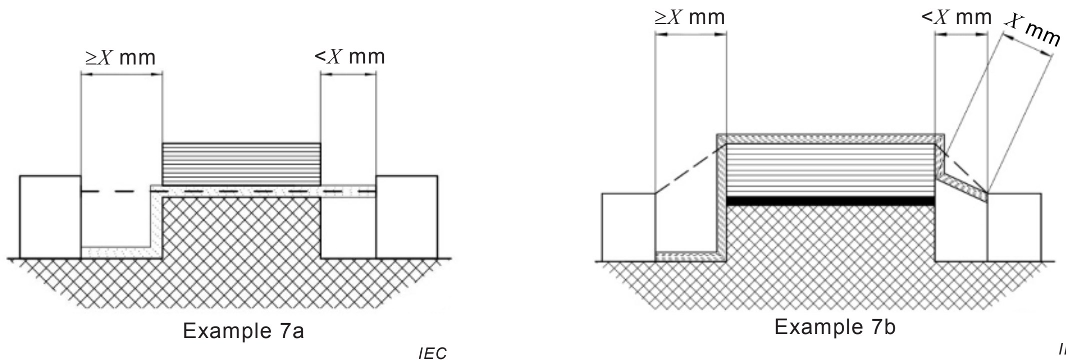


Figure F.7 – Example 7a and 7b

Condition: Path under consideration includes an uncemented/cemented (7a/7b) joint with a groove less than "*X*" mm wide on one side and a groove equal to or more than "*X*" mm width on the other side.

Rule: Clearance and creepage paths are as shown.

Condition: Path under consideration includes an uncemented joint with a groove on one side less than "*X*" mm wide and the groove on the other side equal to or more than "*X*" mm wide.

Rule: Clearance and creepage paths are as shown.

Clearance bonding Creepage distance

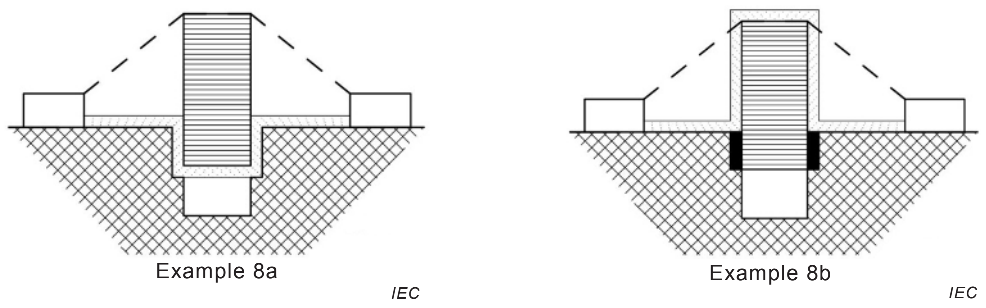


Figure F.8 – Example 8a and 8b

Condition: Path under consideration includes an uncemented/cemented barrier as shown.

Rule Ex. 8a: Clearance is the shortest direct air path over the top of the barrier. Creepage distance through an uncemented barrier is less than creepage distance over a barrier.

Rule Ex. 8b: Clearance is the shortest direct air path over the top of the barrier. Creepage distance follows the contour of the barrier.

- - - - Clearance | ▬ bonding | ▒ Creepage distance

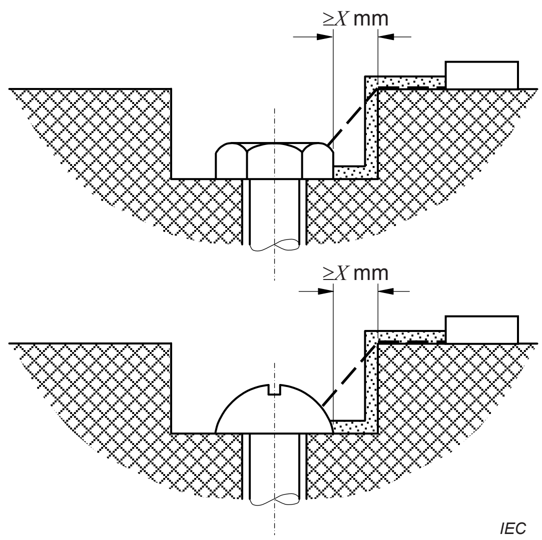


Figure F.9 – Example 9

Gap between head of screw and wall of recess wide enough to be taken into account.

