BRITISH STANDARD

BS EN
60470:2001
IEC 60470:2000

High-voltage alternating current contactors and contactor-based motor starters

The European Standard EN 60470:2000 has the status of a British Standard

ICS 29.130.10

National foreword

This British Standard is the official English language version of EN 60470:2000. It is identical with IEC 60470:2000. It supersedes BS 5856 Part 1:1980 and BS 775 Part 2:1974 which are both withdrawn; the former being identical to IEC 60632-1:1978 and the latter being related to IEC 60470, which are themselves now combined into IEC 60470:2000.

The UK participation in its preparation was entrusted to Technical Committee PEL/17/1, High-voltage switchgear and controlgear, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

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

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Cross-references

Attention is drawn to the fact that CEN and CENELEC Standards normally include an annex which lists normative references to international publications with their corresponding European publications. The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled “International Standards Correspondence Index”, or by using the “Find” facility of the BSI Standards Electronic Catalogue.

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EUROPEAN STANDARD **EN 60470**

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English version

High-voltage alternating current contactors and contactor-based motor starters
(IEC 60470:2000)

Contacteurs pour courants alternatifs haute tension et démarreurs de moteurs à contacteurs
(CEI 60470:2000)

Hochspannungs-Wechselstrom-Schütze und -Motorstarter mit Schützen
(IEC 60470:2000)

This European Standard was approved by CENELEC on 2000-04-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

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CENELEC
European Committee for Electrotechnical Standardization
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Foreword*)

The text of document 17A/545/FDIS, future edition 2 of IEC 60470, prepared by SC 17A, High-voltage switchgear and controlgear, of IEC TC 17, Switchgear and controlgear, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60470 on 2000-04-01.

The following dates were fixed:

– latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop) 2001-01-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow) 2003-04-01

Annexes designated "normative" are part of the body of the standard.
In this standard, annexes A and ZA are normative.
Annex ZA has been added by CENELEC.

This standard is to be read in conjunction with EN 60694:1996, which is applicable unless otherwise specified in this standard. In order to simplify the indication of corresponding requirements, the same numbering of clauses and subclauses as in EN 60694 is used. Amendments to these clauses and subclauses are given under the same references whilst additional subclauses are numbered from 101.

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Endorsement notice

The text of the International Standard IEC 60470:1999 was approved by CENELEC as a European Standard without any modification.

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*) Updated as per corrigendum June 2000

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HIGH-VOLTAGE ALTERNATING CURRENT CONTACTORS AND CONTACTOR-BASED MOTOR-STARTERS

1 General

1.1 Scope and object

This International Standard is applicable to a.c. contactors and/or contactor-based motor-starters designed for indoor installation and operation at frequencies up to and including 60 Hz on systems having voltages above 1 000 V but not exceeding 12 000 V.

It is applicable only to three-pole contactors and starters for use in three-phase systems, and single-pole contactors and starters for use in single-phase systems. Two-pole contactors and starters for use in single-phase systems are subject to agreement between manufacturer and user.

Contactors and/or starters dealt with in this standard are not normally designed to interrupt short-circuit currents. Therefore, suitable short-circuit protection (see 3.4.110.12 and note 2 below) forms part of the installation, but not necessarily of the contactor or the starter.

In this context, this standard gives requirements for

– contactors associated with overload and/or short-circuit protective devices (SCPD);
– starters associated with separate short-circuit protective devices and/or with separate short-circuit and integrated overload protective devices;
– contactors or starters combined, under specified conditions, with their own short-circuit protective devices. Such combinations, for example combination starters (see 3.4.110.9), are rated as units.

Contactors intended for closing and opening electric circuits and, if combined with suitable relays, for protecting these circuits against operating overloads which may occur therein, are covered in this standard.

This standard is also applicable to the operating devices of contactors and to their auxiliary equipment.

Motor-starters intended to start and accelerate motors to normal speed, to ensure continuous operation of motors, to switch off the supply from the motor and to provide means for the protection of motors and associated circuits against operating overloads are dealt with.

Motor-starter types included are

– direct-on-line starters;
– reversing starters;
– two-direction starters;
– reduced kVA (voltage) starters;
– auto-transformer starters;
– rheostatic starters;
– reactor starters.

Starters, the operation of which depends on thermal electrical relays for motor protection complying with IEC 60255-8, or motor-incorporated thermal protective devices dealt with in IEC 60034-11, do not necessarily meet all the relevant requirements of this standard.

Overload relays for starters, including those based on solid-state technology, are covered by this standard.

This standard does not apply to

– circuit-breaker-based motor-starters;

– single-pole operation of multi-pole contactors or starters;

– two-step auto-transformer starters designed for continuous operation in the starting position;

– unbalanced rheostatic rotor starters, i.e. where the resistances do not have the same value in all phases;

– equipment designed not only for starting, but also for adjustment of speed;

– liquid starters and those of the "liquid-vapour" type;

– semiconductor contactors and starters making use of semiconductor contactors in the main circuit;

– rheostatic stator starters;

– contactors or starters designed for special applications.

This standard does not deal with components contained in contactors and contactor-based motor-starters, for which individual specifications exist.

NOTE 1 Thermal electrical relays are covered by IEC 60255-8.

NOTE 2 High-voltage current-limiting fuses are covered by IEC 60282-1 and IEC 60644.

NOTE 3 Metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV are covered by IEC 60298.

NOTE 4 Disconnectors and earthing switches are covered by IEC 60129.

NOTE 5 High-voltage switches above 1 kV and less than 52 kV are covered by IEC 60265-1.

The object of this standard is to state

a) the characteristics of contactors and starters and associated equipment;

b) the conditions with which contactors or starters shall comply with reference to:
   1) their operation and behaviour,
   2) their dielectric properties,
   3) the degrees of protection provided by their enclosures, where applicable,
   4) their construction,
   5) for combinations, interactions between the various components, for example SCPD co-ordination;

c) the tests intended for confirming that these conditions have been met, and the methods to be adopted for these tests;

d) the information to be given with the equipment or in the manufacturer's literature.

1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60034-11:1978, *Rotating electrical machines – Part 11: Built-in thermal protection – Chapter 1: Rules for protection of rotating electrical machines*

IEC 60050(441):1984, *International Electrotechnical Vocabulary (IEV) – Chapter 441: Switchgear, controlgear and fuses*

IEC 60056:1987, *High-voltage alternating-current circuit-breakers*

IEC 60076-2:1993, *Power transformers – Part 2: Temperature rise*

IEC 60129:1984, *Alternating current disconnectors and earthing switches*

IEC 60255-8:1990, *Electrical relays – Part 8: Thermal electrical relays*

IEC 60265-1:1983, *High-voltage switches – Part 1: High-voltage switches for rated voltages above 1 kV and less than 52 kV*

IEC 60282-1:1994, *High-voltage fuses – Part 1: Current-limiting fuses*

IEC 60298:1990, *A.C. metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*
Amendment 1 (1994)

IEC 60417, (all parts) *Graphical symbols for use on equipment – Index, survey and compilation of the single sheets*

IEC 60644:1979, *Specification for high-voltage fuse-links for motor circuit applications*

IEC 60694:1996, *Common specifications for high-voltage switchgear and controlgear standards*

IEC 60726:1982, *Dry-type power transformers*

IEC 60947-5-1:1997, *Low-voltage switchgear and controlgear – Part 5: Control circuit devices and switching elements – Section one: Electromechanical control circuit devices*

IEC 61233:1994, *High-voltage alternating current circuit-breakers – Inductive load switching*

IEC 61812-1:1996, *Specified time relays for industrial use – Part 1: Requirements and tests*

2 Normal and special service conditions

2.1 Normal service conditions

Subclause 2.1 of IEC 60694 is applicable with the following modification.

For outdoor installations, refer to 8.102.6.

2.2 Special service conditions

Subclause 2.2 of IEC 60694 is applicable with the following modification.

2.2.1 Altitude

Altitude classes of 1 000 m, 2 000 m and 3 000 m are recognized. See 8.102.7.

NOTE These classes are necessary for some types of operating mechanism.

3 Definitions

For the purpose of this International Standard, clause 3 of IEC 60694 applies with the following additional definitions.

3.1 General terms

3.1.101
controlgear
a general term covering switching devices and their combination with associated control, measuring, protective and regulating equipment, also assemblies of such devices and equipment with associated interconnections, accessories, enclosures and supporting structures, intended in principle for the control of electric energy consuming equipment [IEV 441-11-03]

3.1.102
over-current
a current exceeding the rated current [IEV 441-11-06]

3.1.103
short-circuit current
an over-current resulting from a short circuit due to a fault or an incorrect connection in an electric circuit [IEV 441-11-07]

3.1.104
overload
operating conditions in an electrically undamaged circuit, which cause an over-current [IEV 441-11-08]

3.1.105
conductive part
a part which is capable of conducting current although it may not necessarily be used for carrying service current [IEV 441-11-09]

3.1.106
ambient air temperature
the temperature, determined under prescribed conditions, of the air surrounding the complete switching device or fuse [IEV 441-11-13]

NOTE For switching devices or fuses installed inside an enclosure, it is the temperature of the air outside the enclosure.

3.2 Assemblies of switchgear and controlgear

No particular definitions.

3.3 Parts of assemblies

No particular definitions.

3.4 Switching devices

3.4.101
switching device
a device designed to make or break the current in one or more electric circuits [IEV 441-14-01]

3.4.102
mechanical switching device
a switching device designed to close and open one or more electric circuits by means of separable contacts [IEV 441-14-02]

NOTE Any mechanical switching device may be designated according to the medium in which its contacts open and close, e.g. air, SF_6, oil.

3.4.103
disconnector
a mechanical switching device which provides, in the open position, an isolating distance in accordance with specified requirements [IEV 441-14-05]

NOTE A disconnector is capable of opening and closing a circuit either when negligible current is broken or made, or when no significant change in the voltage across the terminals of each of the poles of the disconnector occurs. It is also capable of carrying currents under normal circuit conditions and carrying for a specified time currents under abnormal conditions such as those of short circuit.

3.4.104
earthing switch
a mechanical switching device for earthing parts of a circuit, capable of withstanding for a specified time currents under abnormal conditions such as those of short circuit, but not required to carry current under normal conditions of the circuit [IEV 441-14-11]

NOTE An earthing switch may have a short-circuit making capacity.

3.4.105
contactor (mechanical)
a 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 [IEV 441-14-33]

NOTE 1 A contactor may also be capable of making and breaking short-circuit currents.

NOTE 2 A contactor is usually intended to operate frequently.

3.4.106
electromagnetic contactor
a contactor in which the force for closing the normally open main contacts or for opening the normally closed main contacts is provided by an electromagnet

3.4.107
vacuum contactor
a contactor in which the main contacts open and close within a highly evacuated envelope

3.4.108
SF_6 contactor
a contactor in which the main contacts open and close within an SF_6 gas-filled compartment

3.4.109
latched contactor
a 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 [IEV 441-14-34]

NOTE The latching, and the release of the latching, may be mechanical, electromagnetic, pneumatic, etc.

3.4.110
starter
the combination of all the switching means necessary to start and stop a motor in combination with suitable overload protection [IEV 441-14-38]

NOTE Starters may be designated according to the method by which the force for closing the main contacts is provided.

3.4.110.1
direct-on-line starter
a starter which connects the line voltage across the motor terminals in one step [IEV 441-14-40]

3.4.110.2
reversing starter
a starter intended to cause the motor to reverse the direction of rotation by reversing the motor primary connections even when the motor is running

3.4.110.3
two-direction starter
a starter intended to cause the motor to reverse the direction of rotation by reversing the motor primary connections only when the motor is not running

3.4.110.4
reduced kVA (voltage) starter
a starter which reduces the starting kVA of the motor

NOTE Reduced kVA starters may include auto-transformer, reactor, rheostatic starters.

