



IEC 61095

Edition 3.0 2023-10
REDLINE VERSION

INTERNATIONAL STANDARD



Electromechanical contactors for household and similar purposes





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Electromechanical contactors for household and similar purposes

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FOR HOUSEHOLD AND SIMILAR PURPOSES****FOREWORD**

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IEC 61095 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, in conjunction with subcommittee 23E: Circuit-breakers and similar equipment for household use, of IEC technical committee 23: Electrical accessories. It is an International Standard.

This third edition cancels and replaces the second edition published in 2009. This edition constitutes a technical revision.

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

- a) addition of requirements for screwless terminals;
- b) addition of requirements for the switching of LED lamps. Contactors for domestic and similar applications can be used for controlling lighting loads which is increasingly using LED lamp technology. A specific category for contactors is created: AC-7d. Requirements and tests are added to cover this market development, mainly for making and breaking and conventional operational performance;
- c) addition of requirements for contactors with electronically controlled electromagnet. Household contactors with electronically controlled electromagnet are available for years on the market. To fully cover such device, requirements and tests are added, dealing mainly with operating limits, behaviour in abnormal conditions, breakdown of components, EMC tests, etc.
- d) Embedded software. More and more contactors are incorporating electronic circuits with embedded software. A reference is provided to guide the design of the software.

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

Draft	Report on voting
121A/566/FDIS	121A/573/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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- reconfirmed,
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INTRODUCTION

This document gives requirements for contactors household and similar purposes, including contactors for distribution control in buildings.

Contactors for such purposes have particular requirements which include test sequences and sampling plans to facilitate testing.

Contactors according to this document are limited in the range of operational currents and operational voltages to values appropriate to the applications. Such contactors are for use in circuits of limited prospective short-circuit fault current for which they ~~need to be~~ are co-ordinated with an appropriate short-circuit protective device to provide suitable co-ordination.

This document defines in a single document the specific utilization category for a described application and states the relevant requirements. As far as possible, it is in line with the requirements contained in IEC 60947-4-1.

This document also applies to contactors which are components of an appliance, unless otherwise stated in the standard covering the relevant appliance.

ELECTROMECHANICAL CONTACTORS FOR HOUSEHOLD AND SIMILAR PURPOSES

1 Scope

This document applies to electromechanical air break contactors for household and similar purposes provided with main contacts intended to be connected to circuits the rated voltage of which does not exceed 440 V AC (between phases) with rated operational currents less than or equal to 63 A for utilization category AC-7a, and 32 A for utilization categories AC-7b, AC-7c and AC-7d (expressed in rated power), and rated conditional short-circuit current less than or equal to 6 kA.

~~The contactors dealt with in this standard are not normally designed to interrupt short-circuit currents. Therefore, suitable short-circuit protection (see 9.3.4) shall form part of the installation.~~

NOTE Today, most LED lamp manufacturers provide information in Watt. So, the main contactor characteristic for utilization category AC-7d is expressed in Watt to be directly applicable to the corresponding LED lamp load.

Specific requirements apply to contactors equipped with screwless-type terminals.

This document does not apply to

- contactors complying with IEC 60947-4-1;
- semiconductor contactors;
- contactors designed for special applications;
- auxiliary contacts of contactors. These are dealt with in IEC 60947-5-1.

This document states

- 1) the characteristics of contactors.
- 2) the conditions with which contactors ~~shall~~ comply with reference to:
 - a) their operation and behaviour;
 - b) their dielectric properties;
 - c) the degrees of protection provided by their enclosures, where applicable;
 - d) their construction;
 - e) their electromagnetic compatibility characteristics.
- 3) the tests intended for confirming that these conditions have been met, and the methods to be adopted for these tests.
- 4) the test sequences and the number of samples.
- 5) the information to be given with contactors or in the manufacturer's literature.

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.

IEC 60028:1925, *International standard of resistance for copper*

~~IEC 60050-151:2001, International Electrotechnical Vocabulary (IEV) – Part 151: Electrical and magnetic devices~~

~~IEC 60050-441:1984, International Electrotechnical Vocabulary (IEV) – Chapter 441: Switchgear, controlgear and fuses
Amendment 1 (2000)~~

~~IEC 60050-604:1987, International Electrotechnical Vocabulary (IEV) – Chapter 604: Generation, transmission and distribution of electricity – Operation
Amendment 1 (1998)~~

~~IEC 60050-826:2004, International Electrotechnical Vocabulary (IEV) – Part 826: Electrical installations~~

IEC 60068-2-78:20012012, Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state

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

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

~~IEC 60099-1:1991, Surge arresters – Part 1: Non-linear resistor type gapped surge arresters for a.c. systems
Amendment 1 (1999)~~

IEC 60112:20032020, Method for the determination of the proof and the comparative tracking indices of solid insulating materials

~~IEC 60216 (all parts), Electrical insulating materials – Properties of thermal endurance~~

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

IEC 60417-DB:2007⁴, Graphical symbols for use on equipment, available at <https://www.graphical-symbols.info/equipment>

IEC 60445:20062021, Basic and safety principles for man-machine interface, marking and identification – Identification of equipment terminals, conductor terminations and conductors

IEC 60447:2004, Basic and safety principles for man-machine interface, marking and identification – Actuating principles

IEC 60529:1989, Degrees of protection provided by enclosures (IP Code)

IEC 60529:1989/AMD1:1999

IEC 60529:1989/AMD2:2013

IEC 60664-1:20072020, Insulation coordination for equipment within low-voltage supply systems – Part 1: Principles, requirements and tests

IEC 60695-2-10:20002021, Fire hazard testing – Part 2-10: Glowing/hot-wire based test methods – Glow-wire apparatus and common test procedure

⁴ – “DB” refers to the IEC on-line database.

IEC 60695-2-11:~~2000~~2021, *Fire hazard testing – Part 2-11: Glowing/hot-wire based test methods – Glow-wire flammability test method for end products (GWEPT)*

IEC 60695-11-10:~~1999~~2013, *Fire hazard testing – Part 11-10: Test flames – 50 W horizontal and vertical flame test methods*
~~Amendment 1 (2003)~~

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

IEC 60947-4-1:~~2000~~2018, *Low-voltage switchgear and controlgear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters*
~~Amendment 1 (2002)~~
~~Amendment 2 (2005)~~

IEC 60947-5-1:~~2003~~2016, *Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices*

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

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

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

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

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

IEC 61000-4-11, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests for equipment with input current up to 16 A per phase*

IEC 61000-4-34, *Electromagnetic compatibility (EMC) – Part 4-34: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests for equipment with input current more than 16 A per phase*

IEC 61140:~~2001~~2016, *Protection against electric shock – Common aspects for installation and equipment*
~~Amendment 1 (2004)~~

IEC 61180:2016, *High-voltage test techniques for low-voltage equipment – Definitions, test and procedure requirements, test equipment*

CISPR 14-1:2020, *Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus – Part 1: Emission*

ISO 7000:~~2004~~2019, *Graphical symbols for use on equipment – ~~Index and synopsis~~ Registered symbols*

ISO 2039-2:1987, *Plastics – Determination of hardness – Part 2: Rockwell hardness*

3 Terms and definitions

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

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

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

3.1 General terms

3.1.1

overcurrent

current exceeding the rated current

[SOURCE: IEC 60050-441:1984, 441-11-06]

3.1.2

short-circuit

accidental or intentional conductive path between two or more conductive parts forcing the electric potential differences between these conductive parts to be equal to or close to zero

[SOURCE: IEC 60050-151:2001, 151-12-04]

3.1.3

short-circuit current

overcurrent resulting from a short circuit due to a fault or an incorrect connection in an electric circuit

[SOURCE: IEC 60050-441:1984, 441-11-07]

3.1.4

overload

operating conditions in an electrically undamaged circuit, which cause an overcurrent

[SOURCE: IEC 60050-441:1984, 441-11-08]

3.1.5

overload current

overcurrent occurring in an electrically undamaged circuit

3.1.6

ambient air temperature

temperature, determined under prescribed conditions, of the air surrounding the complete switching device or fuse

Note 1 to entry: For switching devices or fuses installed inside an enclosure, it is the temperature of the air outside the enclosure.

[SOURCE: IEC 60050-441:1984, 441-11-13]

3.1.7

conductive part

part which is capable of conducting current although it may not necessarily be used for carrying service current

[SOURCE: IEC 60050-441:1984, 441-11-09]

3.1.8**exposed conductive part**

conductive part which can readily be touched and which is not normally alive, but which may become alive under fault conditions

Note 1 to entry: Typical exposed conductive parts are walls of enclosures, operating handles, etc.

[SOURCE: IEC 60050-441:1984, 441-11-10]

3.1.9**electric shock**

physiological effect resulting from an electric current through a human or ~~animal body~~ livestock

[SOURCE: IEC 60050-826:2022, 826-12-01]

3.1.10**live part**

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

Note 1 to entry: This concept does not necessarily imply a risk of electric shock.

[SOURCE: IEC 60050-826:2022, 826-12-08, modified — Rewording of the definition and addition of a Note 1 to entry.]

