

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Low-voltage switchgear and controlgear –
Part 6-2: Multiple function equipment – Control and protective switching devices
(or equipment) (CPS)**

**Appareillage à basse tension –
Partie 6-2: Matériels à fonctions multiples – Appareils (ou matériel) de connexion
de commande de protection (ACP)**



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CONTENTS

FOREWORD	7
1 Scope	10
2 Normative references	10
3 Terms and definitions	11
3.1 General	11
3.2 Terms and definitions related to the equipment	12
3.3 Terms and definitions concerning characteristic quantities	13
3.4 Terms and definitions concerning safety aspects	14
4 Classification	15
5 Characteristics	15
5.1 Summary of characteristics	15
5.2 Type of equipment	15
5.2.1 Number of poles	15
5.2.2 Kind of current (alternating current or direct current)	15
5.2.3 Method of operation	15
5.2.4 Method of control	16
5.2.5 Method of resetting after overload	16
5.2.6 Method of rearming after short-circuit	16
5.3 Rated and limiting values of the main circuit	16
5.3.1 Rated voltages	16
5.3.2 Currents and powers	16
5.3.3 Rated frequency	16
5.3.4 Rated duties	16
5.3.5 Normal load and overload characteristics – Rated making and breaking capacities	17
5.3.6 Short circuit characteristics – Rated service short-circuit breaking capacity (I_{CS})	17
5.3.7 Pole impedance of a CPS (Z)	17
5.4 Utilization categories	17
5.4.1 General	17
5.4.2 Assignment of utilization categories based on the results of tests	18
5.4.3 Application of utilization categories for motor control duty	19
5.5 Control circuits	19
5.6 Auxiliary circuits	20
5.7 Relays or releases	20
5.7.1 Summary of characteristics	20
5.7.2 Types of relays or releases	20
5.7.3 Characteristic values	21
5.7.4 Designation and current setting of overload relays or releases	21
5.7.5 Time-current characteristics of over current relays or releases	21
5.7.6 Influence of ambient air temperature	22
6 Product information	22
6.1 Nature of information	22
6.1.1 Identification	22
6.1.2 Characteristics	22
6.2 Marking	23
6.3 Instructions for installation, operation and maintenance	24

6.4	Environmental information	24
7	Normal service, mounting and transport conditions	24
8	Constructional and performance requirements	25
8.1	Constructional requirements	25
8.1.1	General	25
8.1.2	Materials	25
8.1.3	Current-carrying parts and their connections	26
8.1.4	Clearances and creepage distances	26
8.1.5	Actuator	26
8.1.6	Indication of the contact position	27
8.1.7	Additional requirements for equipment suitable for isolation	27
8.1.8	Terminals	27
8.1.9	Additional requirements for equipment provided with a neutral pole	27
8.1.10	Provisions for protective earthing	27
8.1.11	Enclosures for equipment	27
8.1.12	Degrees of protection of enclosed equipment	28
8.1.13	Conduit pull-out, torque and bending with metallic conduits	28
8.1.14	Limited energy source	28
8.1.15	Stored charge energy circuit	30
8.1.16	Fault and abnormal conditions	30
8.1.17	Short-circuit and overload protection of ports	31
8.2	Performance requirements	31
8.2.1	Operating conditions	31
8.2.2	Temperature-rise	37
8.2.3	Dielectric properties	39
8.2.4	Performance under no load, normal load and overload conditions	39
8.2.5	Ability to make, carry and break short-circuit currents	45
8.2.6	Pole impedance	46
8.2.7	Leakage currents of equipment suitable for isolation	46
8.2.8	Coil power consumption	46
8.2.9	Co-ordination between a CPS and another short-circuit protective device	46
8.3	Electromagnetic compatibility (EMC)	46
8.3.1	General	46
8.3.2	Immunity	47
8.3.3	Emission	47
9	Tests	48
9.1	Kind of tests	48
9.1.1	General	48
9.1.2	Type test	48
9.1.3	Routine tests	48
9.1.4	Sampling tests	48
9.1.5	Special tests	48
9.2	Compliance with constructional requirements	49
9.2.1	General	49
9.2.2	Electrical performance of screwless-type clamping units	49
9.2.3	Ageing test for screwless-type clamping units	50
9.2.4	Limited energy source test	50
9.2.5	Breakdown of components	50

9.3	Compliance with performance requirements	51
9.3.1	Test sequences	51
9.3.2	General test conditions	52
9.3.3	Performance under no load, normal load and overload conditions.....	52
9.3.4	Performance under short-circuit conditions	61
9.4	EMC tests	63
9.4.1	General	63
9.4.2	Immunity.....	64
9.4.3	Emission.....	69
9.5	Test sequences	70
9.5.1	General	70
9.5.2	Test sequence I: temperature-rise, operating limits, dielectric properties	71
9.5.3	Test sequence II: performance under normal load and overload conditions	75
9.5.4	Test sequence III: operational performance before and after operating sequences at conventional prospective current I_{Cr} and conventional prospective current "r" test	76
9.5.5	Test sequence IV: operational performance before and after operating sequences at I_{CS}	77
9.5.6	Test sequence V: additional breaking capacity	78
9.5.7	Test sequence VI: additional test sequence for four-pole CPS's.....	78
9.5.8	Test sequence VII: additional test sequence for CPS's intended for use in an individual enclosure	79
9.5.9	Test sequence VIII: EMC	79
9.6	Routine tests.....	79
9.6.1	General	79
9.6.2	Operation and operating limits	80
9.6.3	Dielectric tests	80
Annex A (normative)	Special tests	81
A.1	General.....	81
A.2	Mechanical durability	81
A.2.1	General	81
A.2.2	Verification of mechanical durability.....	81
A.3	Electrical durability	83
Annex B (xxx)	Vacant	84
Annex C (normative)	Marking and identification of CPS terminals	85
C.1	General.....	85
C.2	Marking and identification of terminals of main circuits.....	85
C.2.1	General	85
C.2.2	Marking and identification of terminals of auxiliary circuits	85
Annex D (informative)	Items subject to agreement between manufacturer and user	86
Annex E (xxx)	Vacant	87
Annex F (normative)	Requirements for auxiliary contact linked with power contact (mirror contact)	88
F.1	Application and object.....	88
F.1.1	Application.....	88
F.1.2	Object.....	88
F.2	Terms and definitions.....	88
F.3	Characteristics	88

F.4	Product information.....	88
F.5	Normal service, mounting and transport conditions	89
F.6	Constructional and performance requirements	89
F.7	Tests	89
F.7.1	General	89
F.7.2	Tests on products in a new condition	89
F.7.3	Test after conventional operational performance (defined under Table 10)	90
Annex G (normative)	Test sequence for CPS's for IT systems	91
G.1	General.....	91
G.2	Individual pole short circuit	91
G.3	Verification of dielectric withstand	92
G.4	Verification of overload releases	92
G.5	Marking.....	92
Annex H (xxx)	Vacant	93
Annex I (informative)	Glossary of symbols and graphical representation of characteristics	94
Annex J (xxx)	Vacant	95
Annex K (normative)	Procedure to determine data for electromechanical CPS used in functional safety applications	96
K.1	General.....	96
K.2	Test requirements	96
K.3	Characterization of a failure mode	96
K.4	Failure ratios of a CPS.....	96
Annex L (xxx)	Vacant.....	98
Annex M (informative)	Load monitoring indicators	99
M.1	General.....	99
M.2	Indicators list	99
M.3	Uncertainty	101
M.4	Tests	102
M.4.1	Routine tests	102
M.4.2	Type tests.....	102
Annex N (normative)	Additional requirements and tests for equipment with protective separation.....	104
N.1	General.....	104
N.2	Terms and definitions.....	104
N.3	Requirements	104
N.3.1	Test method for implementing protective impedance.....	104
N.3.2	Touch current measurement	105
Bibliography		107
Figure 1	Multiple of current setting limits for ambient air temperature time-delay overload relays or releases (see 8.2.1.5.1)	34
Figure 2	Thermal memory test	36
Figure 3	Voltage drop measurement at contact point of the clamping terminal	50
Figure 4	Example of a pole impedance measurement for a three-pole CPS.....	59
Figure 5	Representation of test current produced by back-to-back thyristors.....	67
Figure 6	Test current for the verification of the influence of the current dips and interruptions.....	68

Figure F.1 – Mirror contact.....	89
Figure M.1 – Example of quantification of a process change	101
Figure N.1 – Protection by means of protective impedance	105
Figure N.2 – Measuring instrument	106
Table 1 – Utilization categories	18
Table 20 – Limits for limited energy sources without an over-current protective device	29
Table 21 – Limits for limited energy sources with an over-current protective device	29
Table 22 – Limits for limited energy source with current limiting impedance	30
Table 2 – Limits of operation of inverse time-delay overload relays or releases when energized on all poles	33
Table 3 – Trip classes of overload relays or releases for utilization categories AC-2, AC-3, AC-3e, AC-4, DC-3, DC-5	34
Table 4 – Limits of operation of three-pole inverse time-delay overload relays or releases when energized on two poles only	35
Table 5 – Temperature-rise limits of terminals	37
Table 6 – Temperature-rise limits for insulated coils in air.....	38
Table 7 – Intermittent duty test cycle data.....	38
Table 8 – Rated making and breaking capacities – Making and breaking conditions corresponding to the utilization categories	40
Table 9 – Relationship between current broken I_C and OFF-time for the verification of rated making and breaking capacities	41
Table 10 – Conventional operational performance after making/breaking capacity tests – Making and breaking conditions according to utilization category	43
Table 11 – Operational performance before and after short-circuit tests at I_{Cr} and I_{Cs} – Making and breaking conditions according to utilization category	44
Table 12 – Value of the prospective test current according to the rated operational current	45
Table 13 – Value of the prospective test current according to the rated operational current (harmonized table).....	46
Table 14 – Performance criteria when EM disturbances are present	47
Table 15 – EMC immunity tests.....	64
Table 16 – Test parameters for harmonics and interruptions	68
Table 17 – Terminal disturbance voltage limits for conducted radio-frequency emission (for mains ports)	69
Table 18 – Radiated emission test limits	70
Table 19 – Test sequences	70
Table F.1 – Test voltage according to altitude.....	90
Table G.1 – Individual pole	91
Table K.1 – Failure mode of CPS.....	96
Table K.2 – Typical failure ratios for CPS.....	97
Table M.1 – AC monitoring indicators list.....	100
Table M.2 – Different possibilities authorized for verification of indicators	102
Table M.3 – Reference for verification conditions	103
Table M.4 – Harmonic levels.....	103

INTERNATIONAL ELECTROTECHNICAL COMMISSION

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

**Part 6-2: Multiple function equipment –
Control and protective switching devices (or equipment) (CPS)**

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International Standard IEC 60947-6-2 has been prepared by subcommittee 121A: Low-voltage switchgear and controlgear, of IEC technical committee 121: Switchgear and controlgear and their assemblies for low-voltage.

This third edition cancels and replaces the second edition published in 2002 and its Amendment 1:2007. This edition constitutes a technical revision.

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

- editorial changes according to ISO/IEC directives Part 2,
- alignments with IEC 60947-1:2020:
 - markings ("s", "sol", "r" or "f");
 - constructional requirements including material requirements;
 - requirements for screwless terminals;

- measurement method of the pole impedance;
- EMC requirement and testing;
- procedure to determine data for electromechanical CPS's used in functional safety applications;
- harmonisation with IEC 60947-2:2016:
 - operation tests of under-voltage relays and shunt releases;
 - CPS for IT systems (Annex G);
 - coordination with other short-circuit protective devices;
- alignments with IEC 60947-4-1:2018:
 - test at the rated conditional short-circuit current I_q of protected switching devices;
 - short-circuit tests harmonisation with North America;
 - reliability data for functional safety applications (new Annex K);
 - safety aspects related to electronic circuits and protective impedance (new Annex N);
 - introduction of provisions covering the impact of higher locked rotor current to achieve high efficiency class;
 - mention of dedicated wiring accessories;
 - definitions and measurement method of the power consumption of the control circuit during holding and pick-up operations;
 - load monitoring indicators (new Annex M).

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

FDIS	Report on voting
121A/384/FDIS	121A/392/RVD

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

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

A list of all the parts in the IEC 60947 series, under the general title *Low-voltage switchgear and controlgear*, can be found on the IEC website.