3.4.110.5
auto-transformer starter
a starter which uses one or more reduced voltages derived from an auto-transformer

3.4.110.6
rheostatic starter
a starter utilizing one or several resistors for obtaining, during starting, stated motor torque characteristics and for limiting the current [IEV 441-14-42]

NOTE A rheostatic starter generally consists of three basic parts, which may be supplied either as a composite unit or as separate units to be connected at the place of utilization:
– the mechanical switching devices for supplying the stator (generally associated with an overload protective device);
– the resistor(s) inserted in the rotor circuit;
– the mechanical switching devices for cutting out the resistor(s) successively.

3.4.110.7
rheostatic rotor starter
a rheostatic starter for an asynchronous wound-rotor motor which, during the starting period, cuts out successively one or several resistors previously provided in the rotor circuit [IEV 441-14-43]

3.4.110.8
reactor starter
a starter that includes a reactor connected in series with the stator winding of an alternating current motor to furnish reduced voltage for starting

3.4.110.9
combination starter (often referred to as a controller)
equipment consisting of a contactor, overload protection, a manual externally operated disconnector and a short-circuit protective device, mounted and wired in a dedicated enclosure

NOTE 1 A dedicated enclosure is an enclosure specifically designed and dimensioned for its application, in which all tests are conducted, and which may also include an earthing function.

NOTE 2 A combination starter may be used for functions other than motor starting, for example transformer control and protection.

3.4.110.10
electromagnetic starter
a starter in which the force for closing the main contacts is provided by an electromagnet

3.4.110.11
***n*-step starter**
a starter in which there are (n – 1) intermediate accelerating positions between the off and full on positions [IEV 441-14-41]

NOTE 1 A starter in which there is no intermediate accelerating position between the OFF and ON positions is a single step or direct-on-line starter (see 3.4.110.1).

NOTE 2 A starter in which there is only one intermediate accelerating position between the OFF and ON positions is known as a two-step starter.

NOTE 3 A three-step rheostatic starter has two sections of resistors used for starting.

3.4.110.12
short-circuit protective device (SCPD)
a device intended to protect a circuit or parts of a circuit against short-circuit currents by interrupting them

3.5 Parts of switchgear and controlgear

3.5.101
pole of a switching device
the 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 [IEV 441-15-01]

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

3.5.102
main circuit (of a switching device)
all the conductive parts of a switching device included in the circuit which it is designed to close or open [IEV 441-15-02]

3.5.103
control circuit (of a 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 [IEV 441-15-03]

3.5.104
auxiliary circuit (of a 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 [IEV 441-15-04]

NOTE Some auxiliary circuits fulfil supplementary functions such as signalling, interlocking, etc., and, as such, they may be part of the control circuit of another switching device.

3.5.105
main contact
a contact included in the main circuit of a mechanical switching device, intended to carry, in the closed position, the current of the main circuit [IEV 441-15-07]

3.5.106
control contact
a contact included in a control circuit of a mechanical switching device and mechanically operated by this device [IEV 441-15-09]

3.5.107
auxiliary contact
a contact included in an auxiliary circuit and mechanically operated by the switching device [IEV 441-15-10]

3.5.108
"a" contact; make contact
a control or auxiliary contact which is closed when the main contacts of the mechanical switching device are closed and open when they are open [IEV 441-15-12]

3.5.109
"b" contact; break contact
a control or auxiliary contact which is open when the main contacts of a mechanical switching device are closed and closed when they are open [IEV 441-15-13]

3.6 Operation

3.6.101
operation (of a mechanical switching device)
the transfer of the moving contact(s) from one position to an adjacent position [IEV 441-16-01]

NOTE 1 For a circuit-breaker, this may be a closing operation or an opening operation.

NOTE 2 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.

3.6.102
operating cycle (of a mechanical switching device)
a succession of operations from one position to another and back to the first position through all other positions, if any [IEV 441-16-02]

NOTE 1 This may be a closing operation followed by an opening operation.

NOTE 2 A succession of operations not forming an operating cycle is referred to as an operating series.

3.6.103
closing operation (of a mechanical switching device)
an operation by which the device is brought from the open position to the closed position [IEV 441-16-08]

3.6.104
opening operation (of a mechanical switching device)
an operation by which the device is brought from the closed position to the open position [IEV 441-16-09]

3.6.105
closed position (of a mechanical switching device)
the position in which the predetermined continuity of the main circuit of the device is secured [IEV 441-16-22]

3.6.106
open position (of a mechanical switching device)
the position in which the predetermined clearance between open contacts in the main circuit of the device is secured [IEV 441-16-23]

3.6.107
position of rest (of a contactor)
the position which the moving elements of the contactor take up when its electromagnet or its compressed-air device is not energized [IEV 441-16-24]

3.6.108
overload relay or release
an over-current relay or release intended for protection against overloads (including, where applicable, operating transformer(s) and interconnections)

3.6.109
thermal overload relay or release
an inverse time-delay overload relay or release depending for its operation (including its time delay) on the thermal action of the current flowing in the relay or release

3.6.110
current setting of an overload relay or release
the value of current for which the relay or release is adjusted and in accordance with which its operating conditions are defined

3.6.111
current setting range of an overload relay or release
the range between the minimum and maximum values over which the current setting of the relay or release can be adjusted

3.6.112
phase failure sensitive overload relay or release
a multi-pole overload relay or release which, in accordance with specified requirements, operates at a current value lower than its current setting in the case of current unbalance

3.6.113
under-current (under-voltage) relay or release
a measuring relay or release which operates automatically when the current through it (or the voltage applied to it) is reduced below a pre-determined value

3.6.114
starting time (of a rheostatic starter)
the period of time during which the starting resistors or parts of them carry current

NOTE The starting time of a starter is shorter than the total starting time of the motor, which takes into account the last period of acceleration following the switching operation ON position.

3.6.115
starting time (of an auto-transformer starter)
the period of time during which the auto-transformer carries current

NOTE The starting time of a starter is shorter than the total starting time of the motor, which takes into account the last period of acceleration following the switching operation ON position.

3.6.116
open transition (with an auto-transformer starter)
a circuit arrangement so that the supply to the motor is interrupted and reconnected when changing over from one step to another

NOTE The transition stage is not considered an additional step.

3.6.117
closed transition (with an auto-transformer starter)
a circuit arrangement so that the supply to the motor is not interrupted (even momentarily) when changing over from one step to another

NOTE The transition stage is not considered an additional step.

3.6.118
inching (jogging)
energizing a motor or solenoid repeatedly for short periods to obtain small movements of the driven mechanism

3.6.119
plugging
stopping or reversing a motor rapidly by reversing the motor primary connections while the motor is running

3.7 Characteristic quantities

3.7.101
breaking current (of a switching device or a fuse)
the current in a pole of a switching device or in a fuse at the instant of initiation of the arc during a breaking process [IEV 441-17-07]

3.7.102
breaking capacity (of a switching device or a fuse)
a 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 [IEV 441-17-08]

NOTE 1 The voltage to be stated and the conditions to be prescribed are dealt with in the relevant publications.

NOTE 2 For switching devices, the breaking capacity may be termed according to the kind of current included in the prescribed conditions, e.g. line charging breaking capacity, cable charging breaking capacity, single capacitor bank breaking capacity, etc.

3.7.103
making capacity (of a switching device)
a value of prospective making current that a switching device is capable of making at a stated voltage under prescribed conditions of use and behaviour [IEV 441-17-09]

NOTE The voltage to be stated and the conditions to be prescribed are dealt with in the relevant specifications.

3.7.104
take-over current
the current coordinate of the intersection between the time-current characteristics of two over-current protective devices [IEV 441-17-16]

3.7.105
short-time withstand current
the current that a circuit or a switching device in the closed position can carry during a specified short time under prescribed conditions of use and behaviour [IEV 441-17-17]

3.7.106
recovery voltage
the voltage which appears across the terminals of a pole of a switching device or a fuse after the breaking of the current [IEV 441-17-25]

NOTE This voltage may 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 or the steady-state recovery voltage alone exists.

3.7.107
transient recovery voltage (TRV)
the recovery voltage during the time in which it has a significant transient character [IEV 441-17-26]

NOTE 1 The transient recovery voltage may be oscillatory or non-oscillatory, or a combination of these, depending on the characteristics of the circuit and the switching device. It includes the voltage shift of the neutral of a polyphase circuit.

NOTE 2 The transient recovery voltage in three-phase circuits is, unless otherwise stated, that across the first pole to clear, because this voltage is generally higher than that which appears across each of the other two poles.

3.7.108
power frequency recovery voltage
the recovery voltage after the transient voltage phenomena have subsided [IEV 441-17-27]

3.7.109
prospective current (of a circuit and with respect to a combination situated therein)
the current that would flow in the circuit if each pole of the combination were replaced by a conductor of negligible impedance [IEV 441-17-01, modified]

3.7.110
prospective peak current
the peak value of a prospective current during the transient period following initiation [IEV 441-17-02]

NOTE 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.

3.7.111
maximum prospective peak current (of an a.c. circuit)
the prospective peak current when initiation of the current takes place at the instant which leads to the highest possible value [IEV 441-17-04]

NOTE For a multiple device in a polyphase circuit, the maximum prospective peak current refers to a single pole only.

3.7.112
prospective breaking current (for a pole of a switching device or a fuse)
the prospective current evaluated at a time corresponding to the instant of the initiation of the breaking process [IEV 441-17-06]

NOTE Specifications concerning the instant of the initiation of the breaking process are to be found in the relevant publications. For mechanical switching devices or fuses, it is usually defined as the moment of initiation of the arc during the breaking process.

3.7.113
minimum breaking current
a minimum value of prospective current that a fuse-link is capable of breaking at a stated voltage under prescribed conditions of use and behaviour [IEV 441-18-29]

3.7.114
cut-off current; let-through current
the maximum instantaneous value of current attained during the breaking operation of a switching device or a fuse [IEV 441-17-12]

NOTE 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.

3.7.115
take-over current
the current coordinate of the intersection between the time-current characteristics of two over-current protective devices [IEV 441-17-16]

3.7.116
minimum take-over current
current determined by the point of intersection of the time-current characteristics of the SCPD and the contactor corresponding to

a) the maximum break time plus, where applicable, the maximum operating time of an external over-current or earth-fault relay;

b) the minimum pre-arcing time of the SCPD.

See also figure 10.

3.7.117
maximum take-over current
current determined by the point of intersection of the time-current characteristics of the SCPD and the contactor corresponding to

a) the minimum opening time of the contactor, or minimum response time if operated by an overcurrent relay and/or time delay devices;

b) the maximum operating time of the SCPD of highest rated current.

See also figure 10.

3.7.118
maximum acceptable power dissipation
power which is dissipated by the combination when fitted with fuses of maximum power dissipation as determined by the temperature-rise tests

3.7.119
fused short-circuit current
the conditional short-circuit current when the current limiting device is a fuse [IEV 441-17-21]

3.7.120
applied voltage (for a switching device)
the voltage which exists across the terminals of a pole of a switching device just before the making of the current [IEV 441-17-24]

3.7.121
prospective transient recovery voltage (of a circuit)
the transient recovery voltage following the breaking of the prospective symmetrical current by an ideal switching device [IEV 441-17-29]

NOTE The definition assumes that the switching device or the fuse, for which the prospective transient recovery voltage is sought, is replaced by an ideal switching device, i.e. having instantaneous transition from zero to infinite impedance at the very instant of zero current, i.e. at the "natural" zero. For circuits where the current can follow several different paths, e.g. a polyphase circuit, the definition further assumes that the breaking of the current by the ideal switching device takes place only in the pole considered.

3.7.122
release-initiated opening time (of the contactor)
the release-initiated opening time is defined according to the tripping method as stated below with any time-delay device forming an integral part of the contactor adjusted to a specified setting.

a) For a contactor tripped by any form of auxiliary power, the release-initiated opening time is the interval of time between the instant of energizing the opening release, the contactor being in the closed position, and the instant when the arcing contacts have separated in all poles.

b) For a contactor tripped (other than by the striker) by a current in the main circuit without the aid of any form of auxiliary power, the release-initiated opening time is the interval of time between the instant at which, the contactor being in the closed position, the current in the main circuit reaches the operating value of the over-current release and the instant when the arcing contacts have separated in all poles.