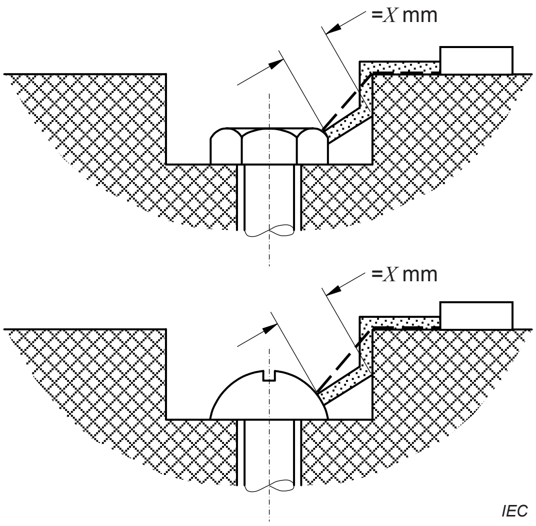


Figure F.10 – Example 10

Gap between head of screw and wall of recess too narrow to be taken into account.

Measurement of creepage distance is from screw to wall when the distance is equal to "X" mm.

– – – – – Clearance

Creepage distance

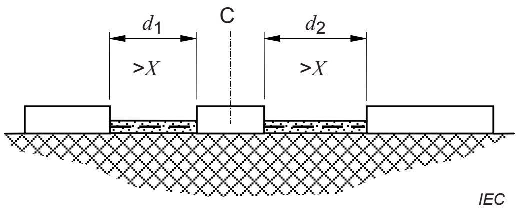


Figure F.11 – Example 11

Key

C floating part

Clearance is the distance $d_1 + d_2$

Creepage distance is also $d_1 + d_2$

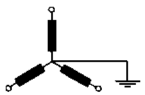
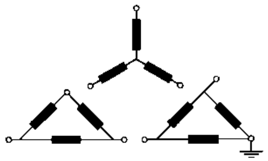
– – – – – Clearance

Creepage distance

Annex G
(normative)

Relation between rated impulse voltage, nominal voltage and overvoltage category

Table G.1 – Correspondence between the nominal voltage of the supply system and the equipment rated impulse withstand voltage, in case of overvoltage protection by surge-arresters according to IEC 60099-1

Maximum value of rated operational voltage to earth	Nominal voltage of the supply system[a] (≤ rated insulation voltage of the equipment)				Preferred values of rated impulse withstand voltage (1,2/50 μs) at 2 000 m kV			
					Overvoltage category			
					IV	III	II	I
a.c. r.m.s. or d.c. V	a.c. r.m.s. V	a.c. r.m.s. V	a.c. r.m.s. or d.c. V	a.c. r.m.s. or d.c. V	Origin of installation (service entrance) level	Distribution circuit level	Load (appliance, equipment) level	Specially protected level
50	–	–	12,5, 24, 25 30, 42, 48	60-30	1,5	0,8	0,5	0,33
100	66/115	66	60	–	2,5	1,5	0,8	0,5
150	120/208 127/220	115, 120 127	110, 120	220-110, 240-120	4	2,5	1,5	0,8
300	220/380, 230/400 240/415, 260/440 277/480	220, 230 240, 260 277	220	440-220	6	4	2,5	1,5
600	347/600, 380/660 400/690, 415/720 480/830	347, 380, 400 415, 440, 480 500, 577, 600	480	960-480	8	6	4	2,5
1 000	–	660, 690, 720 830, 1 000	1 000	–	12	8	6	4

[a] In accordance with IEC 60038.

Remark: The descriptions of overvoltage categories below are for information. The actual overvoltage category to be considered has to be taken from the product

standard defining the application of the relay.	
Overvoltage category I	Applies to equipment intended for connection to fixed installations of buildings, but where measures have been taken (either in the fixed installation or in the equipment) to limit transient overvoltages to the level indicated.
Overvoltage category II	Applies to equipment intended for connection to fixed installations of buildings.
Overvoltage category III	Applies to equipment in fixed installations, and for cases where a higher degree of availability of the equipment is expected.
Overvoltage category IV	Applies to equipment intended for use at or near the origin of the installation, from the main distributor towards the supply mains.

Annex H
(normative)

Pollution degrees

For the immediate external environment of the relay, the following three pollution degrees are defined for the assessment of the clearances and creepage distances:

Pollution degree 1: No pollution or only dry, non-conductive pollution occurs. The pollution has no influence.

Pollution degree 2: Only non-conductive pollution occurs except that occasionally a temporary conductivity caused by condensation is to be expected.

Pollution degree 3: Conductive pollution occurs or dry non-conductive pollution occurs which becomes conductive due to condensation which is to be expected.

The influence on the interior of the relay by the pollution in the immediate environment external to the relay is determined by the quality of encapsulation:

RT 0: The interior of the relay is influenced by the immediate environment of the relay.

RT I and RT II: The interior of the relay is partly influenced by the immediate environment of the relay.

RT III to RT V: The interior of the relay is not influenced by the immediate environment of the relay.