This document shall be read in conjunction with IEC 60947-1, *Low voltage switchgear and controlgear – Part 1: General rules*.

The provisions of the general rules are applicable to this part of IEC 60947-6, where specifically called for. General rules clauses and subclauses thus applicable as well as tables, figures and annexes are identified by reference to IEC 60947-1, for example, 1.2.3, Table 4, or Annex A of IEC 60947-1:2020.

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

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LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 6-2: Multiple function equipment – Control and protective switching devices (or equipment) (CPS)

1 Scope

This document applies to control and protective switching devices (or equipment) (CPS), the main contacts of which are intended to be connected to circuits of rated voltage not exceeding 1 000 V AC or 1 500 V DC.

It covers control and protective switching device (CPS):

- which provides protective and control functions for circuits and motors;
- where its control function is operated exclusively otherwise than by hand;
- which provides continuity of service after over-current conditions; and
- which can have additional functions, such as isolation or communication.

This document does not apply to:

- auxiliary contacts, covered by IEC 60947-5-1;
- CPS used downstream to frequency drive¹;

NOTE Additional requirements for CPS used downstream to frequency drive are under consideration for the next maintenance cycle.

- the use of the product with additional measure within explosive atmospheres, covered by IEC 60079 (all parts);
- embedded software design rules, covered by IEC TR 63201;
- cyber security aspects, covered by IEC TS 63208.

The object of this document is to state:

- the characteristics of CPS's;
- the conditions with which CPS's are complying with reference to their operation and behaviour, their dielectric properties, the degree of protection provided by their enclosure where applicable, its construction including safety measures against electric shock, fire hazard and mechanical hazard;
- the tests intended to verify that these conditions have been met, and the methods to be adopted for these tests;
- the information to be marked on or given with the CPS's.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

¹ For this subject, the manufacturer is responsible to take additional safety measures.

IEC 60034-1:2017, *Rotating electrical machines – Part 1: Rating and performance*

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

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

IEC 60617, *Graphical symbols for diagrams* (available at <http://std.iec.ch/iec60617>)

IEC 60715:2017, *Dimensions of low-voltage switchgear and controlgear – Standardized mounting on rails for mechanical support of switchgear, controlgear and accessories*

IEC 60730-1, *Automatic electrical controls – Part 1: General requirements*

IEC 60947-1:2020, *Low-voltage switchgear and controlgear – Part 1: General rules*

IEC 60947-2:2016, *Low-voltage switchgear and controlgear – Part 2: Circuit-breakers*
IEC 60947-2:2016/AMD1:2019

IEC 60947-5-1:2016, *Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices*

IEC 61000-6-2, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity standard for industrial environments*

IEC 61051-2, *Varistors for use in electronic equipment – Part 2: Sectional specification for surge suppression varistors*

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

CISPR 11:2015/AMD1:2016

CISPR 11:2015/AMD2:2019

CISPR 32, *Electromagnetic compatibility of multimedia equipment – Emission requirements*

ISO 3864-2, *Graphical symbols – Safety colours and safety signs – Part 2: Design principles for product safety labels*

3 Terms and definitions

3.1 General

For the purposes of this document, the terms and definitions of Clause 3 of IEC 60947-1:2020, as well as the following terms, definitions, symbol and abbreviations apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.2 Terms and definitions related to the equipment

3.2.1

control and protective switching device

CPS

mechanical switching device with a control function operated otherwise than by hand capable of:

- making, carrying and breaking currents under normal conditions;
- making, carrying for a specified time in overload condition;
- breaking currents under specified abnormal operating condition such as those of short-circuits;
- continuity of service,

with or without local manual operating means

Note 1 to entry The term "with a control function operated otherwise than by hand" means that the device is intended to be controlled and kept in working position from one or more external controls.

Note 2 to entry: A CPS can consist of a single device but is always rated as a unit. Coordination can be either inherent or obtained by correct selection of releases in accordance with the manufacturer's instructions.

3.2.2

direct-on-line CPS

CPS which connects the line voltage across the motor terminals in one step

3.2.3

reversing CPS

CPS for starting a motor, intended to cause a motor to reverse the direction of rotation by reversing the motor primary connections when the motor is not running

Note 1 to entry An application where reversing the motor primary connections while the motor is running is called plugging.

3.2.4

electronically controlled electromagnet

electromagnet in which the coil is controlled by a circuit with active electronic elements

[SOURCE IEC 60947-4-1:2018, 3.3.8]

3.2.5

dedicated wiring accessory

prefabricated connection wiring system specifically intended for identified switchgear or controlgear

Note 1 to entry A dedicated wiring accessory can be integrated in the switchgear or controlgear or delivered separately.

Note 2 to entry A typical dedicated wiring accessory is for example a connection link.

3.2.6

phase-loss sensitive relay or release

<motor protection> multipole relay or release for motor protection which operates in case of loss of phase in accordance with specified requirements

3.2.7

under-current relay or release

relay or release which operates automatically when the current through it is reduced below a predetermined value

3.2.8**under-voltage relay or release**

relay or release which operates automatically when the voltage applied to it is reduced below a predetermined value

3.2.9**stall relay or release**

electronic overload relay or release which operates when the current has not decreased below a predetermined value for a specific period of time during start-up or when the relay or the release receives the input indicating there is no rotation of the motor after a predetermined time in accordance with specified requirements

Note 1 to entry Explanation of stall: rotor locked during start.

Note 2 to entry With appropriate adjustment of the current and starting time settings, such relay or release can be used to detect starts requiring longer than specified times.

3.2.10**jam relay or release**

electronic overload relay or release which operates in the case of overload and also when the current has increased above a predetermined value for a specific period of time during operation in accordance with specified requirements

Note 1 to entry A jam is a high overload occurring after the completion of starting which causes the current to reach the locked rotor current value of the motor being controlled.

3.2.11**inhibit time**

time-delay period during which the tripping function of the relay is inhibited (may be adjustable)

3.3 Terms and definitions concerning characteristic quantities**3.3.1****continuity of service**

<of a control and protective switching device> capability to return into service after occurrence of an over-current fault in the circuit under control at all current up to the rated service short-circuit breaking capacity I_{CS} of the control and protective switching device

3.3.2**holding power**

power needed to maintain the operation of the electromagnet

[SOURCE: IEC 60947-4-1:2018, 3.3.9, modified – Without “(of a contactor)”.]

3.3.3**pick-up power**

power needed to operate the device from the de-energized state

[SOURCE: IEC 60947-4-1:2018, 3.3.10, modified – Deletion of “(of a contactor)” in the term and of “to the energized state” in the definition.]

3.3.4**O**

<operation> breaking operation by the device under short-circuit current

3.3.5**CO**

<operation> making operation under short-circuit current followed, after the appropriate opening time, by a breaking operation

3.3.6

rCO

<operation> remote controlled CO operation

3.3.7

galvanic separation

prevention of electric conduction between two electric circuits intended to exchange power and/or signals

Note 1 to entry Galvanic separation can be provided e.g. by an isolating transformer or an opto-coupler.

[SOURCE: IEC 60050-151:2001, 151-12-26]

3.3.8

conventional prospective current “r”

specified value of prospective short-circuit current for which the switching device is tested under specified conditions

3.3.9

conventional prospective current I_{cr}

specified values of prospective short-circuit current for which the switching device is tested under specified conditions followed by operational performance tests

3.4 Terms and definitions concerning safety aspects

3.4.1

abnormal operating condition

temporary operating condition that is not a normal operating condition and is not a single fault condition of the equipment itself

Note 1 to entry An abnormal operating condition is a temporary condition which can be introduced by the equipment or by a person and can result in a failure of a component, a device or a safeguard

Note 2 to entry This definition is used in the context of component failure risk analysis.

3.4.2

accessible part

part which can be touched by means of the standard test finger

[SOURCE: IEC 60050-442:1998, 442-01-15]

3.4.3

hazardous-live-part

live part which, under certain conditions, can give a harmful electric shock

[SOURCE: IEC 60050-195:1998, 195-06-05]

3.4.4

limited energy source

source that is designed and protected that, under both normal operating conditions and single fault conditions, the current that can be delivered is not hazardous with respect to fire hazard

3.4.5

protective impedance

impedance connected between hazardous live parts and accessible conductive parts, of such value that the current, in normal use and under likely fault conditions, is limited to a safe value, and which is so constructed that its ability is maintained throughout the life of the equipment

[SOURCE: IEC 62477-1:2012, 3.42]

3.4.6

reasonably foreseeable misuse

use of a product or system in a way not intended by the supplier, but which can result from readily predictable human behaviour

[SOURCE: ISO/IEC Guide 51:2014, 3.7, modified – Notes to entry have been deleted]

3.4.7

single fault condition

condition in which there is a fault of a single protection (but not a reinforced protection) or of a single component or a device

Note 1 to entry If a single fault condition results in one or more other fault conditions, all are considered as one single fault condition.

Note 2 to entry: Reinforced protection is defined in IEC 60050-903:2013, 903-02-08.

[SOURCE: IEC Guide 104:2019, 3.8]

4 Classification

Data which may be used as criteria for classification are given in 5.2.

5 Characteristics

5.1 Summary of characteristics

The characteristics of a CPS shall be stated in terms of the following, as applicable:

- type of CPS (5.2);
- rated and limiting values of the main circuit (5.3);
- utilization categories (5.4);
- control circuits (5.5);
- auxiliary circuits (5.6);
- relays and releases (5.7);
- items subject to agreement between manufacturer and user (see Annex D).

NOTE In the context of this document, the term "manufacturer" means any person, company or organization with ultimate responsibility as follows:

- to verify compliance with this document;
- to provide the product information according to Clause 6 (marking, identification, characteristics).

For information exchange in electronic format, e.g. electronic catalogue, IEC 62683-1 gives the data format of the essential characteristics of motor-starter combination and their accessories.

5.2 Type of equipment

5.2.1 Number of poles

5.2.2 Kind of current (alternating current or direct current)

5.2.3 Method of operation

For example: electromagnetic, manual, motor operated.

5.2.4 Method of control

For example:

- automatic (by pilot switch or sequence control);
- non-automatic (such as by handle or by push-buttons).

5.2.5 Method of resetting after overload

The following types are recognized:

- self resetting;
- local manual resetting;
- remote resetting.

5.2.6 Method of rearming after short-circuit

The following types are recognized:

- CPS capable of remote re-arming after operation;
- CPS incapable of remote re-arming after operation:
 - those not requiring replacement of a renewable short-circuit protective element, for example a normally operated circuit-breaker;
 - those requiring replacement of a renewable short-circuit protective element, for example a fuse-link.

5.3 Rated and limiting values of the main circuit

5.3.1 Rated voltages

Subclause 5.3.1 of IEC 60947-1:2020 applies with the following addition.

CPS's for unearthed or impedance earthed systems (IT) require additional tests according to Annex G.

5.3.2 Currents and powers

A CPS is defined by the following currents and powers:

- conventional free air thermal current (I_{th}): 5.3.2.1 of IEC 60947-1:2020 applies;
- conventional enclosed thermal current (I_{the}): 5.3.2.2 of IEC 60947-1:2020 applies;
- rated operational current (I_e) or, if applicable, rated operational power: 5.3.2.3 of IEC 60947-1:2020 applies.

5.3.3 Rated frequency

Subclause 5.3.3 of IEC 60947-1:2020 applies.

5.3.4 Rated duties

Subclause 5.3.4 of IEC 60947-1:2020 applies with the following addition to 5.3.4.3 of IEC 60947-1:2020 (intermittent periodic duty or intermittent duty).

In case of utilization categories AC-2, AC-3 and AC-3e, an operating cycle comprises starting, running to full speed and switching off the supply to the motor.

NOTE In the case of a CPS controlling a motor for intermittent duty, the difference between the thermal time-constant of the overload relay and that of the motor can render a thermal relay unsuitable for overload protection. For installations intended for intermittent duty, the question of overload protection is subject to an agreement between manufacturer and user.

5.3.5 Normal load and overload characteristics – Rated making and breaking capacities

Subclauses 5.3.5.2 and 5.3.5.3 of IEC 60947-1:2020 apply with the following additions.

Requirements for the various utilization categories (5.4) are given in 8.2.4.1.