3.7.123
minimum release-initiated opening time (of the contactor)
the release-initiated opening time when the specified setting of any time-delay device forming an integral part of the contactor is its minimum setting

3.7.124
maximum release-initiated opening time (of the contactor)
the release-initiated opening time when the specified setting of any time-delay device forming an integral part of the contactor is its maximum setting

3.7.125
arcing time (of a pole or a fuse)
the interval of time between the instant of the initiation of the arc in a pole or a fuse and the instant of final arc extinction in that pole or that fuse [IEV 441-17-37]

3.7.126
break time (of the contactor in a release-operated combination)
the interval of time between the beginning of the release-initiated opening time of the contactor and the instant of final arc extinction in all poles

NOTE This term may be qualified by prefixing it with "minimum" or "maximum" depending upon the opening time and the arcing time used.

3.101 Fuses

3.101.1
fuse
a 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. The fuse comprises all the parts that form the complete device [IEV 441-18-01]

3.101.2
striker
a mechanical device forming part of a fuse-link which, when the fuse operates, releases the energy required to cause operation of other apparatus or indicators, or to provide interlocking [IEV 441-18-18]

3.101.3
pre-arcing time; melting time
the interval of time between the beginning of a current large enough to cause a break in the fuse-element(s) and the instant when an arc is initiated [IEV 441-18-21]

3.101.4
operating time; total clearing time
the sum of the pre-arcing time and the arcing time [IEV 441-18-22]

3.101.5
Joule integral (I^2t)
the integral of the square of the current over a given time interval:

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

NOTE 1 The pre-arcing I^2t is the I^2t integral extended over the pre-arcing time of the fuse.

NOTE 2 The operating I^2t is the I^2t integral extended over the operating time of the fuse.

NOTE 3 The energy in joules liberated in one ohm of resistance in a circuit protected by a fuse is equal to the value of the operating I^2t expressed in $A^2 \cdot s$.

[IEV 441-18-23]

4 Ratings

Clause 4 of IEC 60694 is applicable with the additions and exceptions indicated below.

A contactor, starter or combination in the correct condition of maintenance and adjustment shall be able to withstand all the stresses that occur in service provided that these do not exceed its rated characteristics.

The characteristics of a contactor, starter or combination, including its operating devices and auxiliary equipment, that shall be used to determine the ratings are given in table 1.

Under this heading, consideration is also given to the characteristics which are not necessarily ratings but need to be taken into consideration in the specification and design stages.

The use of an SCPD other than that utilized in the type tests may change the ratings of the combination. In this case, the new ratings shall be assigned by the manufacturer.

NOTE Ratings may differ between the table columns.

Table 1 – Ratings and characteristics

Rating/characteristic		Contactor 3.4.105	Starter 3.4.110	Combination 3.4.110.9
(A) *Rated characteristics*				
a) Rated voltage (U_r)	4.1	X	X	X
b) Rated insulation level	4.2	X	X	X
c) Rated frequency (f_r)	4.3	X	X	X
d) Rated operational current (I_e) or rated operational power	4.101	X	X	X
e) Rated short-time withstand current (I_k)	4.5	X	X	X
f) Rated peak withstand current (I_p)	4.6	X	X	X
g) Rated duration of short-circuit (t_k)	4.7	X	X	X
h) Rated short-circuit breaking current (I_{sc})	4.107			X
i) Rated short-circuit making current (I_{ma})	4.107			X
j) Rated duties	4.102	X	X	(X)
k) Rated load and overload characteristics, by utilization category	4.103, 4.104	X	X	X
l) Rated supply voltage of operating devices, and of auxiliary and control circuits (U_a)	4.8	X	X	X
m) Rated supply frequency of operating devices and of auxiliary circuits	4.9	X	X	X
n) Rated pressure of compressed gas supply for insulation and/or operation	4.10	X	X	X
(B) *Characteristics to be given on request*				
p) Thermal current (I_{th})	4.4.101	X	X	X
q) Electrical endurance	4.106	X		
r) Coordination with short-circuit protective devices	4.107	X	X	X
s) Damage classification	4.107.3	X	X	X
t) Short-circuit breaking capacity	4.107, 6.104	X	X	
u) Short-circuit making capacity	4.107, 6.104	X	X	
v) Motor switching characteristics	6.108	X		
w) Take-over current for release-operated combination	4.107.2			X
(C) *Characteristics dependent on starter type*				
x) Automatic change-over devices and automatic acceleration control devices	4.108		X	X
y) Starting auto-transformer characteristics	4.109		X	X
z) Starting resistor characteristics	4.110		X	X
aa) Starting reactor characteristics	4.109		X	X

X: applicable for this configuration
(X): applicable, but see note 2 of 4.102.2 regarding intermittent duty

4.1 Rated voltage (U_r)

The rated voltage indicates the upper limit of the highest voltage of the system for which the device is intended. Standard values of rated voltages are:

2,5 kV – 3,6 kV – 5,0 kV – 7,2 kV – 12 kV

For rheostatic rotor starters, the rated voltage refers to the stator.

4.1.101 Rated rotor voltage (U_{ro})

For rheostatic rotor starters, the value of the rated voltage is that of the voltage which, when combined with a rated rotor current, determines the application of the rotor circuit including its mechanical switching devices and to which are referred the making and breaking capacities, the type of duty and the starting characteristics.

It is taken as equal to the voltage measured between slip-rings, with the motor stopped and the rotor open-circuited, when the stator is supplied at its rated voltage.

The rated rotor voltage is only applied for a short duration during the starting period. For this reason, it is permissible that the rated rotor voltage exceeds the rated rotor insulation voltage by 100 %.

The maximum voltage between the different live parts (for example switching devices, resistors, connecting parts, etc.) of the rotor circuit of the starter will vary and account may be taken of this fact in choosing the equipment and its disposition.

4.2 Rated insulation level

Subclause 4.2 of IEC 60694 is applicable with the following additions.

For rheostatic rotor starters, the rated insulation level refers to the stator.

NOTE The insulation levels for 2,5 kV and 5,0 kV systems are 3,6 kV and 7,2 kV respectively.

4.2.101 Rated rotor insulation level

For rheostatic rotor starters, the rated rotor insulation level is that which is assigned to the devices inserted in the rotor circuit as well as the unit they are part of (connecting links, resistors, enclosure), and to which dielectric tests and creepage distances are referred.

4.2.102 Rated starting voltage (U_{tap}) of an auto-transformer starter

The rated starting voltage of an auto-transformer starter is the reduced voltage derived from the transformer.

Preferred values of rated starting voltage (U_{tap}) are 50 %, 65 % or 80 % of the rated voltage.

4.2.103 Rated starting voltage (U_{tap}) of a reactor starter

The rated starting voltage of a reactor starter is the reduced voltage derived from the impedance of the reactor and the motor current before rotation.

Preferred values of rated starting voltage (U_{tap}) are 50 %, 65 % or 80 % of the rated voltage.

4.3 Rated frequency (f_r)

The supply frequency for which the device is designed and to which the other characteristic values correspond. The standard values of the rated frequency are 50 Hz and 60 Hz.

4.4 Rated normal current and temperature rise

4.4.1 Rated normal current (I_r)

A rated normal current is normally not assigned to the contactor or motor starter. When contactors or motor starters are combined into larger assemblies, the rated normal current of the connecting busbars shall be in accordance with IEC 60298.

See also thermal current (4.4.101).

4.4.2 Temperature rise

IEC 60694 applies and, as far as fuses are concerned, IEC 60282-1.

Subclause 4.4.2 of IEC 60694 is applicable with the following addition.

It is recognized that a starter combination may be fitted with types and ratings of fuses other than those utilized in the temperature-rise tests and this may change the thermal current of the combination. For any particular case, the thermal current of the combination shall be assigned by the manufacturer of the combination. For further information, see the application guide (clause 8).

A contactor or starter is also defined by its rated operational currents or powers. See 4.101.

4.4.101 Thermal current (I_{th})

The thermal current is the maximum current carried on continuous duty (see 4.102.1) without the temperature rise of the various parts exceeding the limits specified in 6.5. Selection from the R10 series is not applicable.

Because, in an auto-transformer or reactor starter, the auto-transformer or reactor is energized only intermittently, a maximum temperature rise 15 K greater than the limits stated in the appropriate component standard (for example IEC 60076-2 or IEC 60726) is permissible for the windings of the transformer or reactor when the starter is operated according to the requirements of 4.102 and 4.111.

4.4.101.1 Stator thermal current (I_{ths})

For rheostatic rotor starters, the stator thermal current is the maximum current it can carry on continuous duty without the temperature rise of its several parts exceeding the limits specified in 4.4.2 when tested in accordance with 6.5.3.

4.4.101.2 Rotor thermal current (I_{thr})

For rheostatic rotor starters, the rotor thermal current is the maximum current that those parts of the starter through which the rotor current flows in the ON position, viz. after cutting out resistors, can carry on continuous duty without their temperature rise exceeding the limits specified in 4.4.2 when tested in accordance with 6.5.3.

4.5 Rated short-time withstand current (I_k)

Subclause 4.5 of IEC 60694 is applicable with the following addition.

For a contactor, or starter, this is the r.m.s. value of the current which can be carried in a closed position for a time sufficient for an external SCPD to operate. Alternatively, the value of current may be assigned for use of a specified SCPD. In this case, the value of the current need not be selected from the R10 series. For a combination, this is the prospective r.m.s. value of current.

4.6 Rated peak withstand current (I_p)

Subclause 4.6 of IEC 60694 is applicable.

4.7 Rated duration of short circuit (t_k)

Subclause 4.7 of IEC 60694 is applicable with the following addition.

Alternatively, the interval of time for which a contactor, or starter, can carry its short-time withstand current may be that resulting from operation of the specified SCPD.

4.8 Rated supply voltage of closing and opening devices, and of auxiliary and control circuits (U_a)

Subclause 4.8 of IEC 60694 is applicable with the following addition.

A single-phase control supply voltage of 110 V is recognized in addition to those in table 5 of IEC 60694.

NOTE 1 For starters with short-time rated coils such as closing and trip coils for latched contactors, operating limits should be agreed between manufacturer and user.

The drop-out voltage shall be not higher than 75 %, nor (with worn contacts) lower than 10 % of the rated control supply voltage U_a.

NOTE 2 Drop-out voltage is the voltage below which the contacts of the device change state.

NOTE 3 Close voltage is the voltage above which the contacts of the device change state.

The close and drop-out values specified above are applicable after the coils have reached a stable temperature corresponding to indefinite application of 100 % U_a. In the case of a.c. coils, the voltage limits apply at rated frequency.

4.9 Rated supply frequency of closing and opening devices, and of auxiliary circuits

Subclause 4.9 of IEC 60694 is applicable.

4.10 Rated pressure of compressed gas supply for insulation and/or operation

Subclause 4.10 of IEC 60694 is applicable.

4.101 Rated operational current (I_e) or rated operational power

A rated operational current of a contactor or starter is stated by the manufacturer and takes into account the rated voltage (see 4.1), the rated frequency (see 4.3), the rated duties (see 4.102), the utilization category (see 4.104) and the type of protective enclosure, if appropriate.

In the case of contactors or starters for direct switching of individual motors, the indication of a rated operational current may be replaced or supplemented by the indication of the maximum rated power output, at the rated voltage considered, of the motor for which it is intended. The manufacturer shall be prepared to state the relationship assumed between the operational current and the operational power, if any.

For rheostatic rotor starters, the rated operational current refers to the stator.