For the assessment of minimum clearances and creepage distances inside a relay, the values according to pollution degree 2 apply even when conductive pollution by ionized gases or metallic deposits can occur inside a relay.

However, for relays classified as RT 0 to RT II, an internal pollution degree of 3 shall be assumed where pollution degree 3 exists in the immediate environment external to the relay. The same applies to a relay vented to the atmosphere.

For RT IV and RT V relays specified for low loads where no arcing occurs (contact load categories CC 0 and CC 1, see Clause C.4), values according to pollution degree 1 apply.

NOTE The values for pollution degree 1 can however be applicable when the relevant IEC standard for specific equipment into which the relay is to be incorporated allows this.

Annex I
(normative)

Proof tracking test

The proof tracking test indicates the relative resistance of solid electrical insulating materials to tracking for voltages up to 600 V, when the surface is exposed to water with addition of contaminants under electric stress.

For the purposes of this standard, the following applies:

The proof tracking test is carried out in accordance with IEC 60112, using solution A.

Insulating material which can be exposed to tracking shall show a sufficient tracking resistance. Tracking is probable

- between active parts of different potentials;
- between active parts and earthed metal parts.

Compliance with the requirements shall be verified for a proof tracking index of PTI 175 V. However, for existing designs a proof tracking index of PTI 100 V is permitted.

If the application of the relay necessitates more stringent requirements, the tracking resistance shall be PTI 250 V, PTI 400 V, or PTI 600 V, see Table 19.

NOTE 1 PTI (proof tracking index) is the value of the proof voltage in V at which a material withstands 50 drops without tracking.

Any flat surface may be used, provided that the area is sufficient to ensure that no liquid flows over the edges of the specimen during the test. Flat surfaces of not less than 15 mm × 15 mm are recommended. The thickness of the specimen should be 3 mm or more and should be indicated in the test report.

NOTE 2 If the surface 15 mm × 15 mm cannot be obtained because of the small dimensions of the relay, special specimens made with the same manufacturing procedure can be used.

Annex J
(informative)