3.1.11**protective conductor** (identification: PE)

conductor provided for purposes of safety

EXAMPLE Protection against electric shock.

Note 1 to entry: In an electrical installation, the conductor identified PE is normally also considered as protective earthing conductor.

[SOURCE: IEC 60050-826:2022, 826-13-22, modified — Rewording of the definition, addition of a new example and a new Note 1 to entry.]

3.1.12**neutral conductor**

conductor electrically connected to the neutral point and capable of contributing to the distribution of electric energy

[SOURCE: IEC 60050-826:2021, 826-14-07]

3.1.13**PEN conductor**

conductor combining the functions of both a protective earthing conductor and a neutral conductor

[SOURCE: IEC 60050-826:2022, 826-13-25]

3.1.14**PEM conductor**

conductor combining the functions of both a protective earthing conductor and a mid-point conductor

[SOURCE: IEC 60050-826:2022, 826-13-26]

3.1.15

PEL conductor

conductor combining the functions of both a protective earthing conductor and a line conductor

[SOURCE: IEC 60050-826:2022, 826-13-27]

3.1.16

enclosure

part providing a specified degree of protection of equipment against certain external influences and a specified degree of protection against approach to or contact with live parts and moving parts

Note 1 to entry: This definition is similar to IEC 60050-441:1984, 441-13-01, which applies to assemblies.

[SOURCE: IEC 60050-441:1984, 441-13-01, modified — Rewording of the definition and new Note 1 to entry.]

3.1.17

integral enclosure

enclosure which forms an integral part of the equipment

3.1.18

utilization category

<switching device or fuse> combination of specified requirements related to the condition in which the switching device or the fuse fulfils its purpose, selected to represent a characteristic group of practical applications

Note 1 to entry: The specified requirements ~~may~~ can concern e.g. the values of making capacities (if applicable), breaking capacities and other characteristics, the associated circuits and the relevant conditions of use and behaviour.

[SOURCE: IEC 60050-441:1984, 441-17-19]

3.2 Switching devices

3.2.1

switching device

device designed to make or break the current in one or more electric circuits

Note 1 to entry: A switching device ~~may~~ can perform one or both of these operations.

[SOURCE: IEC 60050-441:1984, 441-14-01, modified — Addition of a Note 1 to entry.]

3.2.2

mechanical switching device

switching device designed to close and open one or more electric circuits by means of separable contacts

Note 1 to entry: Any mechanical switching device ~~may~~ can be designated according to the medium in which its contacts open and close, e.g. air, SF₆, oil.

[SOURCE: IEC 60050-441:1984, 441-14-02]

3.2.3

semiconductor switching device

switching device designed to make and/or break the current in an electric circuit by means of the controlled conductivity of a semiconductor

Note 1 to entry: This definition differs from IEC 60050-441:1984, 441-14-03 since a semiconductor switching device is also designed for breaking the current.

[SOURCE: IEC 60050-441:1984, 441-14-03, modified — Addition of “and/or break” and new Note 1 to entry.]

3.2.4

fuse

device that, by the fusing of one or more of its specially designed and proportioned components, opens the circuit in which it is inserted by breaking the current when this exceeds a given value for a sufficient time

Note 1 to entry: The fuse comprises all the parts that form the complete device

[SOURCE: IEC 60050-441:1984, 441-18-01]

3.2.5

circuit-breaker

mechanical switching device, capable of making, carrying and breaking currents under normal circuit conditions and also making, carrying for a specified time and breaking currents under specified abnormal circuit conditions such as those of short circuit

[SOURCE: IEC 60050-441:1984, 441-14-20, modified — “Duration” replaced with “time”.]

3.2.6

~~{mechanical}~~ **contactor**

contactor

mechanical switching device having only one position of rest, operated otherwise than by hand, capable of making, carrying and breaking currents under normal circuit conditions including operating overload conditions

Note 1 to entry: The term “operated otherwise than by hand” means that the device is intended to be controlled and kept in working position from one or more external supplies.

~~NOTE 2 – In French, a contactor the main contacts of which are closed in the position of rest is usually called “rupteur”. The word “rupteur” has no equivalent in the English language.~~

Note 2 to entry: A household contactor can have a handle as additional means for operation. In some countries, contactors can be controlled by a signal from the energy supplier during off-peak hours. An end user is allowed to open or close manually the contactor if necessary.

Note 3 to entry: A contactor is usually intended to operate frequently.

[SOURCE: IEC 60050-441:1984, 441-14-33, modified — Addition of Notes to entry.]

3.2.7

electromagnetic contactor

contactor, in which the force for closing the normally open main contacts or opening the normally closed main contacts is provided by an electromagnet

Note 1 to entry: The electromagnet can be electronically controlled.

3.2.8

electronically controlled electromagnet

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

3.2.9

latched contactor

contactor, the moving elements of which are prevented by means of a latching arrangement from returning to the position of rest when the operating means are de-energized

Note 1 to entry: The latching, and the release of the latching, ~~may~~ can be mechanical, electromagnetic, pneumatic, etc.

Note 2 to entry: Because of the latching, the latched contactor actually acquires a second position of rest and, according to 3.2.6 is not, strictly speaking, a contactor. However, since the latched contactor in both its utilization and its design is more closely related to contactors in general than to any other classification of switching device, it is considered proper to require that it complies with the specifications for contactors wherever they are appropriate.

[SOURCE: IEC 60050-441:1984, 441-14-34]

3.2.10

semiconductor contactor

solid state contactor

device which performs the function of a contactor by utilizing a semiconductor switching device

Note 1 to entry: A semiconductor contactor ~~may~~ can also contain mechanical switching devices.

3.2.11

pilot switch

non-manual control switch actuated in response to specified conditions of an actuating quantity

Note 1 to entry: The actuating quantity ~~may~~ can be pressure, temperature, velocity, liquid level, elapsed time, etc.

[SOURCE: IEC 60050-441:1984, 441-14-48]

3.2.12

push-button

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

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

3.2.13

short-circuit protective device

SCPD

device intended to protect a circuit or parts of a circuit against short-circuit currents by interrupting them

3.2.14

surge arrester

device designed to protect the electrical apparatus from high transient overvoltages and to limit the duration and frequently the amplitude of the follow-on current

[SOURCE: IEC 60050-614:2016, 614-03-51, modified — Addition of “to protect the electrical apparatus from high transient overvoltages and”.]

3.3 Parts of switching devices

3.3.1

pole

<switching device> portion of a switching device associated exclusively with one electrically separated conducting path of its main circuit and excluding those portions which provide a means for mounting and operating all poles together

Note 1 to entry: A switching device is called single-pole if it has only one pole. If it has more than one pole, it ~~may~~ **can** be called multipole (two-pole, three-pole, etc.) provided the poles are or can be coupled in such a manner as to operate together.

[SOURCE: IEC 60050-441:1984, 441-15-01]

3.3.2

main circuit

<switching device> all the conductive parts of a switching device included in the circuit which it is designed to close or open

[SOURCE: IEC 60050-441:1984, 441-15-02]

3.3.3

control circuit

<switching device> all the conductive parts (other than the main circuit) of a switching device which are included in a circuit used for the closing operation or opening operation, or both, of the device

[SOURCE: IEC 60050-441:1984, 441-15-03]

3.3.4

auxiliary circuit

<switching device> all the conductive parts of a switching device which are intended to be included in a circuit other than the main circuit and the control circuits of the device

Note 1 to entry: Some auxiliary circuits fulfil supplementary functions such as signalling, interlocking, etc., and, as such, they ~~may~~ **can** be part of the control circuit of another switching device.

[SOURCE: IEC 60050-441:1984, 441-15-04]

3.3.5

contact

<mechanical switching device> conductive parts designed to establish circuit continuity when they touch and which, due to their relative motion during an operation, open or close a circuit or, in the case of hinged or sliding contacts, maintain circuit continuity

[SOURCE: IEC 60050-441:1984, 441-15-05]

3.3.6

contact

contact (piece)

one of the conductive parts forming a contact

[SOURCE: IEC 60050-441:1984, 441-15-06]

3.3.7

main contact

contact included in the main circuit of a mechanical switching device, intended to carry, in the closed position, the current of the main circuit

[SOURCE: IEC 60050-441:1984, 441-15-07]

3.3.8

control contact

~~contact included in a control circuit of a mechanical switching device and mechanically operated by this device~~

~~[IEV 441-15-09]~~

3.3.8

auxiliary contact

contact included in an auxiliary circuit and mechanically operated by the switching device

[SOURCE: IEC 60050-441:1984, 441-15-10]

3.3.9

auxiliary switch

<mechanical switching device> switch containing one or more control and/or auxiliary contacts mechanically operated by a switching device

[SOURCE: IEC 60050-441:1984, 441-15-11]

3.3.10

"a" contact

make contact

control or auxiliary contact which is closed when the main contacts of the mechanical switching device are closed and open when they are open

[SOURCE: IEC 60050-441:1984, 441-15-12]

3.3.11

"b" contact

break contact

control or auxiliary contact which is open when the main contacts of the mechanical switching device are closed and closed when they are open

[SOURCE: IEC 60050-441:1984, 441-15-13]

3.3.12

release

<mechanical switching device> device, mechanically connected to a mechanical switching device, which releases the holding means and permits the opening or the closing of the switching device

Note 1 to entry: A release can have instantaneous, time-delay, etc. operation.