4.101.1 Rated rotor operational current (I_{er})

For rheostatic rotor starters, a rated rotor operational current is stated by the manufacturer and takes into account the rated rotor voltage (see 4.1.101), the rotor thermal current, the rated frequency (see 4.3), the rated duty (see 4.102), the starting characteristics (see 4.111) and the type of protective enclosure.

It is taken as equal to the current flowing in the connections to the rotor when the latter is short-circuited, the motor is running at full load and the stator is supplied at its rated voltage and rated frequency.

When the rotor part of a rheostatic rotor starter is rated separately, the indication of a rated rotor operational current may be supplemented by the maximum rated power output for motors having the rated rotor voltage considered, of the motor for which that part of the starter (switching devices, connecting links, relays, resistors) is intended. This power varies in particular with the breakaway torque foreseen and consequently takes into account the starting characteristics (see 4.111).

4.102 Rated duties

The rated duties considered as normal for a contactor, or starter, are as follows.

4.102.1 Continuous duty

Duty in which the main contacts remain closed whilst carrying a steady current without interruption for a period sufficient to reach thermal equilibrium.

4.102.2 Intermittent periodic duty or intermittent duty

Duty in which the main contacts remain closed for periods bearing a definite relation to the no-load periods, both periods being too short to allow the device to reach thermal equilibrium.

Intermittent duty is characterized by the value of the current, the duration of 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.

Standard values of on-load factor are 15 %, 25 %, 40 % and 60 %.

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

– Class 1: up to one operating cycle per hour;
– Class 3: up to three operating cycles per hour;
– Class 12: up to 12 operating cycles per hour;
– Class 30: up to 30 operating cycles per hour;
– Class 120: up to 120 operating cycles per hour;
– Class 300: up to 300 operating cycles per hour.

An operating cycle is defined under 3.6.102.

NOTE 1 In the case of starters for intermittent duty, the difference between the thermal time-constant of the overload relay and that of the motor may render a thermal relay unsuited for overload protection. It is recommended that, for installations intended for intermittent duty, the question of overload protection be subject to agreement between manufacturer and user.

NOTE 2 Special consideration may have to be given to the thermal performance of SCPDs in combinations subject to intermittent duty.

4.102.3 Temporary duty

Duty in which the main contacts remain closed for periods of time insufficient to allow the device to reach thermal equilibrium, the current-carrying periods being separated by no-load periods of sufficient duration to restore equality of temperature with the cooling medium.

Standard values of temporary duty are 10 min, 30 min, 60 min and 90 min with contacts closed.

4.103 Rated load and overload characteristics

4.103.1 Rated making and breaking capacities

A contactor or starter is defined by its making capacities and breaking capacities, as specified in table 10, in accordance with utilization categories (see 4.104). For requirements when used in combination with short-circuit protective devices see 4.107.

4.103.1.1 Rated making capacity

The rated making capacity of a contactor or starter is a value of current determined under steady-state conditions which the device can make without welding or undue erosion of the contacts or excessive display of flame, under specified making conditions.

The rated making capacity is stated by reference to the rated operational voltage and rated operational current, and to the utilization category, according to table 10.

The rated making capacity is expressed by the r.m.s. value of the a.c. component of the current.

NOTE The peak value of the current during the first half-cycle following closing of the contactor or starter may be appreciably greater than the peak value of the current under steady-state conditions, depending on the power factor of the circuit and the instant on the voltage wave when closing occurs.

A contactor or starter shall be capable of closing on a current corresponding to the a.c. component of the current that defines its making capacity, whatever the value of the d.c. component may be, within the limits that result from power factors indicated in table 10.

The rated making capacity is based on the contactor or starter being operated in accordance with the requirements of 4.8.

4.103.1.2 Rated breaking capacity

The rated breaking capacity of a contactor or starter is a value of current which the device can break without undue erosion of the contacts or excessive display of flame, under specified breaking conditions at the rated voltage.

The rated breaking capacity is stated by reference to the rated voltage and rated operational current, and to the utilization category, according to table 10.

A contactor or starter shall be capable of breaking any value of the load current up to its highest rated breaking capacity, according to 4.104.

If the contactor or starter exhibits a minimum breaking current, the magnitude and the power factor shall be declared by the manufacturer.

The rated breaking capacity is expressed by the r.m.s. value of the a.c. component of the current.

4.103.2 Ability to withstand overload currents

Contactors or starters with utilization categories AC-3 or AC-4 shall withstand the overload currents given in table 12 as specified in 6.103.

4.104 Utilization category

The utilization categories as given in table 2 are considered standard in this publication. Any other type of utilization category shall be based on agreement between manufacturer and user, but information given in the manufacturer's catalogue or tender may constitute such an agreement.

Each utilization category is characterized by the values of the currents and voltages, expressed as multiples of the rated operational current and of the rated voltage, and by the power factors as shown in table 10 and other test conditions used in the definitions of the rated making and breaking capacities.

For contactors or starters defined by their utilization category, it is therefore unnecessary to specify separately the rated making and breaking capacities, as those values depend directly on the utilization category as shown in table 10.

The utilization categories of table 10 correspond to the applications listed in table 2.

The voltage for all utilization categories is the rated voltage of a contactor or a starter other than a rheostatic starter, and the rated stator voltage for a rheostatic rotor starter.

All direct-on-line starters belong to utilization category AC-3 or AC-4.

All two-step auto-transformer starters belong to utilization category AC-3.

The stator contactor of rheostatic rotor starters belong to utilization category AC-2.

Table 2 – Utilization categories

Category	Typical application
AC-1	Non-inductive or slightly inductive loads, resistance furnaces
AC-2	Starting and plugging – slip-ring motors
AC-3	Starting and switching off motors during running – squirrel-cage motors
AC-4	Starting, plugging and inching – squirrel-cage motors
NOTE The application of contactors or starters to the switching of rotor circuits, capacitors or transformers shall be subject to special agreement between manufacturer and user.	

Typical service conditions for starters (see figure 1) are:

a) one direction of rotation with the motor being switched off during running in normal service conditions (utilization categories AC-2 and AC-3);

b) two directions of rotation, but the running in the second direction is realized after the starter has been switched off and the motor has completely stopped (utilization categories AC-2 and AC-3);

c) one direction of rotation, or two directions of rotation as in item b), but with the possibility of infrequent inching (jogging). For this service condition, direct-on-line starters are usually employed (utilization category AC-3);

d) one direction of rotation with frequent inching (jogging). Usually direct-on-line starters (utilization category AC-4) are used for this duty;

e) one or two directions of rotation, but with the possibility of infrequent plugging for stopping the motor, plugging being associated, if so provided, with rotor resistor braking (reversing starter with braking). Usually a rheostatic rotor starter is used for this duty condition (utilization category AC-2);

f) two directions of rotation, 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, with switching off the motor running in normal service conditions. Usually a direct-on-line reversing starter is used for this duty condition (utilization category AC-4).

Unless otherwise stated, starters are designed on the basis of the starting characteristics of the motors (see table 3) compatible with the making capacities of table 10. When the starting current of a motor, with stalled rotor, exceeds these values, the operational current should be decreased accordingly.

4.105 Mechanical endurance

With respect to its endurance against mechanical wear, a contactor or starter is characterized by the number of no-load operating cycles (i.e. without current on the main contacts) which can be made before it becomes necessary to replace any parts.

The preferred numbers of no-load operating cycles, expressed in millions, are: 0,01 – 0,03 – 0,1 – 0,3 – 1 and 3.

If no mechanical endurance is stated by the manufacturer, a class of intermittent duty implies a minimum mechanical endurance corresponding to 8 000 h of operation at the highest corresponding frequency of operating cycles.

4.106 Electrical endurance

With respect to its endurance against electrical wear, a contactor or starter is characterized by the number of on-load operating cycles, corresponding to the service conditions given in table 14, which can be made without repair or replacement.

For category AC-3, the manufacturer shall state, on request, the number of on-load operating cycles which can be made without any repair or replacement for the corresponding service conditions of table 14 (see 6.107).

4.107 Coordination with short-circuit protective devices

Contactors and starters are characterized by the type, ratings and characteristics of the short-circuit protective devices (SCPD), for example current-limiting fuses, to be used to provide over-current discrimination between starter and SCPD and adequate protection of the contactor and starter against short-circuit currents. Requirements are given in 6.6, 6.104 and 6.106 of this standard.

a) For a contactor or starter not equipped with short-circuit protection, the following information shall be given by the manufacturer to enable design for coordination to be achieved:
   - highest cut-off current of the SCPD intended for use in the combination;
   - maximum short-circuit breaking capacity;
   - maximum prospective short-time withstand current and duration, or the Joule integral ($\int i^2 dt$) withstand capability of the contactor or starter;
   - maximum prospective peak withstand current.

See 6.6 and 6.104.

The short-circuit breaking capacity shall not be limited to the R10 series.

b) The manufacturer of the SCPD shall state
   - the maximum peak current and the maximum Joule integral let through by the SCPD as a function of the short-circuit current;
   - the time-current characteristics of the SCPD.

c) For a contactor or starter equipped with an SCPD, the manufacturer shall state the following in order to achieve a given type of coordination:
   - types and characteristics of the coordinated devices;
   - type of coordination (see 4.107.3);
   - rated short-circuit breaking current (I_{sc});
   - rated short-circuit making current (I_{ma}).

The rated short-circuit breaking current is the highest prospective short-circuit current which the combination shall be capable of breaking, under the conditions of use and behaviour prescribed in this standard, in a circuit having a power frequency recovery voltage corresponding to the rated voltage of the combination. The rated short-circuit breaking current shall be selected from the R10 series.

The rated short-circuit making current is the highest prospective peak current which the combination shall be capable of making, under the conditions of use and behaviour defined in this standard, in a circuit having a power frequency voltage corresponding to the rated voltage of the combination.

The verification of coordination is carried out according to 6.106.

NOTE 1 It is recognized that the series impedance of the combination or rapid operation of the fuses or switch may cause one or both of the following effects:

a) a reduction of short-circuit current to a value appreciably below that which would otherwise be reached;

b) such rapid operation that the short-circuit current wave is distorted from its normal form.

This is why the term "prospective current" is used when assessing breaking and making performances.

NOTE 2 A given combination of a contactor or starter and an SCPD may comply with more than one type of coordination for different values of the rated short-circuit current.

4.107.1 General requirements for coordination

The SCPD shall be located on the supply side of the contactor or starter, and have a short-circuit breaking capacity not less than the prospective short-circuit current at its location. This requirement shall be verified by reference to the results of breaking capacity tests carried out on the SCPD according to the relevant specification.

The SCPD shall not operate in place of the switching device for currents up to the maximum overload levels in normal service (including stalled current of the motor). This requirement shall be verified by reference to the results of overload tests carried out separately on the SCPD according to the relevant specification.

For currents equal to the breaking currents of the contactor or starter indicated in table 10 for AC-3 utilization category, it shall be verified from information supplied by the manufacturer of the SCPD that the latter is able to withstand those currents for times at least equal to the corresponding tripping time of the overload relays.

For all values of overcurrent for which the combination is suitable, the contactor or starter, including the SCPD, if integrally mounted, shall operate in such a manner that the external manifestations (such as emission of flames or hot gases) do not extend beyond a safety perimeter stated by the manufacturer of the starter. If the SCPD is remote from the starter, it shall operate according to its relevant specifications.

4.107.2 Take-over current for release-operated combinations

The value of the three-phase symmetrical current used for test duty C (see 6.106.3.3).

4.107.3 Coordination and acceptable damage classification

For currents exceeding the maximum take-over current of the starter as defined in 6.106.3.3, the flow of current in the contactor or starter during the breaking time may cause damage to the switching device. According to the amount of damage acceptable, several types are considered standard. The type of coordination shall be verified by the tests specified in 6.106.

Type a – Any kind of damage is allowed (with the exclusion of external damage to the enclosure, if any) so as to make necessary the replacement of the device as a whole or the replacement of fundamental parts in addition to those listed in type b coordination.