Schematic diagram of families of terminations

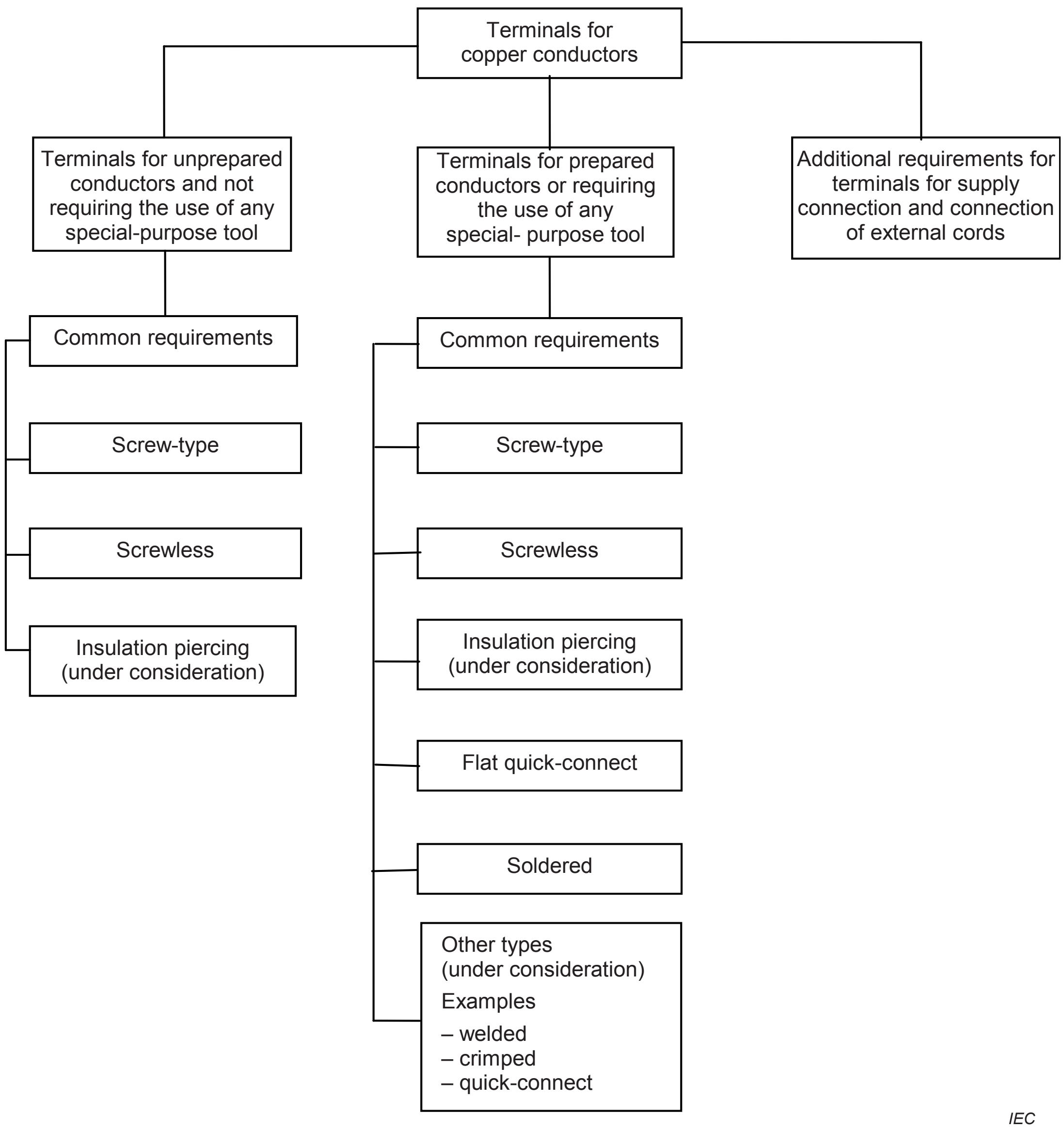


Figure J.1 – Schematic diagram of families of terminations

Annex K
(normative)

Glow-wire test

The glow-wire test is specified in IEC 60695-2-10, simulating the effect of thermal stress which can be produced by heat sources such as glowing parts and overloaded components, in order to assess the risk of fire.

The test described in that standard is applicable mainly to electrotechnical equipment, their subassemblies and components, but may also be used for solid insulating materials and other combustible materials.

The following applies for this standard:

Compliance with the requirements for heat and fire resistance is verified with the glow-wire test of IEC 60695-2-10.

The manufacturer shall specify one or more of the following test methods:

- IEC 60695-2-11 for complete relays (end-products);
- IEC 60695-2-12 for materials (GWFI – Glow-wire flammability index);
- IEC 60695-2-13 for materials (GWIT – Glow-wire ignition temperature).

The temperature of the glow-wire shall be 650 °C.

If the application of the relay necessitates more stringent requirements (e.g. household appliances, consumer electronics), the temperature of the glow-wire shall be either 750 °C or 850 °C for parts which are in contact with or support current-carrying parts or electrical connections, in particular when the deterioration of such parts could cause overheating.

When the relay is either too small (see definition of small parts in 3.1 of IEC 60695-2-11:2000) or of an inconvenient shape to carry out the test, the test is made using a specimen of the respective material from which the relay is manufactured. This specimen shall have a shape in accordance with IEC 60695-2-12 or IEC 60695-2-13, respectively. The manufacturer shall select the thickness of the specimen. It shall be indicated in the test report.

NOTE The preferred values for the thickness are 0,4 mm, 0,75 mm, 1,5 mm, 3 mm and 6,0 mm.

Annex L
(normative)

Ball pressure test

The purpose of the ball pressure test is to assess the ability of materials to withstand mechanical pressure at elevated temperatures without undue deformation.

The following applies for this standard (see also IEC 60695-10-2):

The test apparatus is shown in Figure L.1.

The parts to be tested are stored for 24 h in an atmosphere having a temperature between 15 °C and 35 °C and a relative humidity between 45 % and 75 %, before starting the test.

The test is made in a heating cabinet at a temperature of 20 °C ± 2 °C plus the value of the maximum temperature determined during the heating tests of Clause 8, or at

- 75 °C ± 2 °C for external parts,
- 125 °C ± 2 °C for parts that support active parts,

whichever is the higher.

The support and the test apparatus shall be at the prescribed test temperature before the test is started.

The surface of the part to be tested is placed in the horizontal position supported on a 3 mm thick steel plate. The thickness of the specimen shall be not less than 2,5 mm; if necessary, two or more layers of the part subjected to the test shall be used.

A steel ball of 5 mm diameter is pressed against the surface of the specimen by a force of 20 N ± 2 N. Care should be taken that the ball does not move during the test.

After 1 h, the ball is removed from the specimen which is then cooled down to approximately room temperature by immersion for 10 s in cold water.

The diameter of the impression caused by the ball is measured with an accuracy of 0,1 mm within 3 min after removal of the specimen from the water, and shall not exceed 2 mm. With the exception of the impression caused by the ball, there shall be no other deformations of the specimen in the surrounding area.

NOTE The test is not made on parts of ceramic material.