The rated making and breaking capacities are only valid when the CPS is operated in accordance with the requirements of 8.2.1.1 and 8.2.1.2.

5.3.6 Short circuit characteristics – Rated service short-circuit breaking capacity (I_{cs})

Subclause 5.3.6.3 of IEC 60947-1:2020 applies with the following additions.

A rated short-circuit breaking capacity requires that the CPS shall be able to break any value of short-circuit current up to and including the value corresponding to the rated capacity at a power-frequency recovery voltage corresponding to the prescribed test voltage values and,

- for alternating current, at any power-factor not less than that of Table 16 of IEC 60947-1:2020;
- for direct current, with a time-constant up to that of Table 16 of IEC 60947-1:2020.

The rated service short-circuit breaking capacity of a CPS is the value of service short-circuit breaking capacity assigned to that CPS by the manufacturer for the corresponding rated operational voltage, under the conditions specified in 9.5.3.3. It is expressed as a value of prospective breaking current. I_{cs} shall be equal to or greater than the conventional prospective current I_{cr} (see 8.2.5 a)).

For alternating current, the short-circuit making capacity of a CPS shall be not less than its rated service short-circuit breaking capacity, multiplied by the factor n of Table 16 of IEC 60947-1:2020.

For direct current, the short-circuit making capacity of a CPS shall be not less than its rated service short-circuit breaking capacity.

5.3.7 Pole impedance of a CPS (Z)

Subclause 5.3.7 of IEC 60947-1:2020 applies.

5.4 Utilization categories

5.4.1 General

Subclause 5.4 of IEC 60947-1:2020 applies with the following additions.

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

Each utilization category is characterized by the values of currents (including prospective conventional test current, see 8.2.5 a)), voltages, power factors, or time-constants and other data in Table 9, Table 10, Table 11, Table 12 and Table 13 and by the test conditions specified in this document.

For CPS's defined by their utilization categories, it is therefore unnecessary to specify separately the rated making and breaking capacities as these values depend directly on the utilization category as shown in Table 9.

The voltage for all utilization categories is the rated operational voltage of the CPS.

Table 1 – Utilization categories

Specific utilization categories	Harmonised utilization categories ^d	Typical load
AC-40		Distribution circuits comprising mixed resistive and reactive loads having a resultant inductive reactance
AC-41	AC-1	Non-inductive or slightly inductive loads
AC-42	AC-2	Slip-ring motors or mixed resistive and inductive loads, including moderate overloads
AC-43	AC-3	Squirrel-cage motors ^{a, b}
	AC-3e	Squirrel-cage motors with higher locked rotor current ^{a, c}
AC-44	AC-4	Squirrel-cage motors ^b plugging, inching
AC-45a	AC-5a	Discharge lamp controls
AC-45b	AC-5b	Incandescent lamps
DC-40		Distribution circuits comprising mixed resistive and reactive loads having a resultant inductive reactance
DC-41	DC-1	Non-inductive or slightly inductive loads
DC-43	DC-3	Shunt-motors
DC-45	DC-5	Series-motors
DC-46	DC-6	DC incandescent lamps

^a AC-3 category may be used for occasional inching (jogging) or plugging for limited time periods such as machine set up; during such limited time periods the number of operations should not exceed five per minute nor 10 in a 10-min period.

^b Asynchronous motor of design N and H according to IEC 60034-12:2016.

^c Asynchronous motor of design NE and HE, according to IEC 60034-12:2016, having extended/higher locked rotor apparent power and current than design N and H respectively, to achieve a higher efficiency class according to IEC 60034-30-1.

^d The new utilization categories according to Annex A of IEC 60947-1:2020 are proposed to replace the specific ones but the specific utilization categories are remaining valid.

5.4.2 Assignment of utilization categories based on the results of tests

- a) A CPS which has been tested for one utilization category or at any combination of parameters (such as highest operational voltage and current, etc.) can be assigned other utilization categories without additional testing provided that the values of test current, voltages, power-factors or time-constants, number of operating cycles, the ON-times and OFF-times given in Table 9 and Table 10 and the test circuit for the assigned utilization categories are not more severe than those at which the equipment has been tested and temperature-rise has been verified at a current not less than the highest assigned rated operational current in continuous duty.

For example, when tested for utilization category AC-4, a CPS may be assigned utilization category AC-3 provided that I_e for AC-3 is not higher than 1,2 times I_e for AC-4 at the same rated operational voltage.

- b) DC-3 or DC-5 CPS is assumed to be capable of opening and closing loads other than those on which they have been tested provided that:

– the voltage and current do not exceed the specified values of U_e and I_e ;

- the energy J stored in the actual load is equal to or less than the energy J_c stored in the load with which the CPS has been tested. The values of the energy stored in the test circuit are as follows:
 - For DC-3: $J_c = 0,005\,25 \times U_e \times I_e$
 - For DC-5: $J_c = 0,031\,5 \times U_e \times I_e$

The values of the constants 0,005 25 and 0,031 5 are derived from: $I_c = \frac{1}{2} LI^2$ where the time-constant has been replaced by $2,5 \times 10^{-3}$ s for DC-3 and 15×10^{-3} s for DC-5 and where $U = 1,05 U_e$ and $I = 4 I_e$ (see Table 9).

5.4.3 Application of utilization categories for motor control duty

Typical service conditions are:

- rotation in one direction, the motor being switched off while running under normal service conditions (utilization categories AC-2, AC-3 and AC-3e);
- rotation in two directions, but running of the motor in the second direction being started only after the CPS has been switched off and the motor completely stopped (utilization categories AC-2, AC-3 and AC-3e);
- rotation in one direction, or in two directions as in the previous paragraph, but with the possibility of infrequent inching. For this service condition, a direct-on-line CPS is generally used (utilization category AC-3 and AC-3e);
- rotation in one direction with frequent inching (jogging); a direct-on-line CPS is generally used (utilization category AC-4);
- rotation in one or two directions but with the possibility of infrequent plugging in order to stop the motor, the plugging being associated with rotor resistor braking if this is provided. In this case a CPS may be used in the stator circuit (utilization category AC-2);
- rotation in two directions but with the possibility of reversing the supply connections to the motor while it is running in the first direction (plugging), in order to obtain its rotation in the other direction while switching off the motor running under normal service conditions. A direct-on-line reversing CPS with plugging capability is generally used for this service condition (utilization category AC-4).

Unless otherwise stated, CPS's used as starters are designed on the basis of the starting characteristics of the motors compatible with the making capacities of Table 9. When the starting current of a motor exceeds these values, a CPS having a suitably higher rated operational current should be used.

5.5 Control circuits

Subclause 5.5 of IEC 60947-1:2020 applies with the following additions.

The list of characteristics given in 5.5.1 of IEC 60947-1:2020 shall be completed by:

- limited energy (if the source is in accordance with 8.1.14);
- SELV (PELV) supply (in accordance with Annex N of IEC 60947-1:2020).

NOTE In the USA and Canada, control circuits can be characterised as Class 2 sources as defined in NFPA 70, National Electrical Code and CSA C22.1, Canadian Electrical Code in lieu of or in addition to SELV (PELV) sources.

- the power consumption of the electromagnet of a CPS, necessary for determining the characteristics of the power supply of the control circuit, is given by:
 - holding power;
 - pick-up power.

5.6 Auxiliary circuits

Subclause 5.6 of IEC 60947-1:2020 applies.

Digital inputs and/or digital outputs contained in CPS, and intended to be compatible with PLC's, shall fulfil the requirements of Annex S of IEC 60947-1:2020.

Annex F applies for CPS equipped with mirror contact.

5.7 Relays or releases

5.7.1 Summary of characteristics

The characteristics of relays and releases shall be stated in the following terms, whenever applicable:

- types of relay or release (see 5.7.2);
- characteristic values (see 5.7.3);
- designation and current settings of overload relays (see 5.7.4);
- time-current characteristics of overload relays (see 5.7.5);
- influence of ambient air temperature (see 5.7.6);
- extended functions as given in Annex T of IEC 60947-1:2020;
- load monitoring indicator as given in Annex M.

5.7.2 Types of relays or releases

5.7.2.1 Shunt release (3.6.34 of IEC 60947-1:2020)

5.7.2.2 Under-voltage relay or release (for opening) (3.6.35 of IEC 60947-1:2020).

5.7.2.3 Over-current relays or releases

5.7.2.3.1 Overload relays or releases

- a) Instantaneous overload relay or release (e.g. jam sensitive, 3.2.10);
- b) Definite time-delay overcurrent relay or release (3.6.27 of IEC 60947-1:2020);
- c) Inverse time-delay overcurrent relay or release (3.6.28 of IEC 60947-1:2020):
 - i) substantially independent of previous load;
 - ii) dependent on previous load;
 - iii) dependent on previous load and also sensitive to phase-loss (see 3.2.6).
- d) Stall relay or release (see 3.2.9).

5.7.2.3.2 Short-circuit relays or releases

- a) Instantaneous short-circuit relay or release;
- b) Definite time-delay overcurrent relay or release (3.6.27 of IEC 60947-1:2020).

NOTE A CPS has a combination of relays or releases from 5.7.2.3.1 and 5.7.2.3.2 above.

5.7.2.4 Other relays and releases (e.g. phase failure relay, control relay associated with devices for motor thermal protection, residual current relay)

Types referred to under 5.7.2.4 require consultation between manufacturer and user according to the particular application.

5.7.3 Characteristic values

Shunt, under-voltage (under-current), over-voltage (instantaneous over current), current or voltage asymmetry and phase reversal opening relay or release:

- rated voltage (current);
- rated frequency;
- operating voltage (current);
- operating time (when applicable);
- inhibit time (when applicable).

Over-current relay or release:

- designation and current settings (see 5.7.4);
- rated frequency, when necessary (for example, in the case of a current transformer operated overload relay);
- time-current characteristics (or range of characteristics), when necessary;
- trip class according to classification in Table 3, or the value of the maximum tripping time, in seconds, under the conditions specified in Table 2, column D, when this time exceeds 40 s;
- nature of the relay: thermal, magnetic, electronic or electronic without thermal memory;
- nature of the reset: in case of manual and/or automatic, the position shall be indicated;
- tripping time of overload relays class 10 A if longer than 2 min at $-5\text{ }^{\circ}\text{C}$ or below (see 8.2.1.5.1.1).

Release with residual current sensing relay:

- rated current;
- operating current;
- operating time or time-current characteristic according to Table T.1 of IEC 60947-1:2020;
- inhibit time (when applicable);
- type designation (see Annex T of IEC 60947-1:2020).

5.7.4 Designation and current setting of overload relays or releases

Overload relays or releases are designated by their current setting (or the upper and lower limits of current setting range, if adjustable) and their trip class, where applicable. The current setting (or current setting range) shall be marked on the relay or release.

5.7.5 Time-current characteristics of over current relays or releases

Time-delay relay or release:

- definite time-delay: the time-delay of such relays or releases is independent of the over-current. The tripping time setting shall be stated as the duration in seconds of the opening time of the CPS if the time-delay is not adjustable, or the minimum and maximum values of the opening time, if the time-delay is adjustable.
- inverse time-delay: the time-current characteristics shall be given in the form of curves supplied by the manufacturer. These shall indicate how the opening time, starting from the cold state, varies with current within the range of operation of the relay or release. The manufacturer shall indicate, by suitable means, the tolerances applicable to these curves. These curves shall be given for the minimum and maximum values of the current setting and, if the time setting for a given current setting is adjustable, it is recommended that they be given in addition for each minimum and maximum values of the time setting.
- opening time: subclause 3.7.39 of IEC 60947-1:2020 applies, with the following additions:

- in the case of a CPS tripped by an over-current relay or release, the instant of initiation of the opening time is the instant when the current reaches a value large enough to cause the CPS to operate;
- in the case of a CPS operated by any form of auxiliary power, the instant of initiation of the opening time is the instant of application of the auxiliary power to or its removal from the opening release.

NOTE 1 For CPS's "opening time" is commonly referred to as "tripping time", although strictly speaking, tripping time applies to the time between the instant of initiation of the opening time and the instant when the opening command becomes irreversible.