Type b – The characteristics of the overload relay of the starter may be permanently altered. Other damage shall be confined to the main contacts and/or the arc chambers of the starter which may require replacement or attention.

Type c – Damage shall be confined to the main contacts of the starter (which may require replacement or the breaking of welds).

Cases where the applications call for a practically negligible risk of contact welding are subject to agreement between manufacturer and user, and are not covered by this standard.

For currents not exceeding the maximum take-over current, there shall be no material damage to the contactor or starter and it shall subsequently be capable of normal operation.

4.108 Types and characteristics of automatic change-over devices and automatic acceleration control devices

4.108.1 Types

a) Time-delay devices, for example time-delay contactor relays (see IEC 60947-5-1) applicable to control-circuit devices, or specified-time all-or-nothing relays (see IEC 61812-1)
b) Undercurrent devices (undercurrent relays)
c) Other devices for automatic acceleration control
   – devices dependent on voltage
   – devices dependent on power
   – devices dependent on speed

4.108.2 Characteristics

a) The characteristics of time-delay devices are
   – the rated time-delay, or range of time-delay if adjustable;
   – for time-delay devices fitted with a coil, the rated voltage, when it differs from the starter line voltage.
b) The characteristics of the undercurrent devices are
   – the rated current (thermal current and/or rated short-time withstand current, according to the indications given by the manufacturer);
   – the current setting, or its range if adjustable.
c) The characteristics of the other devices shall be determined by agreement between manufacturer and user.

4.109 Types and characteristics of starting auto-transformers or reactors

Account being taken of the starting characteristics (see 4.111), these shall be characterized by

– the rated voltage;
– the number of taps available for adjusting the starting torque and current;
– the starting voltage, i.e. the voltage at the tapping terminals, as a percentage of the rated voltage;
– the current they can carry for a specified duration;
– the rated duty (see 4.102);
– the method of cooling (air-cooling, oil-cooling).

The auto-transformer or reactor can be

– either built-in into the starter, in which case the resulting temperature rise has to be taken into account in determining the ratings of the starter, or
– provided separately, in which case the nature and dimensions of the connecting links have to be specified by agreement between the manufacturer of the transformer or reactor and the manufacturer of the starter.

4.110 Types and characteristics of starting resistors for rheostatic rotor starters

Account being taken of the starting characteristics (see 4.111), the starting resistors shall be characterized by

– the rated rotor insulation level;
– their resistance value;
– the thermal current, defined by the value of steady current they can carry for a specified duration;
– the rated duty (see 4.102);
– the method of cooling (for example free air, forced air, oil immersion).

The starting resistors can be

– either built-in into the starter, in which case the resulting temperature rise has to be limited, in order not to cause any damage to the other parts of the starter, or
– provided separately, in which case the nature and dimensions of the connecting links have to be specified by agreement between the manufacturer of the resistors and the manufacturer of the starter.

4.111 Characteristics dependent on starter type

Table 3 indicates characteristics of the various starter types. These should be considered as typical, but for some applications there may be very specific starting requirements.

Table 3 – Characteristics dependent on starter type

Type of starter	Utilization category	Number of steps	Power	Duty cycle		U_{ro}	I_{er} [1)]	Cooling	Locked rotor torque T_{lr} [2)]	Locked rotor current I_{lr}	U_{tap} [3)]
				Start time	No. /h						
1. Direct-on-line	AC-3, AC-4	1	x		x						
2. Reversing	AC-4	1	x		x						
3. Two-direction	AC-2, AC-3	1	x		x						
4. Reduced kVA											
Rheostatic	AC-2, AC-3	n [5)]	x	x	x	x	x	x	x		
Auto-transformer	AC-3	2	x	x	x [4)]			x			x
Reactor	AC-3	2	x	x	x [4)]			x	x	x	x

I_{er} Rated rotor operational current (see 4.101.1)
U_{ro} Rated rotor voltage (see 4.1.101)
U_{tap} Tap voltage (see 4.2.102 and 4.2.103)

1) Information usually supplied by the motor manufacturer.
2) To be supplied to the starter manufacturer. Standard values are 70 %, 100 %, 150 % and 200 % of the rated torque T_e.
3) Standard values are 50 %, 65 % and 80 %.
4) Two starts at 30 s intervals, followed by cooling to ambient, assumed unless otherwise specified.
5) For most applications, between two and six starting steps are adequate depending upon load torque, inertia and the severity of the start required.

5 Design and construction

5.1 Requirements for liquids

Subclause 5.1 of IEC 60694 is applicable.

5.2 Requirements for gases

Subclause 5.2 of IEC 60694 is applicable.

5.3 Earthing

Subclause 5.3 of IEC 60694 is applicable with the following modifications.

5.3.101 Earthing of the main circuit

Subclause 5.3.1 of IEC 60298 is applicable.

5.3.102 Earthing of the enclosure

Subclause 5.3.2 of IEC 60298 is applicable.

5.3.103 Earthing of switching devices

The exposed conductive parts (for example chassis, framework and fixed parts of metal enclosures), other than those which cannot constitute a danger, shall be electrically inter-connected 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 equipment is used on its own or incorporated in an assembly. Any connecting point shall be marked with the "protective earth" symbol, as indicated by symbol 5019 of IEC 60417.

5.4 Auxiliary and control equipment

Subclause 5.4 of IEC 60694 is applicable with the following modification.

For the operating range of main, auxiliary and control devices, see 4.8 of this standard.

5.5 Dependent power operation

Subclause 5.5 of IEC 60694 is applicable with the following modification.

A contactor or starter arranged for dependent power operation with external energy supply shall be capable of making and breaking its rated short-circuit current (if any) when the voltage of the power supply of the operating device is at the lower of the limits specified under 4.8. If maximum closing and opening times are stated by the manufacturer, these shall not be exceeded.

5.6 Stored energy operation

Subclause 5.6 of IEC 60694 does not apply.

5.7 Independent manual operation

Subclause 5.7 of IEC 60694 does not apply.

5.8 Operation of releases

Subclauses 5.8.2 to 5.8.4 of IEC 60694 are applicable with the following addition.

For types and characteristics of relays and releases, see 5.101 of this standard.

NOTE In the remainder of this standard, the term overload relay should be taken to apply equally to an overload relay or an overload release as appropriate.

5.9 Low- and high-pressure interlocking and monitoring devices

Subclause 5.9 of IEC 60694 is applicable.

5.10 Nameplates

Subclause 5.10 of IEC 60694 is applicable with the following addition.

Each contactor or starter shall be provided with a nameplate carrying the following data, marked in a durable manner, and located in a place such that they are visible and legible when the contactor or starter is in position:

NOTE In the case of contactors or starters designed as withdrawable or removable units for building into factory assembled switchgear and controlgear, such nameplates need only be visible following such withdrawal or removal.

a) the manufacturer's name or trade mark;

b) type designation or serial number;

c) rated frequency (f_r), for example ~ 50 Hz;

d) rated voltage (U_r) (see 4.1);

e) rated operational current (I_e) or power (see 4.101);

f) altitude class.

Rated operational currents or rated operational powers (see 4.101) and other data required for application purposes shall be made available by the manufacturer, for which purpose the type designation or serial number is an essential part of the nameplate data.

If the available space on the nameplate is insufficient to carry all the above data, the contactor or starter shall carry at least the information under a) and b). In this instance, the complete data shall be displayed elsewhere on the equipment.

The following information concerning the operating coils of the contactor or starter shall be placed either on each coil or on the device:

g) either the indication "d.c." (or the symbol ⎓) or value of the rated frequency, for example ~ 50 Hz;

h) rated coil voltage.

Coils of operating devices shall have a reference mark permitting the complete data to be obtained from the manufacturer.

5.11 Interlocking devices

Subclause 5.11 of IEC 60694 is applicable with the following addition.

Further requirements for interlocking of a combination are specified in 5.106 of IEC 60298. Reversing contactors, and any other arrangement of two or more contactors that would cause a line-to-line fault if they were in the closed position at the same time, shall be mechanically and electrically interlocked to preclude this condition.

5.12 Position indication

Where position indicators are required, subclause 5.12 of IEC 60694 is applicable.

5.13 Degrees of protection by enclosures

Subclause 5.13 of IEC 60694 is applicable.

5.14 Creepage distances

Subclause 5.14 of IEC 60694 does not apply.

5.15 Gas and vacuum tightness

Subclause 5.15 of IEC 60694 is applicable.

5.16 Liquid tightness

Subclause 5.16 of IEC 60694 is applicable.

5.17 Flammability

Subclause 5.17 of IEC 60694 is applicable.

5.18 Electromagnetic compatibility (EMC)

Subclause 5.18 of IEC 60694 is applicable with the following addition.

Emission caused by switching operations is of short duration, of the order of milliseconds. The frequency, level and consequences of such emission are considered to be part of the normal electromagnetic environment of switchgear and controlgear. Such emission shall therefore not be taken to be electromagnetic disturbance.

5.101 Types of relay or release

The following types of release are recognized:

a) release with shunt coil (shunt release);
b) under-voltage relay or release;
c) overload time-delay relay, the time-lag of which is
   1) substantially independent of previous load (for example time-delay magnetic overload relay),
   2) dependent on previous load (for example thermal overload relay),
   3) dependent on previous load (for example thermal overload relay) and also sensitive to phase failure;
d) instantaneous over-current relay or release (when applicable);
e) other relays or releases (for example phase unbalance relay).

5.101.1 Characteristics

a) Release with shunt coil and under-voltage opening relay or release:
   – rated voltage;
   – rated frequency.
b) Overload relay:
   – either the associated motor full-load current, or the ultimate trip current (see 5.101.5.1);
   – rated frequency (when necessary);
   – current setting (or range of settings);
   – time-current characteristics (or range of characteristics), when necessary;
   – number of poles;
   – nature of the relay, for example thermal or magnetic.

NOTE Depending on the nature of the relay, the opening conditions are given in 5.101.5.1.

In the case of a rheostatic rotor starter, the overload relay is commonly inserted in the stator circuit. As a result, it cannot efficiently protect the rotor circuit and more particularly the resistors (generally more easily damageable than the rotor itself or the switching devices in case of a faulty start); protection of the rotor circuit should be the subject of a specific agreement between manufacturer and user.

For rheostatic starters, the overload relay shall be connected in the stator circuit. Special arrangements may be made to protect the rotor contactors and resistors against overheating if requested by the user.

In the case of a two-step auto-transformer starter, the starting auto-transformer is normally designed for use during the starting period only: as a result, it cannot be efficiently protected by the overload relay in the event of faulty starting. Protection of the auto-transformer should be the subject of specific agreement between manufacturer and user.

When starters are used in conditions in which overheating of the starting resistors or transformers would represent an exceptional hazard, it is recommended that a suitable device be fitted to switch off the starter automatically before a dangerous temperature is reached.

5.101.2 Designation and current setting of overcurrent relays

Overload relays are designated by their type and their current setting. An overload relay is said to be:

Type 1 – if the current setting refers to the associated motor full-load current (see item a) of 5.101.5.1.1);

Type 2 – if the current setting is the ultimate trip current (see item b) of 5.101.5.1.1).

Both types are designated by the current setting (or the upper and lower limits of the current setting range, if adjustable).

The current setting (or current setting range) shall be marked, or displayed, on the overload relay or its scale. The marking may be either directly in amperes, or as a function of the current value marked on the relay or on the heaters, if these are replaceable.

However, if the current setting is influenced by the conditions of use or other factors which cannot readily be marked on the relay, then the relay or any interchangeable parts thereof (for example heaters or current transformers) shall carry a number or an identifying mark which makes it possible to obtain the relevant information from the manufacturer or his catalogue or, preferably, from data furnished with the starter.

In the case of indirect (current transformer operated) overload relays, the marking may refer either to the primary current of the current transformer through which they are supplied, or to the current setting of the overload relays. In either case, the ratio of the current transformer shall be stated.