[SOURCE: IEC 60050-441:1984, 441-15-17]

3.3.13

actuating system

<mechanical switching device> whole of the operating means of a mechanical switching device which transmits the actuating force to the contact pieces

Note 1 to entry: The operating means of an actuating system ~~may~~ can be mechanical, electromagnetic, hydraulic, pneumatic, thermal, etc.

3.3.14

actuator

part of the actuating system to which an external actuating force is applied

Note 1 to entry: The actuator ~~may~~ can take the form of a handle, knob, push-button, roller, plunger, etc.

[SOURCE: IEC 60050-441:1984, 441-15-22]

3.3.15

position indicating device

part of a mechanical switching device which indicates whether it is in the open, closed, or, where appropriate, earthed position

[SOURCE: IEC 60050-441:1984, 441-15-25]

3.3.16

terminal

conductive part of a device provided for electrical connection to external circuits

3.3.17

screw-type terminal

terminal intended for the connection and disconnection of conductors or for the interconnection of two or more conductors, the connection being made, directly or indirectly, by means of screws or nuts of any kind

3.3.18

screwless-type terminal

terminal intended for the connection and disconnection of conductors or for the interconnection of two or more conductors, the connection being made, directly or indirectly, by means of springs, wedges, eccentrics or cones, etc.

3.3.19

universal terminal

terminal for the connection and disconnection of all types of conductors (solid, stranded and flexible)

[SOURCE: IEC 60998-2-2:2002, 3.101.1, modified – "(rigid and flexible)" replaced with "(solid, stranded and flexible)".]

3.3.20

non-universal terminal

terminal for the connection and disconnection of a certain kind of conductor only (for example, solid conductors only or solid and stranded conductors only)

[SOURCE: IEC 60998-2-2:2002, 3.101.2, modified – "rigid [solid and stranded]" replaced with "solid and stranded".]

3.3.21

push-wire terminal

non-universal terminal in which the connection is made by pushing in solid or stranded conductors

[SOURCE: IEC 60998-2-2:2002, 3.101.3, modified – "rigid (solid or stranded)" replaced with "solid or stranded".]

3.3.22

thread-forming tapping screw

tapping screw having an uninterrupted thread

Note 1 to entry: It is not a function of this thread to remove material from the hole.

Note 2 to entry: An example of a thread-forming tapping screw is shown in Figure 1.

3.3.23

thread-cutting tapping screw

tapping screw having an interrupted thread

Note 1 to entry: The thread is intended to remove material from the hole.

Note 2 to entry: An example of a thread-cutting tapping screw is shown in Figure 2.

3.3.24

clamping unit

part of a terminal necessary for the mechanical clamping and the electrical connection of the conductor(s)

3.3.25

unprepared conductor

conductor which has been cut and the insulation of which has been removed for insertion into a terminal

Note 1 to entry: A conductor, the shape of which is arranged for introduction into a terminal or the strands of which are twisted to consolidate the end is considered to be an unprepared conductor.

3.3.26

prepared conductor

~~conductor, the strands of which are soldered or the end of which is fitted with a cable lug, eyelet, etc.~~

a conductor the end of which is fitted with an attachment such as eyelet, sleeve or cable lug

[SOURCE: IEC 60050-442:1998, 442-01-27]

3.3.27

solid conductor

conductor consisting of a single wire

Note 1 to entry: The cross-section of the solid conductor can be circular or shaped.

Note 2 to entry: Solid conductor is defined as class 1 conductor in IEC 60228, or by IEC TR 60344, or equivalent AWG/kcmil.

[SOURCE: IEC 60050-461:2008, 461-01-06, modified – In Note 1 to entry, "may" changed to "can", and Note 2 to entry has been added.]

3.3.28

stranded conductor

conductor consisting of a number of wires, all or some of which are wound in a helix

Note 1 to entry: Stranded conductor is defined as class 2 conductor in IEC 60228, or by IEC TR 60344, or equivalent AWG/kcmil.

[SOURCE: IEC 60050-151:2001, 151-12-36, modified – Note 1 to entry has been added.]

3.3.29**rigid conductor**

solid or stranded conductor having wires of such diameters, or so assembled, that the conductor is not suitable for use in a flexible cable.

[SOURCE: IEC 60947-1:2020, 3.5.31]

3.3.30**flexible conductor**

stranded conductor having wires of diameters small enough and so assembled that the conductor is suitable for use in a flexible cable

Note 1 to entry: Flexible conductor is defined as class 5 or class 6 conductor in IEC 60228, or by IEC TR 60344, or equivalent AWG/kcmil.

[SOURCE: IEC 60050-461:2008, 461-01-11, modified – Note 1 to entry has been added.]

3.4 Operation of switching devices**3.4.1****operation**

<mechanical switching device> transfer of the moving contact(s) from one position to an adjacent position

Note 1 to entry: For a circuit-breaker, this ~~may~~ can be a closing operation or an opening operation.

Note 2 to entry: If distinction is necessary, an operation in the electrical sense, e.g. make or break, is referred to as a switching operation, and an operation in the mechanical sense, e.g. close or open, is referred to as a mechanical operation.

[SOURCE: IEC 60050-441:1984, 441-16-01]

3.4.2**operating cycle**

<mechanical switching device> succession of operations from one position to another and back to the first position through all other positions, if any

[SOURCE: IEC 60050-441:1984, 441-16-02]

3.4.3**operating sequence**

<mechanical switching device> succession of specified operations with specified time intervals

[SOURCE: IEC 60050-441:1984, 441-16-03]

3.4.4**~~automatic control~~**

~~control of an operation without human intervention, in response to the occurrence of predetermined conditions~~

~~[IEV 441-16-05]~~

3.4.4**closing operation**

<mechanical switching device> operation by which the device is brought from the open position to the closed position

[SOURCE: IEC 60050-441:1984, 441-16-08]

3.4.5

opening operation

<mechanical switching device> operation by which the device is brought from the closed position to the open position

[SOURCE: IEC 60050-441:1984, 441-16-09]

3.4.6

closed position

<mechanical switching device> position in which the predetermined continuity of the main circuit of the device is secured

[SOURCE: IEC 60050-441:1984, 441-16-22]

3.4.7

open position

<mechanical switching device> position in which the predetermined dielectric withstand voltage requirements are satisfied between open contacts in the main circuit of the device

Note 1 to entry: This definition differs from IEC 60050-441:1984, 441-16-23 to meet the requirements of dielectric properties.

[SOURCE: IEC 60050-441:1984, 441-16-23, modified — Replacement of “clearance” with “dielectric withstand voltage requirements are satisfied”.]

3.4.8

position of rest

<contactor> position which the moving elements of the contactor take up when its electromagnet or its compressed-air device is not energized

[SOURCE: IEC 60050-441:1984, 441-16-24]

3.4.9

inching

jogging

energizing a motor or solenoid repeatedly for short periods to obtain small movements of the driven mechanism

3.4.10

plugging

stopping or reversing a motor rapidly by reversing the motor primary connections while the motor is running

3.5 Characteristic quantities

3.5.1

nominal value

value of a quantity used to designate and identify a component, device, equipment, or system

Note 1 to entry: The nominal value is generally a rounded value.

[SOURCE: IEC 60050-151:2001, 151-16-09]

3.5.2

limiting value

in a specification of a component, device, equipment, or system, the greatest or smallest admissible value of a quantity

[SOURCE: IEC 60050-151:2001, 151-16-10]

3.5.3**rated value**

value of a quantity used for specification purposes, established for a specified set of operating conditions of a component, device, equipment, or system

[SOURCE: IEC 60050-151:2001, 151-16-08]

3.5.4**rating**

set of rated values and operating conditions

[SOURCE: IEC 60050-151:2001, 151-16-11]

3.5.5**prospective current**

<of a circuit and with respect to a switching device or a fuse> current that would flow in the circuit if each pole of the switching device or the fuse were replaced by a conductor of negligible impedance

Note 1 to entry: The method to be used to evaluate and to express the prospective current is specified in the relevant publications.

[SOURCE: IEC 60050-441:1984, 441-17-01]

3.5.6**prospective peak current**

peak value of a prospective current during the transient period following initiation

Note 1 to entry: The definition assumes that the current is made by an ideal switching device, i.e. with instantaneous transition from infinite to zero impedance. For circuits where the current can follow several different paths, e.g. polyphase circuits, it further assumes that the current is made simultaneously in all poles, even if only the current in one pole is considered.

[SOURCE: IEC 60050-441:1984, 441-17-02]

3.5.7**maximum prospective peak current**

<AC circuit> prospective peak current when initiation of the current takes place at the instant which leads to the highest possible value

Note 1 to entry: For a multipole device in a polyphase circuit, the maximum prospective peak current refers to a single pole only.

[SOURCE: IEC 60050-441:1984, 441-17-04]

3.5.8**breaking current**

<switching device or fuse> current in a pole of a switching device or in a fuse at the instant of initiation of the arc during a breaking process

Note 1 to entry: For AC the current is expressed as the symmetrical RMS value of the AC component.