NOTE 2 The current is plotted as abscissa and the time as ordinates, using logarithmic scales. The current is plotted as multiples of the setting current I_r and the time in seconds on the standard graph sheet detailed in 5.6.1 and Figure 1 of IEC 60269-1:2006 and in Figure 104, Figure 504 and Figure 505 of IEC 60269-2:2013.

5.7.6 Influence of ambient air temperature

Unless otherwise specified, the operating value of over-current relays or releases other than those of the thermal type is independent of the ambient air temperature within the limits of -5 °C to $+40\text{ °C}$.

For relays or releases of the thermal type:

The time-current characteristics refer to a stated value of ambient air temperature and are based on no previous loading of the overload relay (i.e. from an initial cold state).

This value of the ambient air temperature shall be clearly given on the time curves; the preferred values are $+20\text{ °C}$ or $+40\text{ °C}$.

The overload-relays or releases shall be able to operate within the ambient air temperature range of -5 °C to $+40\text{ °C}$ and the manufacturer shall be prepared to state the effect of variation in ambient air temperature on the characteristics of overload relays or releases.

6 Product information

6.1 Nature of information

6.1.1 Identification

- The manufacturer's name or trademark;
- Type designation or serial number;
- Number of this part, if the manufacturer claims compliance.

6.1.2 Characteristics

- Rated operational voltages U_e (see 5.3.1 and, where applicable, Annex G);
- Utilization category and rated operational currents (or, where applicable, rated powers) at the rated-operational voltages;
- Either the rated frequency (e.g.: 50 Hz, 50 Hz/60 Hz) and/or the indication "d.c." (or the symbol — — — (IEC 60417-5031:2002-10));
- Rated duty with the indication of the class of intermittent duty, if any;
- Pole impedance of the switching device (Z);
- Rated service short-circuit breaking capacity (I_{cs}) (see 5.3.6);
- Rated insulation voltage according to 5.3.1.2 of IEC 60947-1:2020;
- Rated impulse withstand voltage (U_{imp});
- Indication of the open and closed positions (according to 8.1.6);

- l) Pollution degree (see Clause 7);
- m) Rated control circuit voltage (U_c), nature of current and rated frequency (if alternating current).

NOTE 1 Other information such as the holding or pick-up power could be given e.g. in the product literature.

- n) IP code according to Annex C of IEC 60947-1:2020;

NOTE 2 In the USA and Canada this protection is defined by NFPA 70, National Electrical Code and CSA C22.1, Canadian Electrical Code as the Enclosure Environmental Type Ratings.

- o) If necessary, nature of current, rated frequency and rated control circuit supply voltage (U_s);

In the case of electronically controlled electromagnets, other information may also be necessary, for example control circuit configuration (see 5.5 of this document and Annex U of IEC 60947-1:2020).

- p) Ratings of auxiliary circuits;
- q1) Maximum permissible altitude of the site of installation, if greater than 2 000 m;
- q2) Minimum enclosure size and ventilation data (if any) to which marked ratings apply;
- q3) Details of minimum distance between CPS and earthed metal parts for CPS's intended for use without enclosures;
- r) Current setting and identification of time-current characteristic of over current relays or releases, specifying, according to 5.7, if the electronic overload relay does not contain thermal memory;
- s) Other characteristics of over-current relays or releases according to 5.7;
- t) In the case of renewable short-circuit protective elements (see 5.2) current rating, type and characteristics in accordance with relevant standard;
- u1) Suitability for isolation where applicable (see 6.2 of IEC 60947-1:2020);
- u2) Suitability for IT systems according to Annex G;
- v) Environment A or environment B (see 8.3.1 of IEC 60947-1:2020);
- w1) Length of insulation to be removed before insertion of the conductor into the terminal;
- w2) Maximum number of conductors which may be clamped;
- w3) For non-universal screwless terminals:
 - "s" or "sol" for terminals declared for rigid-solid conductors;
 - "r" for terminals declared for rigid (solid and stranded) conductors;
 - "f" for terminals declared for flexible conductors.
- w4) Special requirements, if applicable, for example shielded or twisted conductors;

NOTE 3 Unshielded or untwisted conductors are considered as normal installation conditions.

- x) Minimum cable cross-section, if different from Table 9 of IEC 60947-1:2020, for ratings ≤ 20 A according to rated ultimate short-circuit breaking capacity I_{cu} ;
- y) Values of tightening torque for the CPS terminals;
- z1) Reference of dedicated wiring accessories which can be used for wiring the CPS;
- z2) Material declaration according to Annex W of IEC 60947-1:2020.

6.2 Marking

Subclause 6.2 of IEC 60947-1:2020 applies with the following additions related to 6.1.1 and 6.1.2 above:

- data under items c) and n) (if the degree of protection is different than IP00) shall be marked on the equipment;
- data under items d) to g), i) to m), o) to q), s) and v) to z2) shall be included on the nameplate or on the equipment or in the manufacturer's published literature;

- data under items h) and t) and relevant operational data under items d), e) and f) shall be marked on the CPS;
- data under item r) shall be marked on the relay or release;



- data under u) shall be marked on the CPS, the global symbol being: (IEC 60417-6410:2018-11);
- terminals shall be marked so as to clearly identify line and load terminals (see 8.1.8.2).

NOTE Data under items a) and b) of 6.1.1 are already covered by 6.2 of IEC 60947-1:2020.

If the manufacturer declares an electronic overload relay without thermal memory, this shall be marked on the device.

For dedicated accessories used for wiring the CPS, data under 6.1.1 c), 6.1.2 i2) and the current I_{th} , if applicable, shall be provided in the manufacturer's published literature.

6.3 Instructions for installation, operation and maintenance

Subclause 6.3 of IEC 60947-1:2020 applies with the following addition.

The instructions shall also cover the dedicated wiring accessories.

Additional information for the decommissioning and dismantling of the device shall be maintained available to the user in case of foreseeable hazardous condition of the device, for example due to stored energy, instability or falling of objects, etc.

The manufacturer of a CPS incorporating an automatic reset overload relay capable of being connected to enable automatic restarting shall provide, with the CPS, that information necessary to alert the user to the possibility of automatic restarting.

If the construction requires energization by an external source that is not a limited energy source as defined in 8.1.14, the manufacturer shall provide the appropriate information for short-circuit and overcurrent protection of the ports.

For each relevant potential hazard, the manufacturer shall provide safety signs, graphical symbols or safety notes of the hazard for example by using e.g. IEC 60417-5036:2002-10. Signal words shall be defined according to ISO 3864-2.

NOTE ISO/IEC 82079-1 provide guidance for developing safety instructions.

6.4 Environmental information

Subclause 6.4 of IEC 60947-1:2020 applies with the following addition.

NOTE Future publication IEC TS 63058² will give the method for assessing the environmental impact of switchgear and controlgear.

7 Normal service, mounting and transport conditions

Clause 7 of IEC 60947-1:2020 applies with the following additions.

² Under preparation. Stage at the time of publication: IEC TS APUB 63058:2020.

Unless otherwise stated by the manufacturer's, a CPS is for use in pollution degree 3 environmental conditions, as defined in 7.1.3.2 of IEC 60947-1:2020. However, other pollution degrees may be considered to apply depending upon the micro-environment.

Rail mounting shall be specified according to IEC 60715:2017, when relevant.

Standard conditions of vibration and shock are defined in footnotes ^b of Table Q.1 of IEC 60947-1:2020.

8 Constructional and performance requirements

8.1 Constructional requirements

8.1.1 General

Subclause 8.1.1 of IEC 60947-1:2020 applies with the following addition.

Measures shall be provided to reduce the likelihood of injury or, in case of fire, property damage, under installation, maintenance, normal operation conditions, abnormal operation conditions and reasonably foreseeable misuses. The requirements of this document are generically providing these measures.

Protection against hazards caused by the electronic circuits shall be maintained under normal and single fault conditions, as specified in this document.

Components used in the construction of the equipment, compliant with a relevant IEC product standard do not require separate evaluation. Components or assemblies of components, for which no relevant product standard exists, shall be tested according to the requirements of this document.

Where the product is intended to be used together with specific auxiliary equipment and dedicated wiring accessories, the safety evaluation and test shall include this auxiliary equipment and accessories unless it can be shown that it does not affect the safety of any equipment.

The accessible part of the device and especially the operating means shall not present sharp edges and corners which can injure the operator.

The user manual shall give details of all safety-relevant measures intended for the user. Clear warning shall be provided in the user manual where adjustments or settings could lead to a hazardous situation.

The setting of the automatic reset of the overload release needs to be identified in the user manual as a specific safety relevant warning.

Annex O of IEC 60947-1:2020 should be considered carefully especially for substitution or reduction in use of hazardous substances or if not possible for providing measures to prevent emission and contact with them.

8.1.2 Materials

8.1.2.1 General materials requirements

Subclause 8.1.2.1 of IEC 60947-1:2020 applies with the following addition.

NOTE Fire hazard aspects are detailed in IEC TR 63054.

Parts of insulating materials located in electrical circuits sourced from limited energy sources according to 8.1.14 are not required to comply with the requirements of this subclause.

8.1.2.2 Glow wire testing

Subclause 8.1.2.2 of IEC 60947-1:2020 applies with the following addition.

When tests on the equipment or on sections taken from the equipment are used, parts of insulating materials necessary to retain current-carrying parts in position shall conform to the glow-wire tests of 9.2.2.1 of IEC 60947-1:2020 at a test temperature of 960 °C.

8.1.2.3 Test based on flammability category

Subclause 8.1.2.3 of IEC 60947-1:2020 applies.

8.1.3 Current-carrying parts and their connections

Subclause 8.1.3 of IEC 60947-1:2020 applies.

8.1.4 Clearances and creepage distances

Subclause 8.1.4 of IEC 60947-1:2020 applies with the following addition.

Creepage and clearance distances within the circuits sourced from limited energy sources as defined in 8.1.14 are not required to comply with the requirements of this subclause.

Clearance and creepage distances on printed wiring boards (PWBs) including components mounted on PWBs, for functional, basic, supplementary and reinforced insulation, designed according to 8.1.14, are considered to meet these requirements and do not need any further investigation.

Where SELV and PELV circuits are accessible, they shall be separated from other hazardous-live-part according to the requirements of Annex N for protective impedance in addition to Annex N of IEC 60947-1:2020.

NOTE If some circuits are only accessible under maintenance or similar conditions, they can, depending on the risk level (severity of harm and the probability of occurrence), be considered under normal service conditions (see 6.1), and use only basic insulation. Accessible parts can be determined using test probes according to IEC 61032.

8.1.5 Actuator

8.1.5.1 Insulation

Subclause 8.1.5.1 of IEC 60947-1:2020 applies.

8.1.5.2 Direction of movement

Subclause 8.1.5.2 of IEC 60947-1:2020 applies.

8.1.5.3 Mounting

Actuators mounted on removable panels or opening doors shall be so designed that, when the panels are replaced or the doors closed, the actuator will engage correctly with the associated mechanism.

8.1.5.4 Protection

There shall be no path or opening which allows incandescent particles to be discharged from the area of the manual operating means.

8.1.6 Indication of the contact position

8.1.6.1 Indicating means

Subclause 8.1.6.1 of IEC 60947-1:2020 applies.

8.1.6.2 Indication by the actuator

Subclause 8.1.6.2 of IEC 60947-1:2020 applies.

8.1.7 Additional requirements for equipment suitable for isolation

Subclause 8.1.7 of IEC 60947-1:2020 applies with the following addition.

If the tripped position of the CPS is not the indicated open position, it should be clearly visible that it is not the open position. The verification of the main contact position suitable for isolation shall be tested according to 9.5.2.6.

CPS's suitable for isolation shall be provided with means for locking in the open position.

8.1.8 Terminals

8.1.8.1 General

Subclause 8.1.8 of IEC 60947-1:2020 applies with the following additional requirements.

8.1.8.2 Terminal identification and marking

Subclause 8.1.8.4 of IEC 60947-1:2020 applies with additional requirements as given in Annex C with the following addition.

Line and load terminals of CPS for utilization categories AC-40 and DC-40 having trip units which are not removable or sealed against removal may not be identified, in which case control circuits shall not be internally connected to the main circuit.

8.1.9 Additional requirements for equipment provided with a neutral pole

Subclause 8.1.9 of IEC 60947-1:2020 applies.

8.1.10 Provisions for protective earthing

Subclause 8.1.10 of IEC 60947-1:2020 applies.