5.101.3 Time-current characteristics of overload relays

The time-current characteristics shall be given in the form of curves supplied by the manufacturer. These shall indicate how the tripping time, starting from the cold state (see 5.101.4) varies with the current up to a value of at least seven times the full-load current of the motor with which it is intended that the relay be used, or the take-over current as per 6.106.3.3, whichever is the greater. The manufacturer shall indicate, by suitable means, the tolerances applicable to these curves.

These curves shall be given for each extreme value of the current setting and, if the time-current characteristics are adjustable, it is recommended that they be given in addition for each extreme value of the time setting.

NOTE It is recommended that the current be plotted as abscissae and the time as ordinates, using logarithmic scales. Further, in order to facilitate the study of coordination of different types of protection, it is recommended that the current be plotted as multiples of the setting current and the time in seconds on the standard graph sheet detailed in 18.9 of IEC 60282-1.

5.101.4 Influence of ambient air temperature

The time-current characteristics (see 5.101.3) refer to a stated value of ambient air temperature.

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

The overload relays shall be able to operate within the ambient air temperature range of –5 °C to +40 °C, and the manufacturer shall be prepared to state the effect of variations in ambient air temperature on the characteristics of overload relays, including, where necessary, the extreme temperature conditions permitted by this standard. (See clause 2.)

5.101.5 Opening by relays or releases

5.101.5.1 Opening by thermal overload relays

5.101.5.1.1 Opening by thermal overload relays when all their poles are equally energized

a) *Type 1 overload relay* (designated by the associated motor full-load current)

At *A* times the current setting, tripping shall not occur in less than 2 h, starting from the cold state, i.e. with the starter in its enclosure, if any, at the value of ambient air temperature stated in table 4. Moreover, when the value of the current is subsequently raised to *B* times the current setting, tripping shall occur less than 2 h later.

b) *Type 2 overload relay* (designated by the ultimate trip current)

At *C* times the current setting, tripping shall not occur in less than 2 h, starting from the cold state, i.e. with the starter in its enclosure, if any, at the value of ambient air temperature stated in table 4. Moreover, when the value of the current is subsequently raised to *D* times the current setting, tripping shall occur less than 2 h later.

The values of factors *A, B, C* and *D* are given in table 4 for both types of overload relays, either compensated or not compensated for ambient air temperature.

NOTE For the purpose of this standard, an overload relay is considered to be compensated for ambient air temperature if it complies with the relevant figures of table 4, by whatever means this is achieved.

Table 4 – Characteristics of the opening operation of overload relays when energized on all poles

Overload relay	Type 1		Type 2		Reference ambient air temperature
	A	*B*	*C*	*D*	
Not compensated for ambient air temperature	1,05	1,20	0,87	1,00	[1)]
Compensated for ambient air temperature	1,05 1,05 1,00	1,20 1,20 1,20	0,87 0,87 0,87	1,05 1,11 1,00	+20 °C –5 °C +40 °C

[1)] See 5.101.4. The ambient air temperature can be any stated value between –5 °C and +40 °C (see 2.1); the preferred values are +20 °C and +40 °C.

5.101.5.1.2 Opening by multi-pole thermal overload relays of type c) 2) of 5.101 when only some of their poles are energized

When all the poles of a multi-pole thermal relay are not energized, the requirements of 5.101.5.1.1 do not apply.

In the special case of a three-pole overload relay operating on two poles only, the values of factors *A, B, C* and *D* are given in table 5.

Table 5 – Characteristics of the opening operation of three-pole thermal overload relays when energized on two poles only

Overload relay	Type 1		Type 2		Reference ambient air temperature
	A	*B*	*C*	*D*	
Not compensated for ambient air temperature	1,05	1,32	0,87	1,10	+20 °C or +40 °C
Compensated for ambient air temperature	1,05	1,32	0,87	1,16	+20 °C only

The figures in this table apply only to type tests. The overload relay is heated on three poles for 2 h with a current equal to *A* or *C* times the current setting; one heater is then disconnected and the current in the two remaining is increased to *B* or *D* times the current setting; then, tripping shall occur less than 2 h later.

For simplicity, the above tests may be made at one ambient air temperature only.

5.101.5.1.3 Opening by three-pole phase failure sensitive thermal overload relays of type c) 3) of 5.101 when their poles are not equally energized

Depending on whether the overload relay is type 1 or type 2 (see 5.101.5.1.1), at *A* or *C* times the current setting, tripping shall not occur in less than 2 h starting from the cold state, i.e. with the starter in its enclosure, if any, at the value of ambient air temperature stated in table 6. Moreover, when the value of the current in the two poles which carried the higher current is respectively increased to *B* or *D* times the current setting and the pole which carried the lower current is disconnected, tripping shall occur less than 2 h later.

Table 6 – Characteristics of the opening by three-pole phase failure sensitive thermal overload relays when their poles are not equally energized

Overload relay	Type 1		Type 2		Reference ambient air temperature
	A	*B*	*C*	*D*	
Compensated for ambient air temperature	2 poles 1,0 1 pole 0,9	2 poles 1,15 1 pole 0	2 poles 0,83 1 pole 0,75	2 poles 0,95 1 pole 0	+20 °C
NOTE Relays not compensated for ambient air temperature are considered as special cases, subject to agreement between manufacturer and user.					

The above values shall apply to all combinations of poles: for example, for columns *B* and *D*: poles I and III energized and pole II disconnected, poles I and II energized and pole III disconnected, poles II and III energized and pole I disconnected.

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

5.101.5.1.4 Opening by magnetic overload relays

For all values of current settings, the overload relay shall trip with an accuracy of ±10 % of the value of the current setting.

5.101.5.1.5 Special protection requirements

Special overload relays may be supplied by arrangement between manufacturer and user, for example to meet special requirements such as closer overload protection or abnormally long starting times.

It is the responsibility of the user to confirm that the characteristics of the protective devices provide adequate protection for the load circuit. The manufacturer shall provide details of the protective relays and SCPD on request.

5.101.5.2 Limits of operation of automatic change-over by under-current relays

For auto-transformer or reactor starters, from the starting to the ON position:

The lowest drop-out current of an under-current relay shall be not greater than 1,5 times the actual current setting of the overload relay which is active in the starting position. The under-current relay shall be able to carry any value of current, from its lowest current setting to the stalled current in the starting position, for the tripping times determined by the overload relay at its highest current setting.

5.102 Enclosures

For metal-enclosed contactors, starters and combinations, subclause 5.102 of IEC 60298 is applicable.

5.103 Combination starters

Combination starters shall be designed so as to be capable of breaking, at the required recovery voltage, any current up to and including the rated short-circuit breaking current.

They shall also be designed so as to be capable of making, at the rated voltage, onto circuits to which the rated short-circuit making current applies.

5.104 Linkages between the fuse striker(s) and the indicator or contactor release

Any linkages between the fuse striker(s), fuse-blown indicator and/or contactor release, where fitted, shall be such that the contactor operates satisfactorily under both three-phase and single-phase conditions at the minimum and maximum requirements of a given type of striker (medium or heavy), irrespective of the method of striker operation (spring or explosive). The requirements for strikers are given in IEC 60282-1.

6 Type tests

6.1 General

Clause 6 of IEC 60694 is applicable with the following modifications.

The type tests also include (refer to table 7 for applicability)

– mechanical endurance tests (see 6.101);
– making and breaking and reversibility tests (see 6.102);
– overload current withstand tests (see 6.103);
– short-circuit current making and breaking tests (see 6.104);
– verification of operating limits and characteristics of overload relays (see 6.105);
– change-over ability and reversibility, where applicable (see 6.102.6 and 6.102.7);
– tests of the striker mechanism (see 6.101.4).

The following special type tests are not mandatory but may be conducted to verify performance claims:

– verification of coordination with SCPDs (see 6.106);
– electrical endurance tests (see 6.107);
– motor switching tests (see 6.108).

The individual tests shall be made on a contactor in a clean and as-new condition, and the various type tests may be made at different times and at different locations.

It is understood that the contactor in a combination will have been tested as an individual component to this standard. Further, it is understood that the SCPD will have been tested to the requirements of the relevant standard.

Thus, for combinations, four groups of tests are involved:

a) tests on the contactor in accordance with this standard; these tests may be done on a combination other than that used for tests according to c);
b) tests on the SCPD in accordance with the relevant standard, for example IEC 60282-1 or IEC 60644;
c) tests on the combination in accordance with this standard;
d) tests on the enclosure in accordance with IEC 60298.

The combination submitted for test shall

a) conform in all essential details to drawings of its type;
b) be in a clean and as-new condition, and fitted with the appropriate SCPD;
c) when release-operated, be equipped with over-current relays or releases of the lowest normal current rating associated with the fuses.

The responsibility of the manufacturer is limited to the specified values and not to the values obtained during the type tests.

The tests shall be made at the rated frequency with a tolerance of ±10 %, unless otherwise specified in the relevant subclauses.

NOTE For convenience of testing, wider tolerances of the rated frequency may be necessary. If the deviations are appreciable, i.e. when controlgear is rated for 50 Hz and tested at 60 Hz and vice versa, care should be taken in the interpretation of results.

Details relating to records and reports of type tests for making, breaking and short-time current performance are given in annex A.

Table 7 – Applicable type tests

Test	Contactor	Starter	Combination	Subclause
Dielectric tests	X	X	X	6.2
Measurement of circuit resistance	X	X	X	6.4
Temperature-rise tests	X	X	X	6.5
Short-time and peak withstand current tests	X	X	–	6.6
Verification of the protection	–	–	X	6.7
Tightness tests	X	–	–	6.8
EMC tests	X	–	X	6.9
Verification of operating limits	X	X	X	6.101.1
Mechanical endurance tests	X	X	X	6.101.2
Interlocking tests	–	X	X	6.101.3
Rated making and breaking capacity tests	X	–	–	6.102
Reversibility tests	–	X	X	6.102.6
Change-over ability tests	–	X	X	6.102.7
Overload current withstand tests	X	–	X	6.103
Short-circuit current making and breaking tests	X	–	–	6.104
Verification of operating limits of overload relays	–	X	X	6.105
Coordination with SCPDs	–	–	X	6.106
Electrical endurance tests	X	–	–	6.107
Motor switching tests	X	–	–	6.108
Tests on the striker mechanism	–	–	X	6.101.4
X: applicable to this configuration.				

6.2 Dielectric tests

Subclause 6.2 of IEC 60694 is applicable with the following modifications.

6.2.1 Conditions during dielectric tests

The dielectric tests shall be made with components giving the most onerous dielectric conditions.

6.2.2 Criteria to pass the test

b) Impulse tests

Where internal disruptive discharges occurring across the open contacts of a contactor do not lead to a sustained passage of current (for example in a vacuum contactor), then such discharges can be disregarded.

6.3 Radio interference voltage (r.i.v.) test

Subclause 6.3 of IEC 60694 does not apply.

6.4 Measurement of the resistance of circuits

Subclause 6.4 of IEC 60694 is applicable with the following modification.

6.4.1 Main circuit

The current during the test shall have any convenient value between 50 A and the rated operational current. If the rated operational current is less than 50 A, the measurement shall be made at the rated operational current.

NOTE Where fuses are used as the SCPD, solid links of negligible resistance may be used instead of fuses but the resistance of the links is to be recorded.

6.5 Temperature-rise tests

6.5.1 Conditions of the contactor to be tested

Subclause 6.5.1 of IEC 60694 is applicable.

6.5.2 Arrangement of the equipment

Subclause 6.5.2 of IEC 60694 is applicable with the following addition.

For values of thermal current I_{th} up to and including 800 A:

a) the connections shall be single-core, insulated, copper conductors with cross-section areas as given in table 8. The use of insulating conductors in accordance with table 8 does not require measurement of the temperature rise at the temporary connections. For values of test current above 400 A, equivalent copper bars may be substituted;

b) the connections shall be in free air and spaced not less than the distance existing between the terminals;

c) for single-phase or multi-phase tests, the minimum length of each temporary connection from an equipment terminal to another terminal or to the test supply or to a star point shall be 1,2 m;

d) for three-pole contactors and starters, the tests may be made with all poles connected in series.