[SOURCE: IEC 60050-441:1984, 441-17-07, modified — Addition of a new Note 1 to entry.]

3.5.9**breaking capacity**

<switching device or fuse> value of prospective current that a switching device or a fuse is capable of breaking at a stated voltage under prescribed conditions of use and behaviour

Note 1 to entry: The voltage to be stated and the conditions to be prescribed are dealt with in the relevant product standard.

Note 2 to entry: For AC, the current is expressed as the symmetrical RMS value of the AC component.

Note 3 to entry: For short-circuit breaking capacity, see 3.5.11.

[SOURCE: IEC 60050-441:1984, 441-17-08, modified — Addition of Notes 2 and 3 to entry.]

3.5.10

making capacity

<switching device> value of prospective making current that a switching device is capable of making at a stated voltage under prescribed conditions of use and behaviour

Note 1 to entry: The voltage to be stated and the conditions to be prescribed are dealt with in the relevant product standard.

Note 2 to entry: For short-circuit making capacity, see 3.5.12.

[SOURCE: IEC 60050-441:1984, 441-17-09, modified — Addition of a new Note 2 to entry.]

3.5.11

short-circuit breaking capacity

breaking capacity for which the prescribed conditions include a short-circuit at the terminals of the switching device

[SOURCE: IEC 60050-441:1984, 441-17-11]

3.5.12

short-circuit making capacity

making capacity for which prescribed conditions include a short circuit at the terminals of the switching device

[SOURCE: IEC 60050-441:1984, 441-17-10]

3.5.13

joule integral

I^2t

integral of the square of the current over a given time interval

$$I^2t = \int_{t_0}^{t_1} i^2 dt$$

[SOURCE: IEC 60050-441:1984, 441-18-23, modified — Deletion of Notes to entry.]

3.5.14

cut-off current

let-through current

maximum instantaneous value of current attained during the breaking operation of a switching device or a fuse

Note 1 to entry: This concept is of particular importance when the switching device or the fuse operates in such a manner that the prospective peak current of the circuit is not reached.

[SOURCE: IEC 60050-441:1984, 441-17-12]

3.5.15

applied voltage

<switching device> voltage which exists across the terminals of a pole of a switching device just before the making of the current

Note 1 to entry: This definition applies to a single-pole device. For a multipole device, it is the phase-to-phase voltage across the supply terminals of the device.

[SOURCE: IEC 60050-441:1984, 441-17-24, modified — New Note 1 to entry.]

3.5.16

recovery voltage

voltage which appears across the terminals of a pole of a switching device or a fuse after the breaking of the current

Note 1 to entry: This voltage ~~may~~ can be considered in two successive intervals of time, one during which a transient voltage exists, followed by a second one during which the power frequency voltage or the steady-state recovery voltage alone exists.

Note 2 to entry: This definition applies to a single-pole device. For a multipole device it is the phase-to-phase voltage across the supply terminals of the device.

[SOURCE: IEC 60050-441:1984, 441-17-25, modified — New Note 2 to entry.]

3.5.17

transient recovery voltage

TRV

recovery voltage during the time in which it has a significant transient character

Note 1 to entry: The transient voltage ~~may~~ can be oscillatory or non-oscillatory or a combination of these depending on the characteristics of the circuit, the switching device or the fuse. It includes the voltage shift of the neutral of a polyphase circuit.

[SOURCE: IEC 60050-441:1984, 441-17-26, modified — Replacement in the note of “and the switching device” with the “switching device or the fuse”.]

3.5.18

power-frequency recovery voltage

recovery voltage after the transient voltage phenomena have subsided

[SOURCE: IEC 60050-441:1984, 441-17-27]

3.5.19

DC steady-state recovery voltage

recovery voltage in a DC circuit after the transient voltage phenomena have subsided, expressed by the mean value where ripple is present

[SOURCE: IEC 60050-441:1984, 441-17-28]

3.5.20

clearance

distance between two conductive parts along a string stretched the shortest way between these conductive parts

[SOURCE: IEC 60050-441:1984, 441-17-31]

3.5.21

creepage distance

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

Note 1 to entry: A joint between two pieces of insulating material is considered part of the surface.

3.5.22

working voltage

highest RMS value of the AC voltage or the highest value of the DC voltage which ~~may~~ can occur (locally) across any insulation at rated supply voltage, transients being disregarded, in open circuit conditions or under normal operating conditions

3.5.23**impulse withstand voltage**

highest peak value of an impulse voltage, of prescribed form and polarity, which does not cause breakdown under specified conditions of test

3.5.24**power-frequency withstand voltage**

RMS value of a power-frequency sinusoidal voltage which does not cause breakdown under specified conditions of test

3.5.25**pollution**

any addition of foreign matter, solid, liquid or gaseous (ionized gases) that ~~may~~ can affect dielectric strength or surface resistivity

3.5.26**pollution degree**

<environmental conditions> conventional number based on the amount of conductive or hygroscopic dust, ionized gas or salt and on the relative humidity and its frequency of occurrence, resulting in hygroscopic absorption or condensation of moisture leading to reduction in dielectric strength and/or surface resistivity

Note 1 to entry: The pollution degree of the micro-environment to which equipment is exposed ~~may~~ can be different from that of the macro-environment where the equipment is located because of protection offered by means such as an enclosure or internal heating to prevent absorption or condensation of moisture.

Note 2 to entry: For the purposes of this document, the pollution degree is that of the micro-environment.

3.5.27**micro-environment**

<clearance or creepage distance> ambient conditions which surround the clearance or creepage distance under consideration

Note 1 to entry: The micro-environment of the creepage distance or clearance and not the environment of the equipment determines the effect on the insulation. The micro-environment ~~may~~ can be better or worse than the environment of the equipment. It includes all factors influencing the insulation such as climatic and electromagnetic conditions, generation of pollution, etc.

3.5.28**overvoltage category**

<in a circuit or within an electrical system> conventional number based on limiting (or controlling) the values of prospective transient overvoltages occurring in a circuit (or within an electrical system having different nominal voltages) and depending on the means employed to influence the overvoltages

Note 1 to entry: In an electrical system, the transition from one overvoltage category to one of a lower category is obtained through appropriate means complying with interface requirements, such as an overvoltage protective device or a series-shunt impedance arrangement capable of dissipating, absorbing, or diverting the energy in the associated surge current, to lower the transient overvoltage value to that of the desired lower overvoltage category.

3.5.29**co-ordination of insulation**

correlation of insulating characteristics of electrical equipment with the expected overvoltages and the characteristics of overvoltage protective devices on the one hand, and with the expected micro-environment and the pollution protective means on the other hand

3.5.30**homogeneous field****uniform field**

electric field which has an essentially constant voltage gradient between electrodes, such as that between two spheres where the radius of each sphere is greater than the distance between them

3.5.31**inhomogeneous field
non-uniform field**

electric field which does not have an essentially constant voltage gradient between electrodes

3.5.32**tracking**

progressive formation of conducting paths which are produced on the surface of a solid insulating material, due to the combined effects of electric stress and electrolytic contamination on that surface

3.5.33**comparative tracking index
CTI**

numerical value of the maximum voltage in volts at which a material withstands 50 drops of a test solution without tracking

Note 1 to entry: The value of each test voltage and the CTI ~~should be~~ are divisible by 25.

Note 2 to entry: This definition is based on 3.5 of IEC 60112: ~~2003~~ 2020.

4 Classification

Subclause 5.2 gives all data which ~~may~~ can be used as criteria for classification.

5 Characteristics of contactors**5.1 Summary of characteristics**

The characteristics shall be stated in the following terms, where such terms are applicable:

- type of contactor (see 5.2);
- rated and limiting values for main circuits (see 5.3);
- utilization category (see 5.4);
- control circuits (see 5.5);
- auxiliary circuits (see 5.6);
- co-ordination with short-circuit protective devices (see 5.7).

5.2 Type of contactor**5.2.1 General**

The following shall be stated (see also Clause 6):

5.2.2 Number of poles**5.2.3 Method of control**

- automatic (by pilot switch or sequence control);
- non-automatic (e.g. by hand operation or by push-buttons);
- semi-automatic (i.e. partly automatic, partly non-automatic).

5.3 Rated and limiting values for main circuits**5.3.1 General**

The rated values established for a contactor shall be stated in accordance with 5.3.2 to 5.4 and 5.7, ~~but it may not be necessary to establish all the listed values.~~

5.3.2 Rated voltages

5.3.2.1 General

A contactor is defined by the rated voltages given in 5.3.2.2 to 5.3.2.4.

5.3.2.2 Rated operational voltage (U_e)

A rated operational voltage of a contactor is a value which, combined with a rated operational current, determines the application of the contactor and to which the relevant tests and the utilization categories are referred.

For a single-pole contactor, the rated operational voltage is generally stated as the voltage across the pole.

For a multipole contactor, it is generally stated as the voltage between phases.

NOTE 1 A contactor ~~may~~ can be assigned a number of combinations of rated operational voltages and rated operational currents or powers for different duties and utilization categories.