8.1.11 Enclosures for equipment

8.1.11.1 Design

Subclause 8.1.11.1 of IEC 60947-1:2020 applies with the following addition.

In the case of enclosed CPS's provided with an externally manually operated actuator, the door or cover shall be interlocked so that they cannot be opened without the CPS being in the open position. However, provision may be made to open the door or cover with the CPS in the ON position by the use of a tool.

8.1.11.2 Insulation

Subclause 8.1.11.2 of IEC 60947-1:2020 applies.

8.1.12 Degrees of protection of enclosed equipment

Subclause 8.1.12 of IEC 60947-1:2020 applies.

8.1.13 Conduit pull-out, torque and bending with metallic conduits

Subclause 8.1.13 of IEC 60947-1:2020 applies.

8.1.14 Limited energy source

8.1.14.1 General

A limited energy source can be implemented as a secondary circuit derived from circuits connected to the hazardous-live-part with the following separation means:

- a) galvanic separation;
- b) current limiting impedance.

NOTE Class 2 sources as defined in NFPA 70, National Electrical Code and CSA C22.1 Canadian Electrical Code (CE Code) have the same electrical output characteristics as limited energy sources with galvanic separation.

8.1.14.2 Limited energy source with galvanic separation

A limited energy source with galvanic separation incorporates an isolating component such as a transformer between the primary circuit and the limited energy output. It shall comply with one of the following requirements:

- a) the output is inherently limited in compliance with Table 20; or
- b) a linear or non-linear impedance limits the output in compliance with Table 20. If a positive temperature coefficient device (e.g. PTC) is used, it shall pass the applicable tests specified in IEC 60730-1; or
- c) a regulating network limits the output in compliance with Table 20, both with and without a single fault in the regulating network; or
- d) an over-current protective device is used and the output is limited in compliance with Table 21.

Where an over-current protective device is used, it shall be a fuse or non-adjustable electromechanical device.

Compliance to determine the maximum available power is checked by test of 9.2.4.

In case of external power supply without overcurrent protective devices, it shall not exceed the values given in Table 20. In case of external power supply with over-current protective, it shall not exceed the values given in Table 21.

Table 20 – Limits for limited energy sources without an over-current protective device

Output voltage ^a U_{oc}		Output current ^{b, d} I_{sc}	Maximum power ^c S
V AC	V DC	A	VA
≤ 30 RMS	≤ 30 V DC	≤ 8	100
-	$30 < U_{oc} \leq 60$ ^e	$\leq \frac{150}{U_{oc}}$	100

NOTE This table will be moved into the future revision of IEC 60947-1 and is therefore numbered differently to the other tables in this document.

U_{oc} : Output voltage measured in accordance with all load circuits disconnected. Voltages are for substantially sinusoidal AC and ripple-free DC. For non-sinusoidal AC and DC with ripple greater than 10 % of the peak, its peak value shall not exceed 42,4 V.

a. I_{sc} : Maximum output current with any non-capacitive load, including a short circuit.

b. S (VA): Maximum output apparent power with any non-capacitive load as determined by 9.2.4.

c. Measurement of I_{sc} is made 5 s after application of the load if protection is by an electronic circuit or a positive temperature coefficient device (e.g. PTC), and 60 s in other cases.

d. In the USA, the limit is 60 V DC continuous or DC switching outside of 10 Hz to 200 Hz, 24,8 V DC switching at 10 Hz to 200 Hz.

Table 21 – Limits for limited energy sources with an over-current protective device

Output voltage ^a U_{oc}		Output current ^{b, d} I_{sc}	Maximum power ^{c, d} S	Current rating of over-current protective device ^e
V AC	V DC	A	VA	A
≤ 20	≤ 20	$\leq \frac{100}{U_{oc}}$	250	≤ 5,0
$20 < U_{oc} \leq 30$	$20 < U_{oc} \leq 30$ ^f			$\leq \frac{100}{U_{oc}}$
-	$30 < U_{oc} \leq 60$ ^f			$\leq \frac{100}{U_{oc}}$

NOTE 1 The reason for making measurements with over-current protective devices bypassed is to determine the amount of energy that is available to cause possible overheating during the operating time of the over-current protective devices.

NOTE 2 This table will be moved into the future revision of IEC 60947-1 and is therefore numbered differently to the other tables in this document.

a. U_{oc} : Output voltage measured with all load circuits disconnected. Voltages are for substantially sinusoidal AC and ripple free DC. For non-sinusoidal AC and for DC with ripple greater than 10 % of the peak, its peak value shall not exceed 42,4 V.

b. I_{sc} : Maximum output current with any non-capacitive load, including a short circuit, measured 60 s after application of the load.

c. S (VA): Maximum output apparent power with any non-capacitive load measured 60 s after application of the load as determined by 9.2.4.

d. Current limiting impedances remain in the circuit during measurement, but over-current protective devices are bypassed.

e. The current ratings of over-current protective devices that break the circuit within 120 s with a current equal to 210 % of the current rating specified in the table.

f. In the USA, the limit is 60 V DC continuous or DC switching outside of 10 Hz to 200 Hz, 24,8 V DC switching at 10 Hz to 200 Hz.

8.1.14.3 Limited energy source with current limiting impedance

A limited energy source with current limiting impedance has the following characteristics:

- a) the output voltage is limited in compliance with Table 22, and
- b) a linear or non-linear impedance limits the output in compliance with Table 22, both with and without a single fault.

A limited energy source with current limiting impedance may be derived from either mains or from a galvanically separated circuit e.g. the secondary of a transformer.

Table 22 – Limits for limited energy source with current limiting impedance

Output voltage ^a		Output current ^{b, d}	Maximum power ^c
U_{oc}		I_{sc}	S
V AC	V DC	A	VA
≤ 30 V RMS	≤ 30 V DC	0,5	15
NOTE This table will be moved into the future revision of IEC 60947-1 and is therefore numbered differently to the other tables in this document.			
^{a.} U_{oc} : Output voltage measured in accordance with all load circuits disconnected. Voltages are for substantially sinusoidal AC and ripple-free DC. For non-sinusoidal AC and DC with ripple greater than 10 % of the peak, its peak value shall not exceed 42,4 V. ^{b.} I_{sc} : Maximum output current measured across the output of the limited energy source. ^{c.} S (VA): Maximum output apparent power as determined by 9.2.4. ^{d.} Measurement of I_{sc} is made 5 s after application of the short-circuit.			

8.1.15 Stored charge energy circuit

Parts including stored charge (capacitors) that are removable for servicing (such as coil replacement), installation, or disconnection shall present no risk of electric energy hazard after disconnection.

Capacitors connected to accessible hazardous-live-parts shall be discharged to an energy level less than 0,5 mJ within 5 s after the removal of power. Otherwise, a readily visible warning notice shall be provided on the product, indicating the time of discharge to the limit values or a preferable method how to discharge the capacitor before touching the connecting parts.

8.1.16 Fault and abnormal conditions

The product shall be designed to avoid operating modes or sequences that can cause a fault condition or component failure leading to a hazard, unless other measures to prevent the hazard are provided by the installation and are described in the installation information provided with the product. The requirements in this subclause also apply to abnormal operating conditions as applicable.

Circuit analysis or testing shall be performed to determine whether or not failure of a particular component (including insulation systems) would result in hazard.

This analysis shall include situations where a failure of the component or the insulation (basic and supplementary) would result in:

- an impact on the risk of electric shock;
- a risk of degradation resulting in emission of flame, burning particles or molten metal of the fire.

The analysis or testing shall include the effect of short-circuit and open-circuit conditions of the component. Testing is necessary unless analysis can conclusively show that, in short-circuit and open circuit conditions, no electric shock and fire hazard will result from failure of the component. Compliance shall be checked by test of 9.2.5.

Components evaluated for their reliability according to relevant product standards are considered to meet these requirements and do not need any further investigation, if tested under conditions that fulfil the conditions for which the product is designed.

8.1.17 Short-circuit and overload protection of ports

Where the power source for a signal port or power port that is external to the device does not comply with the requirements for limited energy sources in 8.1.14, the product shall not present a hazard under short-circuit or overload conditions. Instructions for the installation of external overcurrent protection shall be made available in accordance with 6.3.

Compliance shall be checked by inspection and where necessary, by simulation of single fault conditions.

8.2 Performance requirements

8.2.1 Operating conditions

8.2.1.1 General

Subclause 8.2.1.1 of IEC 60947-1:2020 applies with the following addition.

CPS's shall be so constructed that they are trip free (3.6.24 of IEC 60947-1:2020).

CPS's shall not trip due to the shock caused by their operation when tested according to 9.3.3.1 after having carried their maximum rated operational current at the reference ambient air temperature and reached thermal equilibrium at both minimum and maximum settings of the overload relay if adjustable.

Resetting of relays and releases shall not result in a closing operation of the CPS in the absence of a closing command.

The requirements apply to the product as well as to the dedicated wiring accessories.

If there is no distinction between U_s and U_C , requirements apply with U_C .

8.2.1.2 Limits of operation of power operated CPS's

Subclause 8.2.1.2 of IEC 60947-1:2020 applies.

8.2.1.3 Limits of operation of under-voltage relays and releases

Subclause 8.2.1.3 of IEC 60947-1:2020 applies with the following addition.

Tests are specified in 9.3.3.2.2 of this document.

8.2.1.4 Limits of operation of shunt releases

Subclause 8.2.1.4 of IEC 60947-1:2020 applies with the following addition.

Tests are specified in 9.3.3.2.2 of this document.

8.2.1.5 Limits of operation of current sensing relays and releases

8.2.1.5.1 Opening under overload conditions

8.2.1.5.1.1 General tripping requirements of inverse time-delay overload relays or releases (type c) in 5.7.2.3.1)

i) Utilization categories AC-2, AC-3, AC-3e, AC-4, DC-3, DC-5

NOTE 1 The thermal protection of motors in the presence of harmonics in the supply voltage is under consideration.

When all poles are energized

The relays or releases are classified for these utilization categories according to Table 3 and shall comply with the requirements of Table 2 and Table 3 when tested as follows:

- With the CPS in its enclosure, if normally fitted, and at A times the current setting, tripping shall not occur in less than 2 h starting from the cold state, at the value of reference ambient air temperature stated in Table 2. However, when the overload relay terminals have reached thermal equilibrium at the test current in less than 2 h, the test duration can be the time to reach such thermal equilibrium;
- When the current is subsequently raised to B times the current setting, tripping shall occur in less than 2 h;
- For trip classes 2, 3, 5 and 10 A overload relays or releases energized at C times the current setting, tripping shall occur in less than 2 min, starting from thermal equilibrium at 1,0 times the current setting, in accordance with 9.3.3 of IEC 60034-1:2017 for class 10 A overload relays, for ambient air temperature -5 °C or below, the manufacturer may declare a longer tripping time but not longer than 4 min;

NOTE 2 Subclause 9.3.3 of IEC 60034-1:2017 states: “Polyphase motors having rated outputs not exceeding 315 kW and rated voltages not exceeding 1 kV shall be capable of withstanding a current equal to 1,5 times the rated current for not less than 2 min”.

- For trip classes 10, 20, 30 and 40 overload relays or releases energized at C times the current setting, tripping shall occur in less than 4 min, 8 min, 12 min or 16 min respectively, starting from thermal equilibrium at 1,0 times the current setting;
- At D times the current setting, tripping time T_p shall occur within the limits given in Table 3 for the appropriate trip class and tolerance band starting from the cold state;
- In the case of overload relays or releases having a current setting range, the limits of operation shall apply both when the relay or release is carrying the current associated with the maximum setting and when the relay or release is carrying the current associated with the minimum setting;
- For non-compensated overload relays or releases the current multiple/ambient temperature characteristic shall be not greater than 1,2 %/K.

NOTE 3 1,2 %/K is the derating characteristic of PVC insulated cables.

An overload relay or release is regarded as compensated if it complies with the relevant requirements of Table 2 at 20 °C and is within the limits shown in Figure 1 at other temperatures.