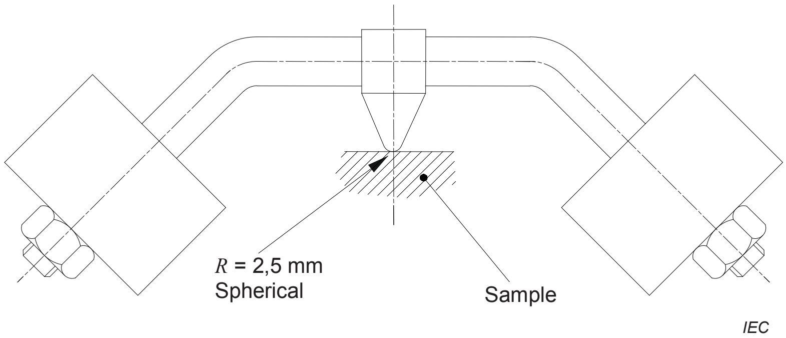


Figure L.1 – Ball pressure test apparatus

Annex M
(informative)

Needle flame test

The purpose of the needle flame test is to assess the fire hazard of electrotechnical equipment, its subassemblies and components, and of solid insulating materials and other combustible materials through simulation of the effect of small flames which may result from fault conditions within the equipment.

The needle flame test is carried out in accordance with IEC 60695-11-5.

For the purposes of this standard, the following applies:

The specimen is stored for 24 h in an atmosphere having a temperature between 15 °C and 35 °C and a relative humidity between 45 % and 75 % before starting the test.

The duration of application of the test flame on the specimen is (30 + 1) s. For relay volumes up to 1 000 mm^3 a reduction to (10 + 1) s may be chosen, however.

At the beginning of the test, the test flame shall be positioned so that at least the tip of the flame is in contact with the surface of the specimen. During the test, the burner shall not be moved. The test flame is removed immediately after the specified time.

The test is carried out on one specimen. If the specimen does not pass the test, it is repeated on two additional specimens, both of which shall pass the test.

The tissue paper shall not ignite, and the white pinewood board shall not show traces of burning; changes in colour of the white pinewood board are ignored.

Annex N
(informative)

Resistance for standard soldering processes

N.1 General

These tests should define reference profiles for the products. They may be used to show the product ability to withstand the heat influence during an industrial soldering process.

The double wave solder profile in Figure N.1 is suitable for all relays with solder terminals as standard profile. The THR (through hole reflow) process in Figure N.2 is only feasible for special reflow relay types.

N.2 Double wave soldering process

N.2.1 Profile

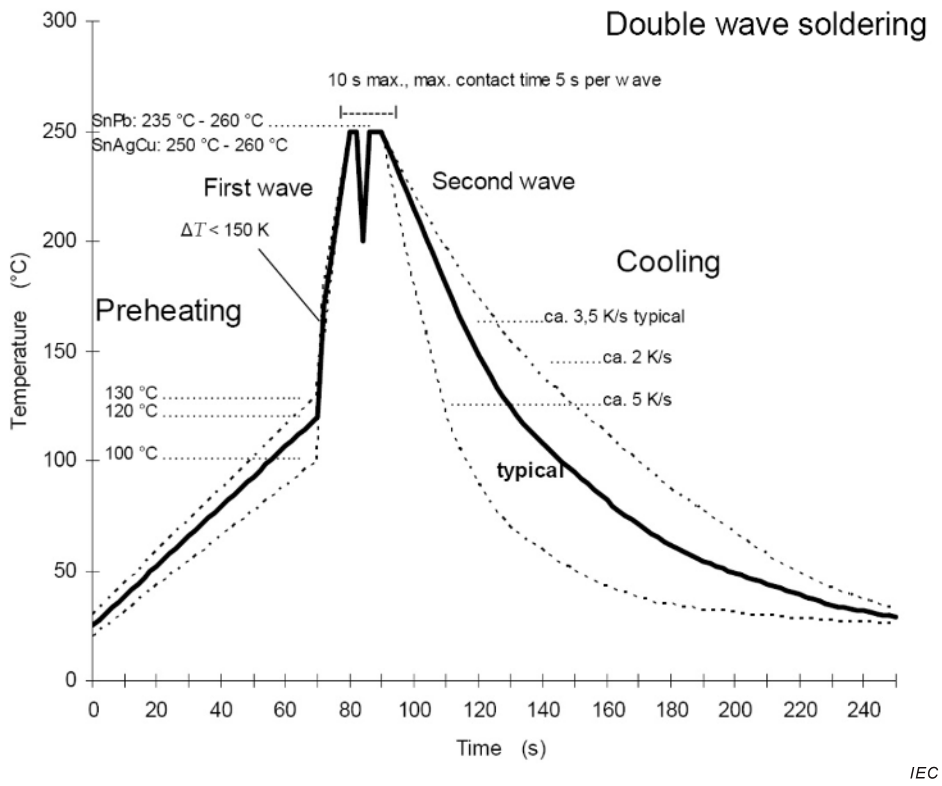


Figure N.1 – Double wave soldering profile

N.2.2 Conditions

In accordance with IEC 61760-1.