NOTE 2 A contactor ~~may~~ can be assigned a number of rated operational voltages and associated making and breaking capacities for different duties and utilization categories.

NOTE 3 Attention is drawn to the fact that the operational voltage ~~may~~ can differ from the working voltage (see 3.5.22) within a contactor.

5.3.2.3 Rated insulation voltage (U_i)

The rated insulation voltage of a contactor is the value of voltage to which dielectric tests voltage and creepage distances are referred.

In no case shall the maximum value of the rated operational voltage exceed that of the rated insulation voltage.

NOTE For contactors without a specified rated insulation voltage, the highest value of the rated operational voltage is considered to be the rated insulation voltage.

5.3.2.4 Rated impulse withstand voltage (U_{imp})

The peak value of an impulse voltage of prescribed form and polarity which the contactor is capable of withstanding without failure under specified conditions of test and to which the values of the clearances are referred.

The rated impulse withstand voltage of a contactor shall be equal to or higher than the values stated for the transient overvoltages occurring in the circuit in which the contactor is fitted.

NOTE Preferred values of rated impulse withstand voltage are given in Table 16.

5.3.3 Currents or powers

5.3.3.1 General

A contactor is defined by the currents given in 5.3.3.2 to 5.3.3.4.

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

The conventional free air thermal current is the maximum value of test current to be used for temperature-rise tests of an unenclosed contactor in free air (see 9.3.3.3).

The value of the conventional free air thermal current shall be at least equal to the maximum value of the rated operational current (see 5.3.3.4) of the unenclosed contactor in eight-hour duty (see 5.3.5.2).

Free air is understood to be air in normal indoor conditions, reasonably free from draughts and external radiation.

NOTE 1 This current is not a rating and is not mandatorily marked on the contactor.

NOTE 2 An unenclosed contactor is a contactor supplied by the manufacturer without an enclosure or a contactor supplied by the manufacturer with an integral enclosure which is not normally intended to be the sole contactor protective enclosure. An unenclosed contactor is characterised by IP00.

5.3.3.3 Conventional enclosed thermal current (I_{the})

The conventional enclosed thermal current is the value of current stated by the manufacturer to be used for the temperature-rise tests of the contactor when mounted in a specified enclosure. Such tests shall be in accordance with 9.3.3.3 and are mandatory if the contactor is described as an enclosed contactor in the manufacturer's catalogues and normally intended for use with one or more enclosures of specified type and size (see Note 2 of 5.3.3.2).

The value of the conventional enclosed thermal current shall be at least equal to the maximum value of the rated operational current (see 5.3.3.4) of the enclosed contactor in eight-hour duty (see 5.3.5.2).

If the contactor is normally intended for use in unspecified enclosures, the test is not mandatory if the test for conventional free air thermal current (I_{th}) has been made. In this case, the manufacturer shall be prepared to give guidance on the value of the enclosed thermal current or the derating factor.

NOTE 1 This current is not a rating and is not mandatorily marked on the contactor.

NOTE 2 An enclosed contactor is a contactor normally intended for use with a specified type and size of enclosure or intended for use with more than one type of enclosure.

5.3.3.4 Rated operational currents (I_e) or rated ~~operational~~ powers

A rated operational current of a contactor is stated by the manufacturer and takes into account the rated operational voltage (see 5.3.2.2), the conventional free air or enclosed thermal current, the rated frequency (see 5.3.4), the rated duty (see 5.3.5), the utilization category (see 5.4) and the type of protective enclosure, if any.

In the case of a contactor for the direct switching of individual motors or LED lamps, the indication of a rated operational current ~~may can~~ be replaced or supplemented by an indication of the maximum rated power ~~output~~, at the rated operational voltage considered, of the ~~motor~~ load for which the contactor is intended. The manufacturer shall be prepared to state the relationship assumed between the operational current and the ~~operational~~ power.

5.3.4 Rated frequency

The supply frequency for which a contactor is designed and to which the other characteristic values correspond.

NOTE The same contactor ~~may can~~ be assigned a number or a range of rated frequencies.

5.3.5 Rated duties

5.3.5.1 General

The rated duties considered as normal are given in 5.3.5.2 to 5.3.5.5.

5.3.5.2 Eight-hour duty (continuous duty)

A duty in which the main contacts of a contactor remain closed while carrying a steady current long enough for the contactor to reach thermal equilibrium but not for more than eight hours without interruption.

NOTE 1 This is the basic duty on which the conventional thermal currents I_{th} and I_{the} of the contactor are determined.

NOTE 2 Interruption means breaking the current by operating the contactor.

5.3.5.3 Intermittent periodic duty or intermittent duty

A duty with on-load periods, during which the main contacts of a contactor remain closed, having a definite relation to off-load periods, both periods being too short to allow the contactor to reach thermal equilibrium.

Intermittent duty is characterized by the value of the current, the duration of the current flow and by the on-load factor which is the ratio of the in-service period to the entire period, often expressed as a percentage.

According to the number of operating cycles which they are capable of carrying out per hour, contactors are divided into the following preferred classes:

– class	1:	1	operating cycle per hour;
– class	3:	3	operating cycles per hour;
– class	12:	12	operating cycles per hour;
– class	30:	30	operating cycles per hour;
– class	120:	120	operating cycles per hour;
– class	300:	300	operating cycles per hour;
– class	1 200:	1 200	operating cycles per hour.

A contactor intended for intermittent duty ~~may~~ can be designated by the characteristics of intermittent duty.

EXAMPLE An intermittent duty comprising a current flow of 32 A for 2 min within every 5 min ~~may~~ can be stated as: 32 A, class 12, 40 %.

5.3.5.4 Temporary duty

Duty in which the main contacts of a contactor remain closed for periods insufficient to allow the contactor to reach thermal equilibrium, the on-load periods being separated by off-load periods of sufficient duration to restore equality of temperature with the cooling medium.

5.3.5.5 Periodic duty

A type of duty in which operation, whether at constant or variable load, is regularly repeated.

5.3.6 Normal load and overload characteristics

5.3.6.1 General

This subclause gives general requirements concerning ratings under normal load and overload conditions.

Detailed requirements are given in 8.2.4.

5.3.6.2 Ability to withstand motor switching overload currents

A contactor intended for switching motors shall be capable of withstanding the thermal stresses due to starting and accelerating a motor to normal speed and due to operating overloads.

Requirements to meet these conditions are given in 8.2.4.4.

5.3.6.3 Rated making capacity

Requirements for the various utilization categories (see 5.4) are given in 8.2.4.2. The rated making and breaking capacities are only valid when the contactor is operated in accordance with the requirements of 8.2.1.1 and 8.2.1.2.

5.3.6.4 Rated breaking capacity

Requirements for the various utilization categories (see 5.4) are given in 8.2.4.2. The rated making and breaking capacities are only valid when the contactor is operated in accordance with the requirements of 8.2.1.1 and 8.2.1.2.

5.3.6.5 Conventional operational performance

Specified as a series of making and breaking operations in 8.2.4.3.

5.3.7 Rated conditional short-circuit current

The rated conditional short-circuit current of a contactor is the value of prospective current stated by the manufacturer, that the contactor, protected by a short-circuit protective device specified by the manufacturer, can withstand satisfactorily for the operating time of this device under the test conditions specified in 9.3.4.

The details of the specified short-circuit protective device shall be stated by the manufacturer.

NOTE The rated conditional short-circuit current is expressed by the RMS value of the AC component.

5.4 Utilization category

5.4.1 General

The utilization category of a contactor defines the intended application and is characterized by one or more of the following service conditions:

- current(s), expressed as multiple(s) of the rated operational current;
- voltage(s), expressed as multiple(s) of the rated operational voltage;
- power-factor.

The standard utilization categories are given in Table 1.

Each utilization category is characterized by the values of the currents, voltages, power-factors and other data of Table 7 and Table 9 and by the test conditions specified in this document.

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 7.

Unless otherwise stated, contactors of utilization category AC-7b are designed on the basis of the starting characteristics of the motors compatible with the making capacities of Table 7. When the starting current of a motor, with stalled rotor, exceeds these values, the operational current should be decreased accordingly.

5.4.2 Assignment of utilization categories based on the results of tests

A contactor 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 another utilization category without testing provided that the test currents, voltages, power-factors, number of operating cycles, ON and OFF times given in Table 7 and Table 9 and the test circuit for the assigned utilization category are not more severe than those at which the contactor has been tested and the temperature-rise has been verified at a current not less than the highest assigned rated operational current in continuous duty.

Table 1 – Utilization categories

Utilization categories ^a	Typical ~~applications~~ loads
AC-7a	Slightly inductive ~~loads~~
AC-7b	Motor ~~loads~~ ^b
AC-7c	Switching of compensated electric discharge lamp control ^c
AC-7d	LED lamp
^a Contactors ~~may~~ ~~can~~ have other utilization categories, in which case they shall comply with the requirements of IEC 60947-4-1 for such categories. ^b The AC-7b category ~~may~~ ~~can~~ be used for occasional inching (jogging) or plugging for limited time periods; during such limited time periods the number of operations should not exceed 5/min or more than 10 in a 10-minute period. ^c This category is similar to a capacitive switching category AC-6b as defined in IEC 60947-4-1 for the switching of capacitor banks, the characteristic being very dependent on the capacitance value of the lamp circuit.	