Table 2 – Limits of operation of inverse time-delay overload relays or releases when energized on all poles

Utilization category	Type of overload relay	Multiples of current setting				Ambient air temperature values
		A	B	C	D	
AC-2 AC-3	Thermal type not compensated for ambient air temperature variations	1,0	1,2 ^b	1,5	7,2	+40 °C
AC-3e AC-4 DC-3 DC-5	Thermal type compensated for ambient air temperature variations	c	c	–	–	less than –5 °C ^d
		1,05	1,3	1,5	–	–5 °C
		1,05	1,2 ^b	1,5	7,2	+20 °C
		1,0	1,2 ^b	1,5	–	+40 °C
		c	c	–	–	more than +40 °C ^d
	Electronic type ^a	1,05	1,2 ^b	1,5	7,2	0 °C, +20 °C and +40 °C
AC-40 AC-1 AC-5a AC-5b DC40 DC-1 DC-6	All types	1,05	1,3	–	–	+30 °C
^a This test shall only be done at 20 °C for A, B and D multiples of current setting. ^b If specified by the manufacturer, the tripping current could be different from 120 % but shall not exceed 125 %. In this case the test current value shall be equal to this tripping current value. In this case, the tripping current value shall be marked on the device. ^c Multiples of current setting should be declared by the manufacturer. ^d See 9.3.3.2.2 for tests outside the –5 °C +40 °C range.						

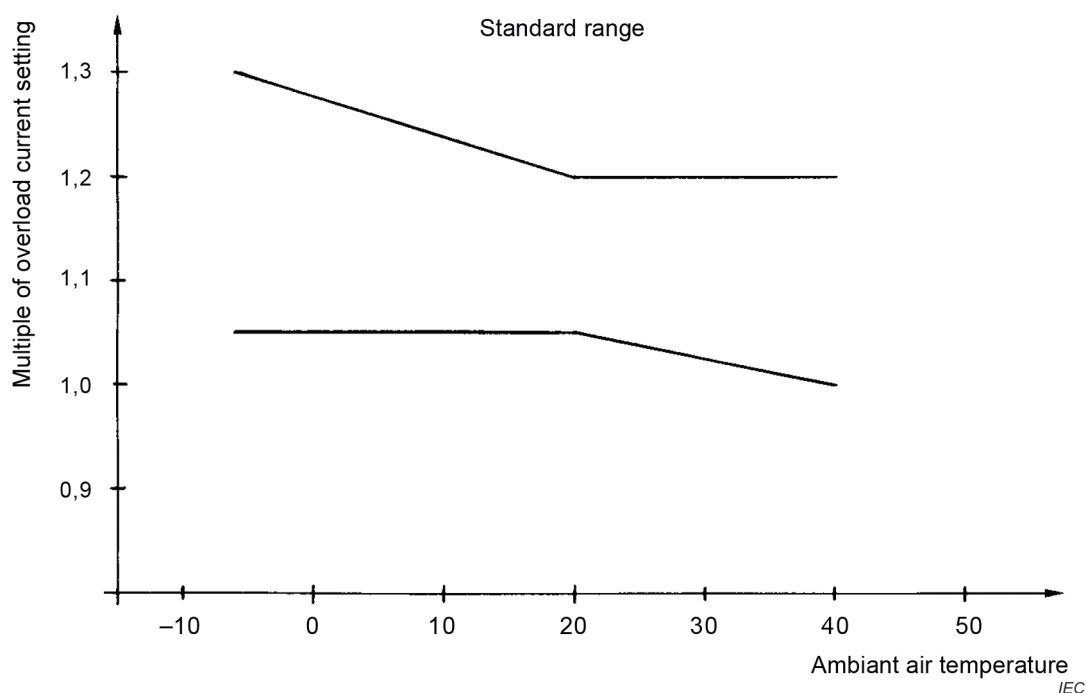


Figure 1 – Multiple of current setting limits for ambient air temperature time-delay overload relays or releases (see 8.2.1.5.1)

Table 3 – Trip classes of overload relays or releases for utilization categories AC-2, AC-3, AC-3e, AC-4, DC-3, DC-5

Trip class	Tripping time T_p under the conditions specified in 8.2.1.5.1.1, Table 2, column D ^a	Tripping time T_p under the conditions specified in 8.2.1.5.1.1, Table 2, column D for tighter tolerances Tolerance band E ^a
	s	s
2	–	$T_p \leq 2$
3	–	$2 < T_p \leq 3$
5	$0,5 < T_p \leq 5$	$3 < T_p \leq 5$
10 A	$2 < T_p \leq 10$	–
10	$4 < T_p \leq 10$	$5 < T_p \leq 10$
20	$6 < T_p \leq 20$	$10 < T_p \leq 20$
30	$9 < T_p \leq 30$	$20 < T_p \leq 30$
40	–	$30 < T_p \leq 40$

^a The manufacturer shall add the letter E to trip classes to indicate compliance with the band E.

When two poles are energized

With reference to Table 4, with the relay or release energized on three poles, at A times the current setting, tripping shall not occur in less than 2 h, starting from the cold state, at the value of the ambient air temperature stated in Table 4.

Moreover, when the value of the current flowing in two poles (in phase-loss sensitive relays or release those carrying the higher current) is subsequently increased to B times the current setting, and the third pole de-energized, tripping shall occur in less than 2 h.

The values shall apply to all combinations of poles.

In the case of relays or releases having an adjustable current setting, the characteristics shall apply both when the relay or release is carrying the current associated with the maximum setting, and when the relay is carrying the current associated with the minimum setting.

Table 4 – Limits of operation of three-pole inverse time-delay overload relays or releases when energized on two poles only

Type of overload relay or release	Multiples of current setting		Reference ambient air temperature
	A	B	
Thermal, compensated for ambient air temperature variations or electronic Not phase-loss sensitive	3 poles 1,0	2 poles 1,32 1 pole 0	+20 °C
Thermal, not compensated for ambient air temperature variations Not phase-loss sensitive	3 poles 1,0	2 poles 1,25 1 pole 0	+40 °C
Thermal, compensated for ambient air temperature variations or electronic Phase-loss sensitive	2 poles 1,0 1 pole 0,9	2 poles 1,15 1 pole 0	+20 °C

ii) Utilization categories AC-40, AC-1, AC-5a, AC-5b; DC-40, DC-1, DC-6

Conventional values for inverse time-delay overload relays or releases operation are given in Table 2.

At the reference temperature of $30\text{ °C} \pm 2\text{ °C}$ and at 1,05 times the current setting, i.e. with the conventional non-tripping current (3.7.30 of IEC 60947-1:2020), the opening release being energized on all poles, tripping shall not occur in less than the conventional time 2 h (1 h when $I_e < 63\text{ A}$) from the cold state i.e. with the CPS at the reference temperature.

Moreover, when at the end of the conventional time the value of current is immediately raised to 1,30 times the current setting, i.e. with the conventional tripping current (3.7.31 of IEC 60947-1:2020), tripping shall occur in less than the conventional time above.

NOTE 4 The reference temperature is the ambient air temperature on which the time/current characteristic of the CPS is based.

If a relay or release is declared by the manufacturer as substantially independent of ambient temperature, the current values of Table 2 shall apply within the temperature band declared by the manufacturer, within a tolerance of 0,3 % per K. The width of the temperature band shall be at least $\pm 10\text{ K}$ from the reference temperature.

8.2.1.5.1.2 Thermal memory test verification for utilization categories AC-2, AC-3, AC-3e, AC-4, DC-3, DC-5

Unless the manufacturer has specified that the device does not contain thermal memory, electronic overload relays shall fulfil the following requirements (see Figure 2):

- apply a current equal to I_e until the device has reached the thermal equilibrium;
- interrupt the current for a duration of $2 \times T_p$ (see Table 3) with a relative tolerance of $\pm 10\%$ (where T_p is the time measured at current D according to Table 2);

- apply a current equal to $7,2 \times I_e$;
- the relay shall trip within 50 % of time T_p .

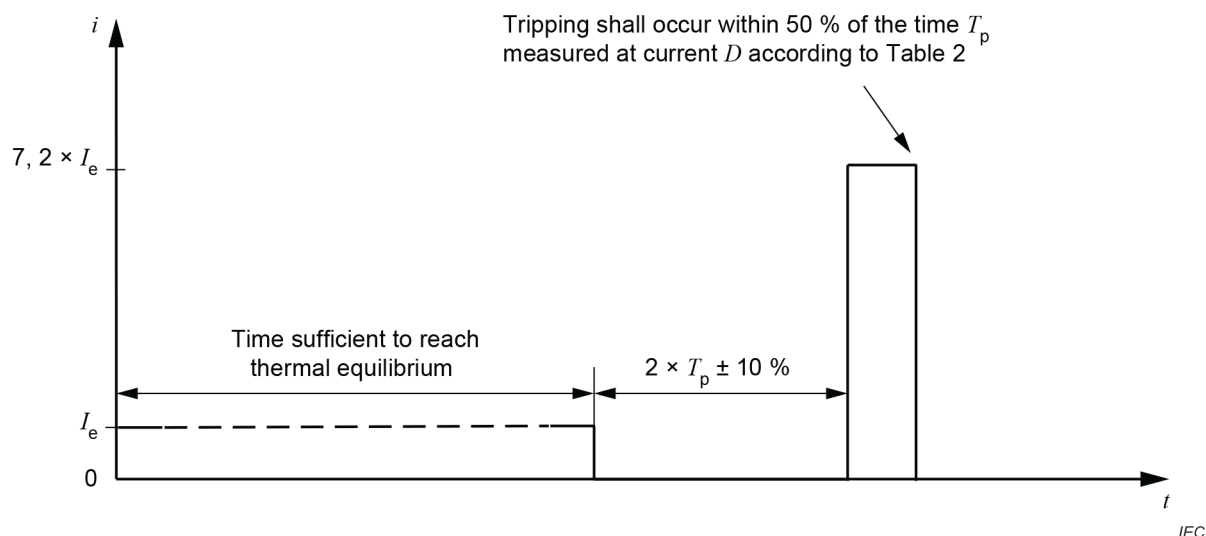


Figure 2 – Thermal memory test

8.2.1.5.1.3 Opening under overload conditions of instantaneous and definite time-delay overload relays or releases (types a) and b) in 5.7.2.3.1)

For all values of the current setting, the CPS shall trip with an accuracy of $\pm 10 \%$ of the specified tripping current value corresponding to the current setting.

8.2.1.5.2 Opening under short-circuit conditions

Instantaneous and definite time-delay short-circuit relays or releases (items a) and b) of 5.7.2.3.2).

For all values of the current setting, the CPS shall trip with an accuracy of $\pm 20 \%$ of the published tripping current value corresponding to the current setting.

8.2.1.5.3 Limits of operation of under-current relays or releases for automatic change-over

An under-current relay or release shall operate to open the CPS within 90 % to 110 % of the set time when the current during run is below 0,9 times the under-current setting in all poles.

8.2.1.5.4 Limits of operation of stall relay or release

A stall relay or release shall operate to open the CPS within 80 % to 120 % of the set time (stall inhibit time) or within the accuracy specified by the manufacturer, in the following cases:

- current sensing relays: the current is 20 % higher than the set stall current value;

EXAMPLE Set current of the stall relay: 100 A; set time: 6 s; accuracy: $\pm 10 \%$, the relay shall trip within 5,4 s and 6,6 s when the current is equal to or greater than $100 \text{ A} \times 1,2 = 120 \text{ A}$.

- rotation sensing relays: an input signal indicating no motor rotation exists.

8.2.1.5.5 Limits of operation of jam relay or release

A jam relay or release shall operate to open the CPS within 80 % to 120 % of the set time (jam inhibit time) or within the accuracy specified by the manufacturer, when the current is above 1,2 times the set current value of the jam relay or release, during running after completion of the starting.

8.2.2 Temperature-rise

8.2.2.1 General

Subclause 8.2.2 of IEC 60947-1:2020 applies to CPS's in a clean, new condition. In the case of conducting the test at a voltage below 100 V, such devices may have the contacts cleaned by any nonabrasive method or cycled with or without load several times prior to initiating the test.

NOTE Contact resistance due to oxidation is not considered to impact the temperature-rise test at test voltages above 100 V.

In the case of an electronically controlled electromagnet, coil temperature measuring by variation of resistance may be impracticable; in such a case, other methods are permitted, e.g. thermocouples or other suitable methods.

8.2.2.2 Terminals

The temperature-rise of terminals shall not exceed the values stated in Table 5.