N.3 SMT and through hole reflow (THR) soldering process

N.3.1 Profile

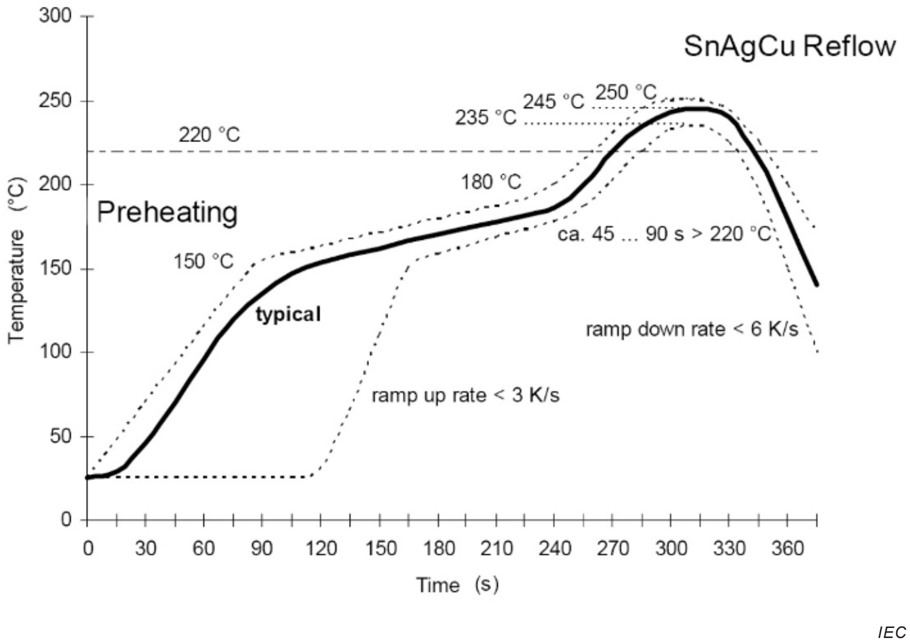


Figure N.2 – SMT and through hole soldering profile

N.3.2 Conditions

In accordance with IEC 61760-1.

N.4 Evaluation

- Visual inspection – absence of mechanical defects and correct housing.
- The mechanical and electrical parameters shall be within the relay specification after the solder process.
- Sealing test (QC2) for RT III types only.

Annex O
(informative)