5.5 Control circuits

The characteristics of control circuits are:

- kind of current;
- rated frequency;
- rated control circuit voltage U_c (nature and frequency);
- rated control supply voltage U_s (nature and frequency), where applicable;
- suitability to be connected to SELV circuits.

NOTE A distinction has been made above between the control circuit voltage, which would appear across the "a" contacts (see 3.3.10) in the control circuit, and the control supply voltage, which is the voltage applied to the input terminals of the control circuit of the contactor and which ~~may~~ ~~can~~ be different from the control circuit voltage owing to the presence of built-in transformers, rectifiers, resistors, etc.

The rated control circuit voltage and rated frequency, if any, are the values on which the operating and temperature-rise characteristics of the control circuit are based.

5.6 Auxiliary circuits

The characteristics of auxiliary circuits are the number and kind of contacts ("a" contact, "b" contact, etc.) in each of these circuits and their ratings according to IEC 60947-5-1.

The characteristics of auxiliary contacts and switches shall comply with the requirements of IEC 60947-5-1.

5.7 Co-ordination with short-circuit protective devices

Contactors are characterized by the type, ratings and characteristics of the short-circuit protective devices (SCPD) to be used to provide adequate protection of the contactor against short-circuit currents. Requirements are given in 8.2.5.

6 Product information

6.1 Nature of information

6.1.1 General

The information given in 6.1.2 to 6.1.3 shall be given by the manufacturer.

6.1.2 Identification

- a) the manufacturer's name or trade mark;
- b) type designation or serial number;
- c) number of this document, ~~if the manufacturer claims compliance.~~

6.1.3 Characteristics, basic rated values and utilization

- c) rated operational voltages (see 5.3.2.2);
- d) utilization category and rated operational currents (or rated powers), at the rated operational voltage (see 5.3.3.4 and 5.4);
- e) value of the rated frequency/frequencies, e.g.: 50 Hz or 50 Hz/60 Hz;
- f) rated duty with indication of the class of intermittent duty, if any (see 5.3.5).

Associated values:

- g) rated making and breaking capacities. These indications ~~may~~ can be replaced, where applicable, by the indication of the utilization category (see Table 7);

Safety and installation:

- h) rated insulation voltage (see 5.3.2.3);
- i) rated impulse withstand voltage (see 5.3.2.4), the marking of U_{imp} is not required if equal to 4 kV;
- j) IP code, in case of an enclosed contactor (see 8.1.11);
- k) pollution degree (see 7.1.4.2);
- l) rated conditional short-circuit current (see 5.3.7) and the type, current rating and characteristics of the associated SCPD;
- m) ~~vacant~~

For non-universal screwless terminals:

- "s" or "sol" for terminals declared for solid conductors;
- "r" for terminals declared for solid and stranded conductors;
- "f" for terminals declared for flexible conductors.

Control circuits (see 5.5):

The following information concerning control circuits shall be placed either on the coil or on the contactor:

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

For contactors, the control circuit of which is intended to be connected to a SELV supply:

- p) suitability of the control circuit to be connected to a SELV supply, the main circuit being supplied with a voltage having a value greater than that of the SELV circuit.

- q) In case the control circuit is supplied by another means than the main power supply (e.g., control circuit connected to a SELV supply), additional characteristics or the reference type should be provided for selection criteria of the power supply unit.

Auxiliary circuits:

- r) ratings of auxiliary circuits (see 5.6).

6.2 Marking

Markings shall be indelible and easily legible.

Marking of the manufacturer's name or trademark and type designation or serial number is mandatory on the contactor, preferably on the nameplate if any, to enable complete data to be obtained from the manufacturer.

NOTE 1 In the USA and Canada, the rated operational voltage U_e ~~may~~ can be marked as follows:

- on equipment for use on three-phase – four-wire systems, by both the value of phase-to-earth voltage and that of phase-to-phase voltage, e.g. 277/480 V;
- on equipment for use on three-phase – three-wire systems, by the value of phase-to-phase voltage, e.g. 480 V.

The following information shall be marked and visible after mounting:

- direction of movement of the actuator (see 8.1.5.3), if applicable;
- indication of the position of the actuator (see also 8.1.6.1 and 8.1.6.2);
- ~~– reference to this standard, if the manufacturer claims compliance.~~

The following information shall be marked and visible after wiring, before installation of covers or lids:

- for miniaturized contactors, symbol, colour code or letter code;
- terminal identification and marking (see 8.1.7.4);
- IP code and class of protection against electric shock, when applicable (marked preferably on the contactor as far as possible).

Markings shall not be placed on screws, removable washers or other removable parts.

Data under k) shall be indicated on the enclosure, if any.

Data under c) shall be ~~indicated~~ marked on the ~~nameplate~~ product.

Data under n), if relevant, shall be indicated on the nameplate, or marked on the contactor or, if the space available is not sufficient, on the smallest package unit or in technical information provided with the product or in the manufacturer's published literature. In the case of a group of terminals located together, a single marking on the device is acceptable. An appropriate marking indicating the length of insulation to be removed before insertion of the conductor into the terminal shall be shown on the contactor.

Data under d) to j), l), m) and o) to s) shall be included on the nameplate, or on the contactor, or in the manufacturer's published literature.

The manufacturer's published literature can be provided digitally for example using an electronically readable identifier on the equipment or its packaging (see IEC 63365).

The marking of terminals shall be in accordance with Annex A of this document.

NOTE 2 Additional utilization categories according to IEC 60947-4-1 ~~may~~ can also be marked (see footnote a to Table 1).

6.3 Instructions for installation, operation and maintenance

~~The manufacturer shall specify in his documents or catalogues the conditions, if any, for installation, operation and maintenance of the contactor during operation and after a fault.~~

~~If necessary, the instructions for the transport, installation and operation of the contactor shall indicate the measures that are of particular importance for the proper and correct installation, commissioning and operation of the contactor.~~

~~These documents shall indicate the recommended extent and frequency of maintenance, if any.~~

The contactor shall be installed in accordance with all specifications given in 6.1, considering its intended use.

Information shall be provided if the control circuit is to be protected by a short circuit protective device.

Maintenance is unusual for contactors intended for household applications.

7 Normal service, mounting and transport conditions

7.1 Normal service conditions

7.1.1 General

Contactors complying with this document shall be capable of operating under the following standard conditions.

7.1.2 Ambient air temperature

The ambient air temperature does not exceed +40 °C and its average over a period of 24 h does not exceed +35 °C.

The lower limit of the ambient air temperature is –5 °C.

Ambient air temperature is that existing in the vicinity of the contactor if supplied without enclosure, or in the vicinity of the enclosure if supplied with an enclosure.

Contactors intended to be used in ambient air temperatures above +40 °C (particularly in tropical countries) or below –5 °C shall either be specially designed or be used according to the information given in the manufacturer's catalogue.

7.1.3 Altitude

The altitude of the site of installation does not exceed 2 000 m.

For installations at higher altitudes than 2000 m, ~~it is necessary to take into account the reduction of the dielectric strength and the cooling effects of the air~~ instruction shall be provided in the contactor documentation.

~~Contactors intended to be so used shall be designed especially or used according to an agreement between manufacturer and user.~~

~~Information in the manufacturer's catalogue may take the place of such an agreement.~~

7.1.4 Atmospheric conditions

7.1.4.1 Humidity

The relative humidity of the air does not exceed 50 % at a maximum temperature of +40 °C. Higher relative humidity ~~may~~ can be permitted at lower temperatures, e.g. 90 % at +20 °C. ~~Special measures may be necessary in cases of occasional condensation due to variation in temperature.~~

NOTE The pollution degrees given in 7.1.4.2 define the environmental conditions more precisely.

7.1.4.2 Pollution degree

The pollution degree (see 3.5.26) refers to the environmental conditions for which the contactor is intended.

NOTE The micro-environment of the creepage distance or clearance and not the environment of the contactor determines the effect on the insulation. The micro-environment ~~may~~ can be better or worse than the environment of the contactor. It includes all the factors influencing the insulation, such as climatic and electromagnetic conditions, generation of pollution, etc.

For contactors intended for use within an enclosure or provided with an integral enclosure, the pollution degree of the environment in the enclosure is applicable.

For the purposes of evaluating clearances and creepage distances, the following four degrees of pollution of the micro-environment are established (the clearances and creepage distances being according to the different pollution degrees given in Table 17 and Table 18)

Pollution degree 1:

No pollution or only dry, non-conductive pollution occurs.

Pollution degree 2:

Normally, only non-conductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation ~~may~~ can be expected.

Pollution degree 3:

Conductive pollution occurs, or dry, non-conductive pollution occurs which becomes conductive due to condensation.

Pollution degree 4:

The pollution generates persistent conductivity caused, for instance, by conductive dust or by rain or snow.

Standard pollution degree of household and similar applications:

Contactors for household and similar applications are generally for use in a pollution degree 2 environment.