Table 5 – Temperature-rise limits of terminals

Terminal material	Temperature-rise limits ^b K
Bare copper	60
Bare brass	65
Tin plated copper or brass	65
Silver plated or nickel plated copper or brass	70 ^a
Other metals	^c
^a The terminal temperature-rise limit of 70 K is based on the connection of PVC cables. The use in service of connected conductors or cables significantly smaller than those listed in Table 9 and 10 of IEC 60947-1:2020 could result in higher terminal and internal part temperatures and such conductors should not be used without the manufacturer's consent since higher temperatures could lead to equipment failure. ^b The specified temperature-rise limits apply to a new sample, as in test sequence I of 9.5.2. Those applicable to temperature-rise verifications, as in test sequence IV (9.5.5) are increased by 10 K. ^c Temperature-rise limits to be based on service experience or life tests but not exceeding 65 K.	

8.2.2.3 Accessible parts

The temperature-rise of accessible parts shall not exceed the values stated in Table 3 of IEC 60947-1: 2020.

8.2.2.4 Ambient air temperature

Subclause 8.2.2.4 of IEC 60947-1:2020 applies.

8.2.2.5 Main circuit

Subclause 8.2.2.5 of IEC 60947-1:2020 applies with the following addition.

The main circuit of a CPS, including the over current relays or releases, shall be capable of carrying the maximum rated operational current corresponding to the utilization category for uninterrupted, intermittent or temporary duty without the temperature-rise exceeding the limits specified in Table 5 of this document and Table 3 of IEC 60947-1:2020. An uninterrupted duty rating is required for utilization categories AC-40 and DC-40.

8.2.2.6 Control circuits

The control circuits, including control circuit devices to be used for the closing and opening operations of a CPS, shall permit the rated duties as specified in 5.3.4 and also the temperature-rise tests specified in 9.3.3.3.5 without the temperature-rise exceeding the limits specified in Table 5 of this document and Table 3 of IEC 60947-1:2020.

8.2.2.7 Windings of coils and electromagnets

8.2.2.7.1 Uninterrupted and 8 h duty windings

With the maximum value of current flowing through the main circuit, the windings of the coils shall withstand under continuous load and at the rated frequency, if applicable, their rated control circuit supply voltage without the temperature-rise exceeding the limits specified in Table 6.

NOTE Depending on the technology, e.g. for some kinds of electronically controlled electromagnets, the control circuit supply voltage cannot be directly applied on the coil winding when connected as in normal service.

8.2.2.7.2 Intermittent duty windings

With no current flowing through the main circuit the windings of the coils shall withstand, at the rated frequency, if applicable, their rated control circuit supply voltage (or the maximum rated control voltage in case of a range) applied as detailed in Table 7 according to their intermittent duty class, without the temperature-rise exceeding the limits specified in Table 6.

NOTE Depending on the technology, e.g. for some kind of electronically controlled electromagnet, the control circuit supply voltage cannot be directly applied on the coil winding when connected as in normal service.

Table 6 – Temperature-rise limits for insulated coils in air

Class of insulating material (according to IEC 60085)	Temperature-rise limit (measured by resistance variation) K
A	85
E	100
B	110
F	135
H	160

Table 7 – Intermittent duty test cycle data

Intermittent duty class of CPS	One close-open operating cycle every:	Interval of time during which the supply to the control coil is maintained
1	3 600 s	"ON time" shall correspond to the ON-load factor specified by the manufacturer
3	1 200 s	
12	300 s	
30	120 s	
120	30 s	
300	12 s	
1 200	3 s	

8.2.2.7.3 Specially rated (short-time or periodic duty) windings

Specially rated windings shall be tested under operating conditions corresponding to the most severe duty for which they are intended and their ratings shall be stated by the manufacturer.

8.2.2.8 Auxiliary circuits

Subclause 8.2.2.8 of IEC 60947-1:2020 applies.

8.2.2.9 Other parts

Subclause 8.2.2.1 of IEC 60947-1:2020 applies.

8.2.3 Dielectric properties

8.2.3.1 General

Subclause 8.2.3 of IEC 60947-1:2020 applies with the following addition.

8.2.3.2 Voltage limiting components between circuits

General requirements for device including voltage limiting components inserted between circuits not connected to the ground/earth to be tested according to the dielectric test are described as follows.

These voltages limiting components called varistors used in order to protect electronic parts from surges within the device shall comply with IEC 61051-2. In this subclause, the intent is not to reduce the clearances. For the type test of the device, the voltage limiting components may be disconnected.

IEC 61051-2 applies as follows:

a) Preferred climatic categories of the varistor:

- maximum lower temperature: $-10\text{ }^{\circ}\text{C}$;
- minimum upper temperature: $+85\text{ }^{\circ}\text{C}$.

The device manufacturer has to verify that the varistor is suitable for use in the extended ambient temperature if any.

b) The minimum rated voltage of the varistor shall be 1,2 times the maximum peak voltage where the varistor is connected.

c) When connected to the mains, varistors shall withstand the surge test according to 9.5.2.5.

NOTE 1 With the verification of the varistors above, it is assumed that a fuse protecting the varistor is not necessary.

NOTE 2 The possibility given in 9.3.3.4.1 item 1) of IEC 60947-1:2020 of disconnecting circuits between poles can be not appropriate in the routine test, because the products are completed and it is not appropriate to reopen and manipulate them. The main purpose of this test is to identify the proper operation of the voltage limiting component.

8.2.4 Performance under no load, normal load and overload conditions

8.2.4.1 Making and breaking capacities

CPS shall be capable of making and breaking currents without failure, under the conditions stated in Table 8 for the required utilization categories.

The OFF-time values stated in Table 8 and Table 9 shall not be exceeded.

Table 8 – Rated making and breaking capacities – Making and breaking conditions corresponding to the utilization categories

Utilization category	Make and break conditions					
	I_c / I_e	U_r / U_e	$\cos \phi$	ON-time ^b s	OFF-time s	Number of operating cycles
AC-40	6	1,05	0,5	0,05	e	24
AC-1	1,5	1,05	0,8	0,05	e	50
AC-2	4,0	1,05	0,65	0,05	e	50
AC-3 ^g	8,0	1,05	a	0,05	e	50
AC-3e ^g	8,5	1,05	a	0,05	e	50
AC-4 ^g	10,0	1,05	a	0,05	e	50
AC-5a	3,0	1,05	0,45	0,05	e	50
AC-5b	1,5 ^c	1,05	c			
			L/R (ms)			
DC-40	2,5	1,05	2,5	0,05	e	24 ^d
DC-1	1,5	1,05	1,0	0,05	e	50 ^d
DC-3	4,0	1,05	2,5	0,05	e	50 ^d
DC-5	4,0	1,05	15,0	0,05	e	50 ^d
DC-6	1,5 ^c	1,05	c	0,05	e	50 ^d
Utilization category	Make conditions					
	I / I_e	U / U_e	$\cos \phi$	ON-time ^b s	OFF-time s	Number of operating cycles
AC-3	10,0	1,05 ^f	a	0,05	e	50
AC-3e	12,0 ^h	1,05 ^f	h	0,05	e	50
AC-4	12,0	1,05 ^f	a	0,05	e	50
<i>I</i> Current made. The making current is expressed in direct current or AC RMS symmetrical values but it is understood that for alternating current the peak value of the asymmetrical current corresponding to the power factor of that circuit may assume a higher value <i>I_c</i> Current made and broken, expressed in direct current or AC RMS symmetrical values <i>I_e</i> Rated operational current <i>U</i> Applied voltage <i>U_r</i> Power frequency recovery voltage <i>U_e</i> Rated operational voltage $\cos \phi$ Power factor of test circuit L/R Time-constant of test circuit						
NOTE The 25 manual operations of footnote^g are intended for checking the continuity of service of the manual actuator of the CPS if any, but not for qualifying a CPS for manual operation.						

- a $\cos \phi$ is 0,45 for $I_e \leq 100$ A, 0,35 for $I_e > 100$ A.
- b Time may be less than 0,05 s provided that contacts are allowed to become properly seated before re-opening. For testing feasibility reason, in agreement with the manufacturer, a longer on-time time may be defined.
- c Tests to be carried out with an incandescent light load.
- d Half the operations with one polarity and the other half with reverse polarity.
- e Maximum OFF-time given in Table 9 which can be reduced in agreement with the manufacturer.
- f For U / U_e a tolerance of ± 20 % is accepted.
- g The make conditions shall also be verified. The verification may be made during the make break test, but only with the manufacturer's agreement. In this case, the making current multiples shall be as shown for I / I_e and the breaking current as shown for I_c / I_e . Twenty-five operating cycles shall be made at a control supply voltage equal to 110 % of the rated control circuit supply voltage U_s and 25 operating cycles at 85 % of U_s .
- h As an alternative the factor I / I_e can be selected at the manufacturer discretion between 12 and 13. In this case, the power factor is given by the following formulas:
 $I_e \leq 100$ A: $\cos \phi = 0,1 \times I / I_e - 0,85$
 $I_e > 100$ A: $\cos \phi = 0,1 \times I / I_e - 0,95$

Table 9 – Relationship between current broken I_c and OFF-time for the verification of rated making and breaking capacities

Current broken I_c A			OFF-time s
	$I_c \leq$	100	10
100	$< I_c \leq$	200	20
200	$< I_c \leq$	300	30
300	$< I_c \leq$	400	40
400	$< I_c \leq$	600	60
600	$< I_c \leq$	800	80
800	$< I_c \leq$	1 200	100
1 000	$< I_c \leq$	1 300	140
1 300	$< I_c \leq$	1 600	180
1 600	$< I_c$		240

8.2.4.2 Operational performance

Subclause 8.2.4.2 of IEC 60947-1:2020 applies with the following addition.

a) Conventional operational performance after making breaking capacity tests

CPS's shall be capable of making and breaking currents after making/breaking capacity tests, without failure under the conventional conditions stated in Table 10 for the required utilization categories and the number of operating cycles indicated.

ON-time shall be 0,05 s. It may be less than 0,05 s provided that contacts are allowed to become properly seated before re-opening.

OFF-time shall be not greater than the values specified in Table 9 except for utilization categories AC-5b and DC-6 where the OFF-time shall be 60 s.

b) *Operational performance before and after short-circuit tests at I_{cr} and I_{cs}*

CPS's shall be capable of making and breaking currents before and after short-circuit tests at I_{cr} and I_{cs} (see 8.2.5 a)) without failure under the conditions stated in Table 11 for the required utilization categories and the number of operating cycles indicated. The first 25 operating cycles after the I_{cs} short circuit test shall be performed by the local manual operating means, if any, the control function circuit being energized. A local manual operating means may be activated locally or remotely (e.g. handle, motor drive, solenoid etc.).

For all but the above 25 operating cycles, ON-time shall be 0,05 s. It may be less than 0,05 s provided that contacts are allowed to become properly seated before re-opening and the OFF-time shall be not greater than the values specified in Table 9 except for utilization categories AC-5b and DC-6 where the OFF-time shall be 60 s.

c) *Conventional mechanical operational performance*

In addition to the electrical operational performance requirements of item a), CPS's shall be capable of effecting mechanical close-open operating cycles without current in accordance with Table 10 and under the test conditions specified in 9.5.3.3.

For CPS's which can be fitted with under-voltage and/or shunt releases, 10 % of the total number of operating cycles shall be closing-tripping operations for each release, 5 % at the beginning and 5 % at the end of the test.