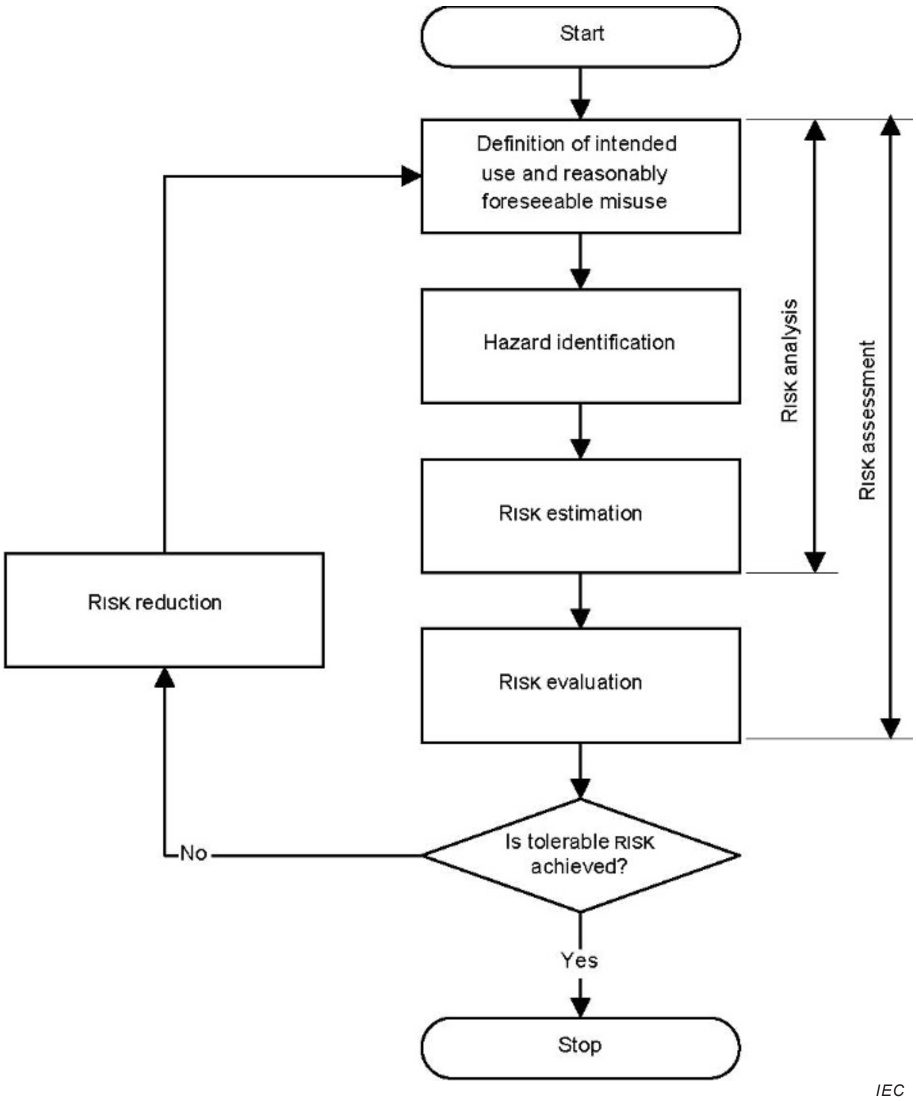
Risk assessment

O.1 General

A risk assessment process based on ISO/IEC Guide 51 (2014) is given below. Other risk assessment procedures are contained in ISO 14971, SEMI S10, IEC 61508 series, ISO 14121-1, and ANSI TR3. Other established procedures which implement similar steps can also be used.

O.2 Risk assessment procedure

Tolerable risk is achieved by the iterative process of risk assessment (risk analysis and risk evaluation) and risk reduction (see Figure O.1).



Is tolerable RISK achieved?

Figure O.1 – Iterative process of risk assessment and risk reduction

O.3 Achieving tolerable risk

The following procedure (see Figure O.1) should be used to reduce risks to a tolerable level:

a) identify the likely user group(s) for the product, process, or service (including those with special needs and the elderly), and any known contact group (e.g. use or contact by children);

b) identify the intended use and assess the reasonably foreseeable misuse of the product, process or service;

c) identify each hazard (including any hazardous situation and harmful event) arising in all stages and conditions for the use of the product, process or service, including installation, maintenance, repair, and destruction or disposal;

d) estimate and evaluate the risk (see Figure O.1) to each identified user/contact group arising from each hazard identified;

e) judge if the risk is tolerable (e.g. by comparison with similar products, processes or services);

f) if the risk is not tolerable, reduce the risk until it becomes tolerable.

When reducing risks the order of priority should be as follows:

1) eliminate or reduce risks as far as possible (inherently safe design and construction);

2) take the necessary protection measures in relation to risks that cannot be eliminated (protection devices);

3) inform users of the remaining risk after design due to any shortcomings of the protection measures adopted, indicate whether any particular training is required, and specify any need to provide personal protection equipment (information for safety).

This procedure is based on the assumption that the user has a role to play in the risk reduction procedure by complying with the information provided by the manufacturer (see Figure O.2).