7.1.5 Normal electromagnetic environmental conditions

The normal electromagnetic environmental conditions are those which relate to low-voltage public networks such as residential, commercial and light industrial locations/installations.

7.2 Conditions during transport and storage

The conditions during transport and storage, e.g. temperature and humidity, are those defined in 7.1, except that, unless otherwise specified, the following temperature range applies during transport and storage: between -25 °C and $+55\text{ °C}$ and, for short periods not exceeding 24 h, up to $+70\text{ °C}$.

7.3 Mounting

The contactor shall be mounted in accordance with the manufacturer's instructions.

8 Constructional and performance requirements

8.1 Constructional requirements

8.1.1 General

The contactor with its enclosure, if any, whether integral or not, shall be designed and constructed to withstand the stresses occurring during installation and normal use and, in addition, shall provide a specified degree of resistance to abnormal heat and fire.

NOTE An enclosed contactor is a contactor mounted in an enclosure, designed and dimensioned to contain one contactor only.

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

8.1.2 Materials

8.1.2.1 General

The suitability of materials used is verified by making the following tests on the contactor and/or, if not practicable, on parts taken from it.

- resistance to ageing (see 8.1.2.2)
- resistance to humidity (see 8.1.2.3)
- resistance to heat (see 8.1.2.4)
- resistance to abnormal heat and fire (see 8.1.2.5)
- resistance to rusting (see 8.1.2.6)

As far as resistance to heat, abnormal heat and fire hazard are concerned, priority shall be given to tests made on the contactor or on a suitable part taken from the contactor.

However, in certain cases, tests on materials ~~may~~ can be used, for practical reasons, as an alternative to tests on the contactor.

8.1.2.2 Resistance to ageing

Contactors shall be resistant to ageing.

In general, it is only necessary to test contactors having (or supplied with) enclosures or parts of p.v.c. or similar thermoplastic material and parts of rubber such as sealing rings and gaskets.

Compliance is checked by inspection and, if necessary, by a test according to 9.2.2.1.

8.1.2.3 Resistance to humidity

The contactor shall be protected against the effects of humidity which ~~may~~ can occur in normal service.

Compliance shall be verified by the test specified in 9.2.2.2.

8.1.2.4 Resistance to heat

All parts of enclosed, partially enclosed and unenclosed contactors intended to prevent access to live parts shall not be adversely affected by the highest temperature likely to be reached during normal service.

Compliance shall be verified by the tests specified in 9.2.2.3.1 and 9.2.2.3.2.

8.1.2.5 Resistance to abnormal heat and fire

Parts of insulating material which might be exposed to thermal stresses due to electrical effects, the deterioration of which might impair the safety of the contactor, shall not be adversely affected by abnormal heat or fire.

Compliance shall be verified by the test specified in 9.2.2.4.

If a test has to be made at more than one place on the same sample, care shall be taken to ensure that any deterioration caused by previous tests does not affect the test to be made. Small parts with surface dimensions not exceeding 14 mm × 14 mm are not subjected to the test.

8.1.2.6 Resistance to rusting

Ferrous parts of the contactor including enclosures and covers, but excluding pole faces of electromagnets, shall be protected against rusting.

Compliance shall be verified by the test specified in 9.2.2.5.

8.1.3 Strength of screws or nuts other than those on terminals which are intended to be operated during installation or maintenance

Screws or nuts intended to be operated during installation or maintenance, as recommended by the manufacturer, shall withstand the mechanical stresses occurring in normal service.

Thread-forming tapping screws and thread-cutting tapping screws intended only for mechanical assembly ~~may~~ can be used provided they are supplied together with the piece in which they are intended to be inserted.

An example of a thread-forming tapping screw is shown in Figure 1. An example of a thread-cutting tapping screw is shown in Figure 2. In addition, thread-cutting tapping screws intended to be operated by the installer shall be captive with the relevant part of the accessory.

Screws or nuts which transmit contact pressure shall be in engagement with metal threads.

For electrical connections, no contact pressure shall be transmitted through insulating material other than ceramic or other material with characteristics not less suitable and compensated for any possible shrinkage or yielding.

Compliance shall be verified by inspection and by the test of 9.2.3.

8.1.4 Vacant

8.1.5 Actuator

8.1.5.1 General

The requirements of 8.1.5.2 and 8.1.5.3 apply to contactors provided with a manually operated actuator.

8.1.5.2 Insulation

The actuator of the contactor shall be insulated from the live parts for the rated insulation voltage and, if applicable, the rated impulse withstand voltage.

Moreover:

- if the activator is made of metal, it shall be capable of being satisfactorily connected to a protective conductor unless it is provided with additional reliable insulation;
- if it is made of or covered by insulating material, any internal metal part which might become accessible in the event of insulation failure shall also be insulated from live parts for the rated insulation voltage.

8.1.5.3 Direction of movement

The direction of operation for actuators of devices shall normally ~~conform to~~ comply with IEC 60447. Where devices cannot ~~conform to~~ comply with these requirements, e.g. due to special applications or alternative mounting positions, they shall be clearly marked such that there is no doubt as to the "I" and "O" positions and the direction of the operation.

8.1.5.4 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.

8.1.6 Indication of the OFF and ON positions

8.1.6.1 Indicating means

When a contactor is provided with means for indicating the closed and open positions, these positions shall be unambiguous and clearly indicated.

NOTE In the case of enclosed contactors, the indication ~~may or may not~~ can be visible from the outside.

This is done by means of a position indicating device (see 3.3.15).

If symbols are used, they shall indicate the closed and open positions respectively, in accordance with IEC 60417:

60417-IEC-5007

(2002-10)



ON (power)

60417-IEC-5008

(2002-10)



OFF (power)

For contactors operated by means of two push-buttons, only the push-button designated for the opening operation shall be red or marked with the symbol "O".

Red colour shall not be used for any other push-button.

The colours of other push-buttons, illuminated push-buttons and indicator lights shall be in accordance with IEC 60073.

8.1.6.2 Indication by the actuator

When the actuator is used to indicate the position of the contacts, it shall automatically take up or stay in, when released, the position corresponding to that of the moving contacts; in this case, the actuator shall have two distinct rest positions corresponding to those of the moving contacts, but for automatic opening, a third distinct position of the actuator ~~may~~ can be provided.

8.1.7 Terminals

8.1.7.1 Constructional requirements

All parts of terminals which maintain contact and carry current shall be of metal having adequate mechanical strength.

Terminal connections shall be such that the force to connect the conductors ~~may~~ can be ~~connected~~ applied by ~~means of~~ screws, ~~springs~~ screwless-type or other equivalent means to ensure that the necessary contact pressure is maintained.

Terminals shall be so constructed that the conductors can be clamped between suitable surfaces without any significant damage either to conductors or terminals.

Terminals shall not allow the conductors to be displaced or be displaced themselves in a manner detrimental to the operation of the contactor and the insulation voltage shall not be reduced below the rated values.

Screwless terminals shall be so designed and constructed that each conductor is clamped individually.

Screwless-type clamping units, unless otherwise specified by the manufacturer, shall accept solid, stranded and flexible conductors.

On screwless-type clamping unit, the connection or disconnection of conductors shall be made as follows:

- on universal clamping units by the use of a general-purpose tool or a convenient device, integral with the clamping unit to open it for the insertion or withdrawal of the conductors;
- on push-wire clamping units by simple insertion. For the disconnection of the conductors an operation other than a pull only on the conductor shall be necessary. The use of a general-purpose tool or of a convenient device, integral with the clamping unit is allowed in order to "open" it and to assist the insertion or the withdrawal of the conductor.

Examples of screwless terminals are given in Figure 23.

The requirements of this subclause shall be verified by the tests of 9.2.5.3, 9.2.5.4, 9.2.5.5, 9.2.5.7 and 9.2.5.8 as applicable.

NOTE North American countries have particular requirements for terminals suitable for aluminium conductors and marking to identify the use of aluminium conductors.

8.1.7.2 Connecting capacity

The manufacturer shall state the type (rigid – solid or stranded – or flexible), the minimum and the maximum cross-sections of conductors for which the terminal is suitable and, if applicable, the number of conductors simultaneously connectable to the terminal. However, the maximum cross-section shall not be smaller than that stated in 9.3.3.3 for the temperature-rise test and the terminal shall be suitable for conductors of the same type (rigid – solid or stranded – or flexible) at least two sizes smaller, as given in the appropriate column of Table 2.

Standard values of cross-sections of round copper conductors (both metric and AWG/MCM sizes) are shown in Table 2 which also gives the approximate relationship between ISO metric and AWG/MCM sizes.

Table 2 – Standard cross-sections of round copper conductors

ISO cross-sections mm ²	AWG/MCM	
	Sizes	Equivalent cross-sections mm ²
0,2	24	0,205
–	22	0,324
0,5	20	0,519
0,75	18	0,82
1	–	–
1,5	16	1,3
2,5	14	2,1
4	12	3,3
6	10	5,3
10	8	8,4
16	6	13,3
25	4	21,2
35	2	33,6

NOTE The dash, when it appears, counts as a size when considering connecting capacity.

8.1.7.3 Connection

Terminals for connection to external conductors shall be readily accessible during installation.