Table 10 – Conventional operational performance after making/breaking capacity tests – Making and breaking conditions according to utilization category

Category	I_c / I_e	U_r / U_e	$\cos \phi^d$	Number of operating cycles	
				with current	without current
AC-40	1,0	1,05	0,8	3 000	4 000
AC-1	1,0	1,05	0,8	6 000	4 000
AC-2	2,0	1,05	0,65	6 000	4 000
AC-3, AC-3e	2,0	1,05	a	6 000	4 000
AC-4	6,0	1,05	a	6 000	4 000
AC-5a	2,0	1,05	0,45	6 000	4 000
AC-5b	1,0 ^b	1,05	b		
			L/R (ms) ^e		
DC-40	1,0	1,05	2,5	3 000 ^c	4 000
DC-1	1,0	1,05	1,0	6 000 ^c	4 000
DC-3	2,5	1,05	2,5	6 000 ^c	4 000
DC-5	2,5	1,05	15,0	6 000 ^c	4 000
DC-6	1,0 ^b	1,05	b	6 000 ^c	4 000
I	Current made. In AC the conditions for making are expressed in RMS values but it is understood that the peak value of asymmetrical current, corresponding to the power-factor of the circuit, may assume a higher value				
I_c	Current made or broken. Except for AC-5b or DC-6, the making current is expressed in direct current or AC RMS symmetrical values but it is understood that the actual value will be the peak value corresponding to the power-factor of the circuit				
I_e	Rated operational current				
U_r	Power frequency or DC recovery voltage				
U	Applied voltage				
U_e	Rated operational voltage				
$\cos \phi$	Power factor of test circuit				
L/R	Time-constant of test circuit				
a	$\cos \phi$ is 0,45 for $I_e \leq 100$ A, 0,35 for $I_e > 100$ A.				
b	The test shall be carried out with an incandescent light load.				
c	Half of the operating cycles with one polarity and the other half with reverse polarity.				
d	Tolerance for $\cos \phi$: $\pm 0,05$.				
e	Tolerance for L/R : ± 15 %.				

Table 11 – Operational performance before and after short-circuit tests at I_{cr} and I_{cs} – Making and breaking conditions according to utilization category

Category	Value of the rated operational current	Make			Break			Number of operating cycles before and after	
		I / I_e	U / U_e	$\cos \phi^d$	I_c / I_e	U_r / U_e	$\cos \phi^d$	I_{cr}	I_{cs}
AC-40	(all values)	1	1	0,8	1	1	0,8	1 500	750
AC-1	(all values)	1	1	0,95	1	1	0,95	3 000	1 500
AC-2	(all values)	2,5	1	0,65	2,5	1	0,65	3 000	1 500
AC-3, AC-3e	$I_e \leq 17 \text{ A}$	6	1	0,65	1	0,17	0,65	3 000	1 500
	$I_e > 17 \text{ A}$	6	1	0,35	1	0,17	0,35	3 000	1 500
AC-4	$I_e \leq 17 \text{ A}$	6	1	0,65	6	1	0,65	3 000	1 500
	$I_e > 17 \text{ A}$	6	1	0,35	6	1	0,35	3 000	1 500
AC-5a	(all values)	2	1	0,45	2	1	0,45	3 000	1 500
AC-5b ^b	(all values)	1	1	a	1	1	a	3 000	1 500
				$L/R_e \text{ (ms)}$			$L/R_e \text{ (ms)}$		
DC-40	(all values)	1	1	1	1	1	1	1 500 ^c	750 ^c
DC-1	(all values)	1	1	1	1	1	1	3 000 ^c	1 500 ^c
DC-3	(all values)	2,5	1	2	2,5	1	2	3 000 ^c	1 500 ^c
DC-5	(all values)	2,5	1	7,5	2,5	1	7,5	3 000 ^c	1 500 ^c
DC-6 ^b	(all values)	1	1		1	1		3 000 ^c	1 500 ^c
I Current made. In alternating current the conditions for making are expressed in RMS values but it is understood that the peak value of asymmetrical current, corresponding to the power-factor of the circuit, may assume a higher value I_c Current made or broken. Except for AC-5b or DC-6, the making current is expressed in direct current or AC RMS symmetrical values but it is understood that the actual value will be the peak value corresponding to the power-factor of the circuit I_e Rated operational current U_r Power frequency or DC recovery voltage U Applied voltage U_e Rated operational voltage $\cos \phi$ Power factor of test circuit L/R Time-constant of test circuit ^a $\cos \phi$ is 0,45 for $I_e \leq 100 \text{ A}$, 0,35 for $I_e > 100 \text{ A}$. ^b The test to be carried out with an incandescent light load. ^c Half of the operating cycles with one polarity and the other half with reverse polarity. ^d Tolerance for $\cos \phi$: $\pm 0,05$. ^e Tolerance for L/R: $\pm 15 \%$.									

8.2.4.3 Durability

8.2.4.3.1 Mechanical durability

Subclause 8.2.4.3.1 of IEC 60947-1:2020 applies.

8.2.4.3.2 Electrical durability

Subclause 8.2.4.3.2 of IEC 60947-1:2020 applies.

8.2.5 Ability to make, carry and break short-circuit currents

The CPS shall be capable of withstanding, the thermal, dynamic and electrical stresses, resulting from short-circuit currents.

Short-circuit currents may be encountered during current making, current carrying in the closed position and current interruption.

- a) The ability of the CPS to make, carry and break short-circuit currents is stated in terms of the following according to Table 12 or preferably Table 13 at the discretion of the manufacturer. Both tables are considered equivalent for the product to comply with this document:
 - conventional prospective current I_{cr} and conventional prospective current "r" (I_r);
 - rated service short-circuit breaking capacity I_{cs} (see 5.3.6).
- b) An additional test of three making and breaking operations shall be made at a current equal to 80 % of the instantaneous maximum tripping value of the instantaneous tripping release if this 80 % value exceeds the value of the I_c/I_e given in Table 8 (see 9.5.6).
- c) Four-pole CPS's shall comply with the requirements of 9.3.4.1.6 items a), b), c), as applicable.

NOTE Table 13 has been introduced for harmonization purpose with UL 60947-4-1 and is equivalent to the corresponding requirements of UL 60947-4-1.

Table 12 – Value of the prospective test current according to the rated operational current

Maximum I_e for a given construction	I_{cr}		Conventional prospective current "r" (I_r) ^a
A	$(I_{cr})/(I_e \text{ max.})$	min. kA	kA
$I_e \leq 16$	30	0,2	1
$16 < I_e \leq 32$	30	0,2	3
$32 < I_e \leq 63$	25	1	3
$63 < I_e \leq 125$	20	1,6	5
$125 < I_e \leq 250$	20	1,6	10
$250 < I_e \leq 315$	15	5	10
$315 < I_e \leq 630$	15	5	18
^a If the CPS is not specified according to utilization category AC-3, the prospective current "r" shall be subject of agreement between manufacturer and user.			

The power-factor or the time-constant shall be according to Table 16 of IEC 60947-1:2020.

Table 13 – Value of the prospective test current according to the rated operational current (harmonized table)

Rated operational current I_e (AC-3) ^{a, e}	I_{cr}		Conventional prospective current " r " ^f	Power factor
A	$(I_{cr})/(I_e \text{ max.})$	min. kA	kA	
$I_e \leq 12$	30	0,2	1	0,7 to 0,8
$12 < I_e \leq 50$ ^b	25	1	3	0,7 to 0,8
$50 < I_e \leq 100$ ^c	20	1,6	5	0,7 to 0,8
$100 < I_e \leq 250$ ^d	20	1,6	10	0,5 to 0,7
$250 < I_e \leq 500$	15	5	18	0,2 to 0,3
NOTE This table will be moved into the future revision of IEC 60947-1 and is therefore numbered differently to the other tables in this document.				
^a If the CPS is not specified according to utilization category AC-3, the conventional prospective current " r " shall be subject of agreement between manufacturer and user. ^b at 690 V and above: $12 < I_e \leq 63$. ^c at 690 V and above: $63 < I_e \leq 125$. ^d at 690 V and above: $125 < I_e \leq 250$ ^e Rated operational current may be marked "motor full load current" in North America. ^f Conventional prospective current " r " is called "standard fault current" in North America.				

8.2.6 Pole impedance

Subclause 8.2.6 of IEC 60947-1:2020 applies.

8.2.7 Leakage currents of equipment suitable for isolation

Subclause 8.2.7 of IEC 60947-1:2020 applies.

8.2.8 Coil power consumption

The power consumption of the electromagnet of a CPS characterises the power supplying its coil necessary for holding and pick up operations.

Where the power consumption of the coil is given, it shall be tested according to 9.3.3.9.

8.2.9 Co-ordination between a CPS and another short-circuit protective device

For the co-ordination between a CPS and another short-circuit protective device, see Annex X of IEC 60947-1:2020.

8.3 Electromagnetic compatibility (EMC)

8.3.1 General

Subclause 8.3.1 of IEC 60947-1:2020 applies with the following addition.

This equipment is inherently sensitive to voltage dips and short time interruptions on the control supply; it shall react within the limits of 8.2.1.2 and this is verified by the operating limits tests given in 9.3.3.2.

The immunity test levels of this document, based on the requirements of IEC 60947-1:2020, correspond to the severe industrial environment defined in IEC 61000-6-2. Higher immunity test levels can be necessary especially for outdoor high voltage substation as defined by IEC 61000-6-5.

8.3.2 Immunity

Subclause 8.3.2 of IEC 60947-1:2020 applies with the following addition.

Table 14 – Performance criteria when EM disturbances are present

Item	Performance criteria		
	A	B	C
Overall performance	No noticeable changes of the operating characteristic Operating as intended	Temporary degradation or loss of performance which is self-recoverable	Temporary degradation or loss of performance which requires operator intervention or system reset
Operation of power and control circuits	No maloperation according to the basis given under ^a	Temporary maloperation which cannot cause tripping according to the basis given under ^b ; unintentional separation or closure of contact is not accepted Self-recoverable	Tripping of overload relay; unintentional separation or closure of contact
Operation of displays, control panels and auxiliary circuits	No changes to display information Only slight light intensity fluctuation of LEDs, or slight movement of characters	Temporary visible changes or loss of information Undesired LED illumination No maloperation of auxiliary contacts	Shut down Permanent loss of display or wrong information Unpermitted operating mode Maloperation of auxiliary contacts Not self-recoverable
Information processing and sensing functions	Undisturbed communication and data interchange to external devices	Temporarily disturbed communication, with error reports of the internal and external devices	Erroneous processing of information Loss of data and/or information Errors in communication Not self-recoverable
^a Performance criterion A is based on the result of the following test procedure: during the test, the CPS when loaded at 0,9 times the current setting shall not trip, and when loaded at 2,0 times the current setting it shall trip within 0,9 times the minimum value and 1,1 times the maximum value of the manufacturer's time-current characteristic, and the monitoring functions, if any, shall correctly indicate the status of the CPS. ^b Performance criterion B is based on the result of the following test procedure: during the test, the CPS when loaded at 0,9 times the current setting shall not trip. After the test, the CPS shall comply with the manufacturer's time-current characteristic when loaded at 2,0 times the current setting and the monitoring functions, if any, shall correctly indicate the status of the CPS.			

The test values and procedures are given in 9.4.2.

8.3.3 Emission

Subclause 8.3.3 of IEC 60947-1:2020 applies with the following addition.

The test values and procedures are given in 9.4.3.

The level of severity required for environment B covers those required for environment A.

The devices covered by this document do not generate significant levels of harmonics and therefore no harmonic tests are required.

9 Tests

9.1 Kind of tests

9.1.1 General

Subclause 9.1.1 of IEC 60947-1:2020 applies with the following addition.

If there is no distinction between U_s and U_c , requirements apply with U_c . Unless otherwise specified all tests are made by energizing and de-energizing remotely the control function circuit.

9.1.2 Type test

Subclause 9.1.2 of IEC 60947-1:2020 applies with the following addition.

The tests are also intended to verify the products with their dedicated accessories.

9.1.3 Routine tests

Subclause 9.1.3 of IEC 60947-1:2020 applies with the following addition.

Routine tests comprise:

- operation and operating limits (9.6.2);
- dielectric tests (9.6.3).

The combined test of 9.3.3.4.2 of IEC 60947-1:2020 is permitted.

For dedicated wiring accessories delivered separately, only dielectric test applies.

9.1.4 Sampling tests

Sampling tests for clearance verification shall be made in accordance with 9.3.3.4.3 of IEC 60947-1:2020.

If by the control of materials and manufacturing processes, the integrity of the dielectric properties has been proven, the routine tests may be replaced by sampling tests according to a recognized sampling plan (see ISO 2859-1:1999).

The combined test of 9.3.3.4.2 of IEC 60947-1:2020 is permitted.

9.1.5 Special tests

9.1.5.1 General

The conducting of special test is at the discretion of the manufacturer.

Special tests include:

- environment tests according to 9.1.5.2;
- mechanical and electrical durability tests according to Annex A. The test results can be used to obtain data needed for functional safety applications (see Annex K).