Table 8 – Test copper conductors for test currents up to 800 A inclusive

Range of test current [1] A		Conductor size [2], [3], [4]	
		mm^2	AWG/MCM
0	8	1,0	18
8	12	1,5	16
12	15	2,5	14
15	20	2,5	12
20	25	4,0	10
25	32	6,0	10
32	50	10	8
50	65	16	6
65	85	25	4
85	100	35	3
100	115	35	2
115	130	50	1
130	150	50	0
150	175	70	00
175	200	95	000
200	225	95	0000
225	250	120	250
250	275	150	300
275	300	185	350
300	350	185	400
350	400	240	500
400	500	2 x 150	2 x 250
500	630	2 x 185	2 x 350
630	800	2 x 240	2 x 500

[1] The test current shall be greater than the first value in the first column, and less than or equal to the second value in that column.

[2] For convenience of testing and with the manufacturer's consent, smaller conductors than those given for a stated test current may be used.

[2] The table gives alternative sizes for conductors in the metric and AWG/MCM systems.

[4] Either of the two conductors specified for a given test current range may be used.

6.5.3 Measurement of the temperature and temperature rise

Subclause 6.5.3 of IEC 60694 is applicable with the following addition.

The main circuit of a contactor, including the over-current releases which may be associated with it, shall be capable of carrying, without the temperature rises exceeding the limits specified in table 3 of IEC 60694:

– for a contactor intended for continuous duty: its thermal current;

– for a contactor intended for intermittent periodic duty or temporary duty: its rated operational current for the appropriate duty;

– for a combination starter with current-limiting fuses as the SCPD.

The test shall be carried out at the thermal current of the combination when fitted with fuses of the highest current rating and/or power dissipation. The temperature rises of the various parts of the combination shall not exceed the values specified in IEC 60282-1 for the fuses and IEC 60694 for the other parts of the combination.

The following characteristics of the fuses used for the test shall be recorded:

a) manufacturer and type;

b) rated voltage and rated current;

c) internal resistance (see 6.4);

d) power dissipation (measured according to the prescriptions of IEC 60282-1).

If the fuses are in an enclosure, the power dissipation at the end of the temperature-rise test is the maximum acceptable power dissipation of the combination and shall be recorded.

6.5.4 Ambient air temperature

Subclause 6.5.4 of IEC 60694 is applicable.

6.5.5 Temperature-rise test of the auxiliary and control equipment

Subclause 6.5.5 of IEC 60694 is applicable with the following additions.

6.5.5.101 Temperature-rise tests on control electro-magnets

The control electro-magnets shall be tested according to the following conditions, with the specified kind of supply current and at their rated voltage.

With rated operational current flowing through the main circuit, the windings of coils shall withstand, under continuous load and at the rated frequency, if applicable, their rated voltage without the temperature rises exceeding the limits specified. Specially rated coils, for example trip coils of latched contactors, shall withstand without damage the most severe operating cycle for which they are intended.

With no current flowing through the main circuit, under the same conditions of supply and without the temperature-rise limits being exceeded, the coil windings of contactors for intermittent duty classes 12 to 300 shall also withstand the following frequencies of operation.

Table 9 – Intermittent duty operating cycles

Intermittent duty class of the contactor (see 4.102.2)	One close-open operating cycle every s	Interval of time during which the supply of the control coil of electrically held contactors is maintained s
12	300	180
30	120	72
120	30	18
300	12	4,8

The temperature shall be measured when thermal equilibrium is reached in both the main circuit and the control electro-magnet.

Electro-magnets shall be tested for a sufficient time for the temperature rise to reach a steady-state value. In practice, this condition is reached when the variation does not exceed 1 K per hour.

At the end of these tests, the temperature rise of the different parts of the control electro-magnets shall not exceed the values specified.

6.5.5.102 Temperature-rise tests of auxiliary circuits

The temperature-rise tests of auxiliary circuits are made under the same conditions as those provided in 6.5.5.101.

At the end of these tests, the temperature rise of auxiliary circuits shall not exceed the values specified.

NOTE When the mutual heating effect between main circuit, control circuits and auxiliary circuits may be of significance, these temperature-rise tests are made simultaneously.

6.5.5.103 Temperature rise of starting resistors for rheostatic rotor starters

The temperature rise of resistors shall not exceed the limits specified in table 3 of IEC 60694, when the starter is operated at its rated duty (see 4.102) and according to its starting characteristics (see 4.111).

The current through each section of the resistors shall be thermally equivalent to the current during the starting time when the controlled motor is operating with the maximum starting torque and the starting time for which the starter is rated (see 4.102 and 4.111); in practice, the average current for that resistor section can be used.

Starting operations shall be evenly spaced in time according to the number of starts per hour.

The temperature rise of the enclosures and the air issuing therefrom shall not exceed the limits specified in table 3 of IEC 60694. Additionally, the exteriors of enclosures and the air issuing from ventilation openings of enclosures for resistors shall not exceed a temperature rise of 200 K. The manufacturer shall provide sufficient information in accordance with clause 10.

NOTE It is not practical to test the performance of the starting resistors of every combination of motor output and rotor voltage and current; it is required only that a sufficient number of tests be made to prove, by interpolation or deduction, compliance with this standard.

6.5.5.104 Temperature rise of the auto-transformer or reactor for two-step auto-transformer or reactor starters

The temperature rise of the auto-transformer or reactor shall not exceed the limits specified in the appropriate component standard (for example IEC 60076-2 or IEC 60726), increased by 15 K (see 4.4.101), when the starter is operated at its rated duty (see 4.102). No damage shall result to the auto-transformer or reactor.

The current through each winding of the auto-transformer or reactor shall be thermally equivalent to the current carried when the controlled motor is operating with six times the rated operational current I_e multiplied by:

$$0{,}8 \times \frac{\textit{starting voltage}}{U_e}$$ for a duration of 30 s (see 4.2.102).

The operating test cycle shall be C – 30 s – O – 30 s – C – 30 s – O (where C is a closing operation and O is an opening operation).

In the case of an auto-transformer or reactor with several sets of taps, the test shall be made with the taps giving the highest power loss in the transformer or reactor.

In order to facilitate this test, star-connected impedances may be used in place of a motor.

6.5.6 Interpretation of the temperature-rise tests

Subclause 6.5.6 of IEC 60694 is applicable.

6.6 Short-time withstand current and peak withstand current tests

Subclause 6.6 of IEC 60694 is applicable with the following addition to 6.6.3.

These tests shall be performed on contactors which are to be assigned a short-circuit capability for coordination with short-circuit protective devices. Refer also to 6.104.

Separation of the contacts of a contactor or starter does not constitute a failure for these devices. The acceptability of damage shall be according to the classification assigned in accordance with 4.107.3.

NOTE Where applicable, solid links of negligible resistance are used in place of the SCPD.

6.7 Verification of the protection

Subclause 6.7 of IEC 60694 is applicable.

6.8 Tightness tests

Subclause 6.8 of IEC 60694 is applicable with the following addition.

The manufacturer may use an alternative test that can be demonstrated to be at least as effective.

6.9 Electromagnetic compatibility tests (EMC)

Subclause 6.9 of IEC 60694 is applicable.

6.101 Mechanical tests

6.101.1 Verification of operating limits

When a contactor or starter can be supplied in several forms, according to the conditions of use (open type, various types of enclosure, etc.), the tests need only be carried out on one form stated by the manufacturer. The details of type and installation shall form part of the test report.

It shall be verified that the contactor or starter completes one operating cycle satisfactorily at each voltage limit specified in 4.8 and within the temperature limits specified when the coil is energized and de-energized long enough to ensure that the contactor comes to its extreme positions. Tests shall be performed with no current flowing through the main circuit.

When tests are performed on a contactor or motor starter destined for installation at high altitude, it may be necessary to make adjustments to the mechanism to achieve correct operation. Refer to 8.102.7.

6.101.2 Mechanical endurance tests

6.101.2.1 Condition for tests

The contactor or starter shall be installed as for normal service; in particular, the conductors shall be connected in the same manner as for normal use.

During the test, there shall be no voltage or current in the main circuit. The device may be lubricated before the test if lubrication is prescribed in normal service.

6.101.2.2 Operating conditions

The coils of the control electro-magnets shall be supplied at their rated voltage and, if applicable, at their rated frequency.

If a resistance or impedance is provided in series with the coils, whether short-circuited or not during the movement, the tests shall be carried out with these elements connected as in normal operation.

6.101.2.3 Test procedure

The tests are carried out at the frequency of operations corresponding to the class of intermittent duty. However, if the manufacturer considers that the device can satisfy the required conditions when using a higher frequency of operations, he may do so in order to reduce the duration of the tests.

The duration of energization of the control coil shall be greater than the time of operation of the device, and the time for which the coil is not energized shall be of such a duration that the device can come to rest at both extreme positions.

The number of operating cycles to be carried out shall be not less than the number of no-load operating cycles specified in 4.105.

The maintenance programme prescribed by the manufacturer shall be followed.

This maintenance work shall not include any replacement of parts.

6.101.2.4 Results to be obtained

Following the tests of mechanical endurance, the contactor or starter shall still be capable of complying with the operating conditions specified in 4.8 and 6.101.1. The integrity of the interrupting medium shall be confirmed by means of a suitable test. There shall be no loosening of the parts used for connecting the conductors.

The results of the interrupting medium integrity tests shall be included in the test report.

NOTE The use of a voltage test as a condition check is recognized under 6.2.11 of IEC 60694.

6.101.3 Interlocking tests

Subclause 6.102 of IEC 60298 is applicable to starters and combinations with the following modification to the first sentence of 6.102.2.

The interlock shall be set in the position intended to prevent the operation of the switching devices and the insertion or withdrawal of removable parts, or the simultaneous operation of two switching devices.

6.101.4 Test of the striker mechanism

a) To test the mechanical reliability of the linkages between the fuse striker(s) and the indicator or release, a total of 100 operations shall be made with the appropriate type of striker, of which 90 shall be made (30 in each pole) with one striker of minimum energy and 10 with three strikers of maximum energy operating simultaneously.

   After performing this test duty, the mechanical functioning of the linkages shall be practically the same as before the tests.

b) Using a dummy fuse-link with an extended striker, set to the minimum actual travel within the tolerance specified in IEC 60282-1, for each pole in turn it shall be shown that the contactor either cannot be closed or cannot remain closed according to its design.

   NOTE For the purpose of these tests, a device simulating fuse-striker operation may be used.

6.102 Verification of rated making and breaking capacity

6.102.1 General

The tests concerning the verification of the making and breaking capacities of a contactor are intended to verify that the device is capable of making and breaking the currents stated in table 10, and not to verify the performance over long periods of operation.

Reversibility and change-over tests are applied to combinations, as appropriate.

Table 10 – Verification of rated making and breaking capacities – Conditions for making and breaking corresponding to the several utilization categories at rated voltage U_r

Category	Make		Break			
			Minimum rated breaking current		Highest rated breaking current	
	I_m/I_e [1)]	cos φ [2)]	I_c/I_e	cos φ [2)]	I_c/I_e	cos φ [2)]
AC-1	1,5	0,95	0,2	0,95	1,5	0,95
AC-2	4	0,65	0,2	0,65	4	0,65
AC-3	8	0,35	0,2	0,15	8	0,35
AC-4[3)]	10	0,35	0,2	0,15	8	0,35

I_e Rated operational current (see 4.101)
I_m Making current
I_c Breaking current

1) The conditions for making are expressed in r.m.s. 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 (see 4.103.1.1, note).

2) Tolerance for cos φ: ±0,05.

3) In the case of re-acceleration or plug braking, it should be noted that, at the instant of making, the voltage and current may be doubled.

The verifications of making and breaking capacity may be made as a combined test.