Clamping screws and nuts shall not serve to fix any other component although they ~~may~~ can hold the terminals in place or prevent them from turning.

8.1.7.4 Terminal identification and marking

Terminals shall be clearly and permanently identified in accordance with IEC 60445.

Terminals intended exclusively for the neutral conductor shall be identified by the letter "N", in accordance with IEC 60445.

The protective earth terminal shall be identified in accordance with 8.1.9.3.

Additional requirements for terminal identification and marking are given in Annex A.

8.1.8 Additional requirements for contactors provided with a neutral pole

When a contactor is provided with a pole intended only for connecting the neutral, this pole shall be clearly identified to that effect by the letter "N" (see 8.1.7.4).

A switched neutral pole shall not break before and shall not make after the other poles.

The value of the conventional thermal current shall be identical for all poles.

8.1.9 Provisions for earthing

8.1.9.1 Constructional requirements

The exposed conductive parts (e.g. chassis, framework and fixed parts of metal enclosures) other than those which cannot constitute a danger shall be electrically interconnected and connected to a protective earth terminal for connection to an earth electrode or to an external protective conductor.

This requirement can be met by the normal structural parts providing adequate electrical continuity and applies whether the contactor is used on its own or incorporated in an assembly.

Exposed conductive parts are not considered to constitute a danger if they cannot be touched on large areas or grasped with the hand or if they are of small size (approximately 50 mm × 50 mm) or are so located as to exclude any contact with live parts.

Examples of these are screws, rivets, nameplates, transformer cores, electromagnets and certain parts of releases, irrespective of their size.

8.1.9.2 Protective earth terminal

The protective earth terminal shall be readily accessible and so placed that the connection of the contactor to the earth electrode or to the protective conductor is maintained when the cover or any other removable part is removed.

The protective earth terminal shall be suitably protected against corrosion.

In the case of contactors with conductive structures, enclosures, etc., means shall be provided if necessary, to ensure electrical continuity between the exposed conductive parts of the contactors and the metal sheathing of connecting conductors.

The protective earth terminal shall have no other function, except when it is intended to be connected to a PEN conductor. In that case, it shall also have the function of a neutral terminal in addition to meeting the requirements applicable to the protective earth terminal.

8.1.9.3 Protective earth terminal marking and identification

The protective earth terminal shall be clearly and permanently identified by its marking.

The identification shall be achieved by colour (green-yellow mark) or by the notation PE, or PEN as applicable, in accordance with Clause 7 of IEC 60445:2006/2021, or, in the case of PEN, by a graphical symbol for use on contactors.

The graphical symbol to be used is symbol:

60417-IEC-5019 (2006-08)  Protective earth (ground) of IEC 60417.

NOTE The symbol  (60417-IEC-5017 (2006-08)) previously recommended is progressively superseded by the preferred symbol 60417-IEC-5019 given above.

8.1.10 Enclosures

8.1.10.1 General

The requirements of 8.1.10.2 and 8.1.10.3 are applicable only to enclosures supplied or intended to be used with the contactor.

8.1.10.2 Design

The enclosure shall be so designed that when it is opened and other protective means, if any, have been removed, all parts requiring access for installation and maintenance, as prescribed by the manufacturer, are readily accessible.

Sufficient space shall be provided inside the enclosure for the accommodation of external conductors from their point of entry into the enclosure to the terminals to ensure adequate connection.

The fixed parts of a metal enclosure shall be electrically connected to the other exposed conductive parts of the contactor and connected to a terminal which enables them to be earthed or connected to a protective conductor.

Under no circumstances shall a removable metal part of the enclosure be insulated from the part carrying the earth terminal when the removable part is in place.

The removable parts of the enclosure shall be firmly secured to the fixed parts by a device such that they cannot be accidentally loosened or detached owing to the effects of operation of the contactor or its vibrations.

For enclosures having a degree of protection IP1X up to and including IP4X, sufficient space shall be provided for establishing a drain-hole; ~~such a drain hole shall meet the requirements of IEC 60947-1.~~ Subclause 11.3 of IEC 60529:1989 applies with the following addition:

Drain and ventilating holes are treated as normal openings.

Enclosures shall have adequate mechanical strength (see 8.1.12).

Furthermore, it shall not be possible to remove any cover of the enclosure without the use of a tool.

An integral enclosure is considered to be a non-removable part.

If the enclosure is used for mounting push-buttons, it shall not be possible to remove the buttons from the outside of the enclosure.

8.1.10.3 Insulation

If, in order to prevent accidental contact between a metallic enclosure and live parts, the enclosure is partly or completely lined with insulating material, this lining shall be securely fixed to the enclosure.

Compliance shall be verified by inspection.

8.1.11 Degrees of protection of enclosed contactors

IEC 60529 defines degrees of protection for enclosed equipment and guidance for the application of that standard to contactors is under consideration.

8.1.12 Resistance to impact

The external parts of enclosed, partially enclosed, and parts of unenclosed contactors, shall withstand impacts which might be expected in normal service.

Compliance shall be verified by the test specified in 9.2.6.

8.1.13 Durability of markings

The contactor shall be provided with a nameplate marked in a durable manner.

Compliance shall be verified by the test specified in 9.2.7.

8.1.14 Fault and abnormal conditions

This clause applies to contactors incorporating electronic circuits only. For the purpose of this document, "electronic circuit" excludes circuits in which all components are passive (including diodes, resistors, varistors, capacitors, surge suppressors, inductors).

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 clause 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.

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 shock and fire hazard will result from failure of the component.

Compliance shall be checked by test of 9.2.8.

Contactors already tested according to Clauses 101 and 102 of IEC 60669-2-1:2021 are deemed to fulfil the requirements of 8.1.14 and therefore, 9.2.8 is covered.

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.

8.2 Performance requirements

8.2.1 Operating conditions

8.2.1.1 General

The contactor shall be operated in accordance with the manufacturer's instructions.

The moving contacts of multipole contactors intended to make and break together shall be so mechanically coupled that all poles make and break substantially together (however, for switched neutral pole, see 8.1.8) whether operated manually or automatically.

8.2.1.2 Limits of operation

Contactors shall close satisfactorily at any value between 85 % and 110 % of their rated control supply voltage U_s . Where a range is declared, 85 % shall apply to the lower value and 110 % to the higher.

The limits between which contactors shall drop out and open fully are 75 % to 20 % of their rated control supply voltage U_s . Where a range is declared, 20 % shall apply to the higher value and 75 % to the lower.

The limits between which a contactor with an electronically controlled electromagnet shall drop out and open fully are 75 % to 20 % of their rated control supply voltage U_s , or 75 % to 10 % of their rated control supply voltage U_s if specified by the manufacturer. In that case, the contactor shall, in addition, be submitted to the capacitive drop out test as follows:

A capacitor C shall be inserted in series in the supply circuit U_s , the total length of the connecting conductors being ≤ 3 m.

The capacitor is short-circuited by a switch of negligible impedance. The supply voltage shall then be adjusted to 110 % U_s .

It shall be verified that the equipment drops out when the switch is operated to the open position.

The value of the capacitor shall be

$$C = 30 + 200\,000 / (f \times U)$$

where C is expressed in nF; f is the minimum rated frequency expressed in Hz; U is the maximum value of U_s expressed in V.

For example, for a coil rated 12...24 V – 50 Hz, the capacitor value is 196 nF (calculation made with U_s max). The test voltage is the highest value of the declared rated supply voltage range U_s .

NOTE The value of the capacitor simulates a typical control wiring of 100 m long cable of 1,5 mm² (0,3 nF/m that is 30 nF for 100 m) connected to a static output having a 1,3 mA leakage current (200 000 in the formula $\approx \frac{10^9 \times 1,3 \times 10^{-3}}{2 \times \pi}$).

Limits for closing are applicable after the coils have reached a stable temperature corresponding to indefinite application of 100 % U_s in an ambient temperature of +40 °C.

Limits for drop-out are applicable with the coil circuit resistance at –5 °C. This can be verified by calculation using values obtained at normal ambient temperature.

The limits apply at declared frequency, if any.

8.2.2 Temperature-rise

8.2.2.1 General

~~The requirements of 8.2.2, 8.2.2.2, 8.2.2.3 and 8.2.2.4 apply to contactors in clean, new condition.~~

The temperature-rises of the several parts of the contactor measured during a test carried out under the conditions specified in 9.3.3.3 shall not exceed the limiting values stated in Table 3 and in 8.2.2.2 and 8.2.2.3.

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

NOTE 1 Temperature-rises in normal service ~~may~~ can differ from the test values, depending on the installation conditions and the size of connected conductors.

Table 3 – Temperature-rise limits for insulated coils in air

Classes of insulating materials	Temperature-rise limits (measured by resistance variation)
	K
	Coils in air
A	85
E	100
B	110
F	135
H	160
NOTE The insulation classification is that given in IEC 60085.	

NOTE 2 The temperature-rise limits given in Table 3 and in Table 5 are applicable only if the ambient air temperature remains within the limits -5°C , $+40^{\circ}\text{C}$.

8.2.2.2 Terminals

The temperature-rise of terminals shall not exceed the values stated in Table 4.