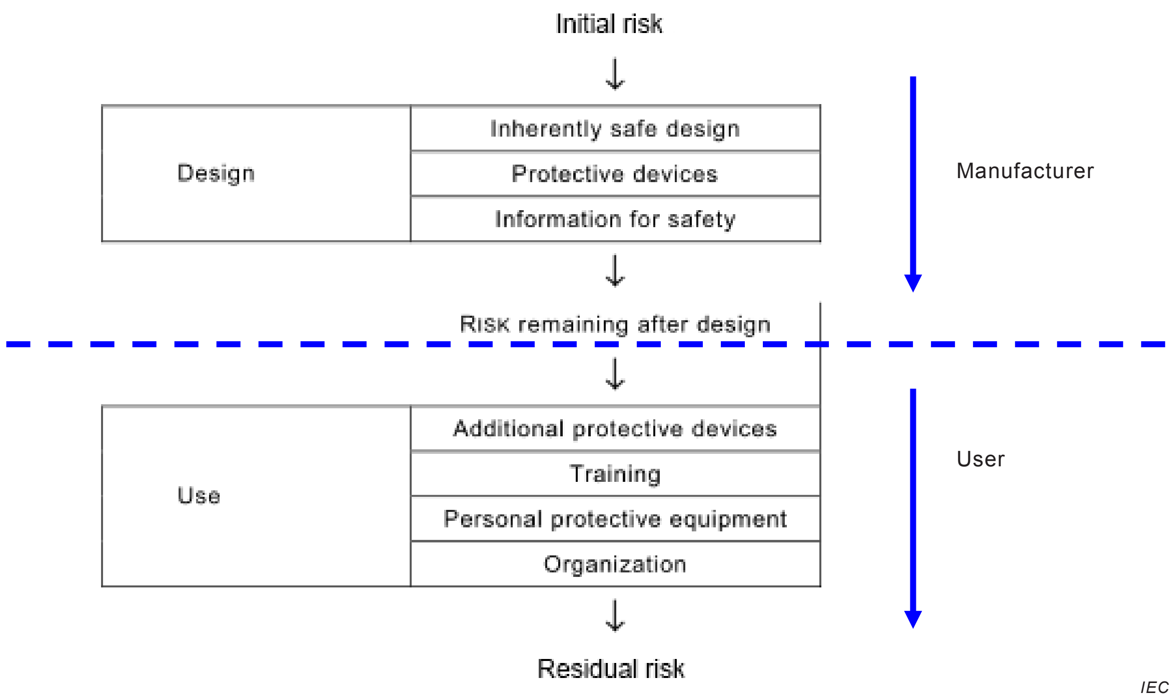


Figure O.2 – Risk reduction

The steps taken in the design procedure are shown in order of priority. The steps to be taken by the user are not in order of priority because this would depend on the application. It is emphasized that the additional protection devices, personal protection equipment and provision of information to users should not be used as substitutes for design improvements.

This steps / procedure has to be done for each component as well for all components together (=device). The responsibility is clearly defined that for the component the responsibility has to by taken by the manufacturer. The responsibility for the assembled / complete device is on side of the user (OEM or manufacturer/developer of the device).

For the relay as component, the considered hazards are given as examples in Table O.1. However, the user has to consider which failure modes are risky and take these or all within his risk consideration.

Table O.1 – Examples for the relation between failure mode, consequences and hazard

Failure mode		Consequences	Hazard
Failure to break		Welded contact ➔ Load stays uncontrolled energized with typically low relay contact resistance	Load stays energized.
		Hocked contact, maybe opened after a while ➔ Load stays uncontrolled energized with unknown contact resistance	Worst case: Uncontrolled heating (overheating), ignition with flame if the power supply is not interrupted.
Failure to make		Contact are not closed	None
		Contact are closed with no sufficient contact resistance	Worst case: Uncontrolled heating (overheating), ignition with flame if the power supply is not interrupted.
Failure of supplementary insulation		Basic insulation shall remain	None, if this is a single failure event.
Failure of reinforced Insulation (Basic insulation shall remain)		Basic insulation shall remain	None, if this is a single failure event.
Failure of functional insulation	Coil	Part of the coil is short circuit ➔ relay will not work proper	Worst case: Uncontrolled heating (overheating), ignition with flame if the power supply is not interrupted.
	Open contact	There is still a leakage current there.	Worst case: Uncontrolled heating (overheating), ignition with flame if the power supply is not interrupted.
Coil interruption		Relay will not work	None
Contact bridging		Depending on the circuit ➔ not sufficient contact up to short circuit of the power supply.	Worst case: Uncontrolled heating (overheating), ignition with flame if the power supply is not interrupted.
Failure of basic insulation		There is no insulation or not sufficient level of insulation available	Worst case: Electrical shock

O.4 An application of risk assessment procedures (proposal for the user)

For hazards in the scope of this standard, examples of severity of harm are given in Table O.2. Probability of harm is given in Table O.3. The risk category, which is selected based on severity and probability, is given in Table O.4.

Table O.2 – Severity of harm

Severity group	People	Equipment / Facility	
Catastrophic	One or more fatalities	Facility loss	
Severe	Disabling injury/illness	Major system loss or facility damage	
Moderate	Medical treatment or restricted work activity	Minor subsystem loss or facility damage	
Minor	First aid only	Non-serious equipment or facility damage	

Table O.3 – Probability of harm

Probability of harm							
Typical occurrence of failure modes (to be assessed by product and application)		Rate of occurrence				
		Frequent	Possible	Rare	Unlikely	
Failure modes	Failure to break	X	X	X	X	
	Failure to make	X	X	X	X	
	Failure of supplementary insulation		X	X	X	
	Failure of reinforced insulation (basic insulation shall remain)		X	X	X	
	Failure of functional insulation		X	X	X	
	Coil interruption			X	X	
	Contact bridging			X	X	
	Failure of basic insulation				X	

Table O.4 – Risk category

risk assessment / risk category						
Severity of harm		Probability of harm				
		Frequent	Possible	Rare	Unlikely	
Severity	Catastrophic	3	3	2	2	
	Severe	3	2	2	1	
	Moderate	3	1	1	1	
	Minor	2	1	1	1	

Key	Category	Description
1	Broadly acceptable	This fulfils the requirement for tolerable risk.
2	As low as reasonably practicable	This does not automatically fulfil the requirement for tolerable risk. If possible, these risks should be reduced further to Category 1. If not possible, then the instructions should contain a description of the risk so that the responsible body can take appropriate steps to protect the safety of operators.
3	Intolerable	This contains risks that are not tolerable risk.

Alphabetical list of terms

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[3] Withdrawn.

[4] Withdrawn.

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