During each series of tests, oscillograph, or equivalent, records shall be taken of the first and last operation (see 4.103.1.1 and 4.103.1.2).

Throughout the tests, there shall be no permanent arcing, no flashover between poles, no blowing of the fuse in the earth circuit (see 6.102.2) and no welding of the contacts.

The tests are made solely with the current of the same kind as the service current specified. In particular, devices intended for use on three-phase loads shall be tested with three-phase current; single-phase tests of such devices are not covered by this standard and shall be the subject of a special agreement.

6.102.2 Condition for tests

The device under test shall be mounted complete on its own support or on an equivalent support. A device whose performance may be influenced by any enclosure in which it is mounted shall be tested in the same type of enclosure as that in which it will be installed.

Air-break contactors intended for open mounting or to be mounted with other apparatus in an enclosure having large dimensions with respect to the volume of the contactor shall, for the verification of the making and breaking capacities, be surrounded by an enclosure. This enclosure shall be fabricated from bare woven wire cloth or perforated mild steel sheet of a thickness to ensure reasonable rigidity. Individual apertures in the wire cloth or perforated steel sheet shall not exceed 100 mm^2 in area. The dimensions of the enveloping earthed enclosure shall be declared to indicate the proximity of earthed metal permitted in subsequent applications.

The connections to the main circuit and auxiliary control circuit shall be similar to those intended to be used when the device is in service.

For verification of the making and breaking capacities, all parts of the device normally earthed in service, including its enclosure, shall be connected to the neutral point of the supply or to a substantially inductive artificial neutral permitting a prospective fault current of at least 100 A. This connection shall include a reliable device (such as a fuse and current transformer combination) for the detection of the fault current and, if necessary, a resistor limiting the value of the prospective fault current to about 100 A.

6.102.3 Test circuit for the verification of rated making and breaking capacities

The power supply used for the verification of making and breaking capacities shall have sufficient power to permit the verification of the characteristics given in table 10.

The test circuit is composed of the supply side and the load side. Earthing of the test circuit shall be in accordance with the requirements of 6.103.3 of IEC 60056.

The supply side TRV requirements shall be in accordance with the requirements of 6.104.5 of IEC 60056. The load side shall be arranged to provide an amplitude factor and frequency of the TRV, on breaking, given by:

$$\text{Amplitude factor: } 1{,}4 \leq K_{af} \leq 1{,}6$$

$$\text{Frequency: } f \geq 2\,000 \times I_c^{0,2} \times U_r^{-0,8} \quad \text{(kHz)}$$

where the values of I_c and U_r are in amperes and volts respectively (see table 10).

The resistance and reactance of the test circuit shall be adjustable to satisfy the specified test conditions. The reactors shall be air-cored and shall be connected in series with the resistors, and their value shall be obtained by series coupling of individual reactors. Parallel connecting of reactors is permitted only when these reactors have practically the same time-constant. A shunt resistor may be connected across the terminals of the reactor arrangement.

The total impedance required to set the test current shall be distributed between the supply side and the load side of the device. However, the impedance on the supply side shall be not greater than 10 % of the total impedance of the test circuit. A load side amplitude factor in excess of 1,6, where required for test purposes, shall be subject to agreement by the manufacturer.

6.102.4 Verification of rated making capacity

The making current to be obtained during the test shall be as given in table 10 for the appropriate utilization category.

The number of closing operations to be made is the following:

a) for contactors or starters of utilization category AC-3 or AC-4, the number is 100, of which 50 operations are made at 85 % and 50 operations at 110 % of the rated coil voltage;
b) for contactors or starters of any other utilization category than AC-3 or AC-4, the number is 20, of which 10 operations are made at 85 % and 10 operations at 110 % of the rated coil voltage.

The time interval between two operations shall not exceed the time interval appropriate to the operating cycle class and shall be recorded in the test report. See 4.102.2.

The duration of the test current shall be not less than 50 ms (thereby exceeding the total bounce time, if any, of the contacts).

6.102.5 Verification of rated breaking capacity (minimum and maximum)

The breaking current to be obtained during the test shall be as given in table 10 for the appropriate utilization category.

The total number of opening operations for each of the minimum and maximum break conditions shall be 25.

The duration of each current flow need not exceed 0,5 s and the time interval between two successive opening operations shall not exceed the time interval appropriate to the operating cycle class and shall be recorded in the test report. See 4.102.2.

6.102.6 Reversibility tests

In the case of a reversing starter, the following test shall be carried out in addition to the making and breaking capacity tests of 6.102.3 and 6.102.4. A new starter may be used for the verification of reversibility.

The test circuit shall be in accordance with 6.102.3, and the current to be obtained shall be as given in table 10 for category AC-4.

The test comprises 10 operating sequences, each sequence comprising the two operating cycles described below:

a) 1st cycle: close A – open A/close B – open B – 10 s to 30 s rest

b) 2nd cycle: close B – open B/close A – open A – 10 s to 30 s rest

(where A and B are either the two mechanical switching devices of the starter or the two circuits of a single switching device).

These cycles are repeated alternately.

The use of a symbolic form such as "open A/close B" implies that the change-over operation concerned shall be made as fast as the normal control system will allow.

During the test, the starter shall be operated in the manner in which it is intended to be used in service, and any mechanical or electrical interlocking devices which are normally provided shall be in use.

6.102.7 Change-over ability tests

In the case of a two-step auto-transformer or reactor starter, the following test shall be carried out in addition to the making and breaking capacity tests of 6.102.3 and 6.102.4. A new starter may be used for the verification of change-over ability.

The test circuit shall be in accordance with 6.102.3 and the current to be obtained in the RUN position shall be as given in table 10 for category AC-3. The current obtained in the STARTING position shall be as derived from the auto-transformer or reactor. When an auto-transformer or reactor has more than one output voltage or tap connection, it shall be connected to give the highest starting current.

The test comprises 10 operating sequences as follows:

– make the current in the STARTING position;

– transition to the RUN position;

– break the current in the RUN position;

– OFF time.

The ON time in the STARTING and RUN positions shall be not less than 0,05 s, and the OFF time shall not be greater than stated in table 11.

The load circuit shall be connected to the starter as would be the windings of a motor. The RUN position is that in which the auto-transformer or reactor is not in effect, and the motor is connected directly to rated voltage (U_r). During the test, the starter shall be operated in the manner in which it is intended to be used in service, and any mechanical or electrical interlocking devices which are normally provided shall be in use.

Table 11 – Relationship between current broken I_c and OFF time

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

The OFF time values may be reduced if agreed by the manufacturer.

6.102.8 Behaviour during making, breaking, reversibility and change-over tests

During tests within the limits of specified making and breaking capacities, and with the specified number of operations, there shall be no permanent arcing, no flash-over between poles, no blowing of the fuse in the earth circuit (see 6.102.2) and no welding of the contacts.

6.102.9 Condition following making and breaking tests

The contactor shall, after performing the number of operations for rated making and breaking capacity (6.102.4 and 6.102.5), be capable of operating satisfactorily.

In addition, the contactor shall be capable of carrying its normal current with a temperature rise not in excess of the temperature rise permitted by table 3 of IEC 60694.

The resistance of the main circuit shall be measured according to 6.4. If the resistance has increased by more than 20 %, and if it is not possible to confirm the condition of the contacts by visual inspection, it will be necessary to perform an additional temperature-rise test.

There shall be no evidence of internal puncture, flashover or tracking of insulating materials, except that moderate wear of the parts of arc control devices exposed to the arc is permissible.

NOTE 1 Verification of compliance with the above requirements is necessary only in case of doubt.

NOTE 2 The use of a voltage test as a condition check is recognized under 6.2.11 of IEC 60694.

6.103 Overload current withstand tests

The overload current to be obtained during the tests shall be as given in table 12, where I_e is selected for the appropriate utilization category.

The tests shall be performed, as three-phase tests, on a contactor or combination which has been closed by its normal means at the rated voltage of the closing device and held closed, or latched, for the duration of each test. The test voltage shall be sufficient to cause the required current to flow through all poles simultaneously for the specified duration.

Following these tests, the contactor or combination shall be capable of making and breaking its rated operational current at the rated voltage although its overload withstand performance may be impaired.

The main contacts shall be in such a condition, in particular with regard to burning, contact area, pressure and freedom of movement, that they are capable of carrying the rated operational current of the contactor or combination. The resistance of the main circuit shall be measured according to 6.4. If the resistance has increased by more than 20 %, and if it is not possible to confirm the condition of the contacts by visual inspection, it will be necessary to perform an additional temperature-rise test.

Table 12 – Overload current withstand requirements

Test current	Duration of test s
$15 \times I_e$	1
$6 \times I_e$	30

6.104 Short-circuit current making and breaking tests

These tests shall be performed on contactors which are to be assigned a short-circuit capability for coordination with short-circuit protective devices. Refer also to 6.6.

The tests shall be performed in accordance with the relevant conditions of 6.102 and 6.106.4 of IEC 60056, test duty 4.

Where appropriate, an SCPD shall be replaced by solid links of negligible impedance.

6.105 Verification of operating limits and characteristics of overload relays

When a starter can be supplied in several forms, according to the conditions of use (open type, various types of enclosure, etc.), the tests need only be carried out on one form stated by the manufacturer, taking into account the last paragraph of 5.101.2. However, in the case of tests at –5 °C on overload relays compensated for ambient air temperature, the tests may be carried out on a starter without enclosure. The details of type and installation shall form part of the test report.

The starter shall be connected as in service, using cables the cross-sections of which shall be chosen, depending on the current setting of the overload relay, in accordance with the relation given in table 8 between cross-sections and the value of the rated operational current.

Operating characteristics shall be verified in accordance with the performance requirements of 5.101.5.1 and need only be carried out at one specified value of ambient temperature.

6.106 Verification of coordination with SCPDs

The verification of the general condition of coordination under 4.107 shall be performed as follows:

– short-circuit breaking capacity of the SCPD: by reference to the results of breaking capacity tests carried out on the SCPD according to the relevant specification;

– overload current withstand of the SCPD: by reference to the results of overload tests carried out separately on the SCPD according to the relevant specification;

– the type of coordination may be verified by the tests specified in 6.106.1 to 6.106.3. Such tests are special type tests.

6.106.1 Test conditions

6.106.1.1 Condition of the combination before test

The combination under test shall be mounted complete on its own support or on an equivalent support, and connected as in normal operation. The starter shall be operated in the manner specified and, in particular, it shall be operated at 85 % of the rated control circuit quantities.

It shall be shown that the starter will operate satisfactorily under the above conditions on no-load. The travel of the switching contacts shall be recorded, if practicable.

The tests shall be performed on the starter in association with an SCPD having the highest rated current declared by the manufacturer as suitable for use with the starter. The overload relay or release shall be of the lowest rated operational current rating associated with that SCPD, and of the shortest time setting, if adjustable. The tests shall be carried out at the ambient temperature and without previous loading.

6.106.1.2 Frequency

The combination shall be tested at rated frequency with a tolerance of ±10 %.

However, for convenience of testing, some deviations from the above tolerance are allowable; for example, when combinations rated at 50 Hz are tested at 60 Hz and vice versa, care should be exercised in the interpretation of results, taking into account all significant facts such as the type of the contactor and the type of test performed.

6.106.1.3 Power factor

The power factor of the test circuit shall be determined by calculation from the circuit constants or by measurement and shall be taken as the average of the power factors of all phases.

6.106.1.4 Arrangement of test circuits

For test duties A and B, the starter in association with the SCPD shall preferably be connected in a circuit having the neutral point of the supply earthed and the three-phase short circuit isolated, as shown in figure 2. Alternatively, a circuit as indicated in figure 3 may be used.

For test duty C, the preferred circuit shall be as indicated in figure 4. Alternatively, a circuit as indicated in figure 5 may be used. The source side impedance shall be set to correspond to the conditions required for test duties A and B. The impedance necessary to set the test current to the value required for test duty C shall be added on the load side of the starter. However, if necessary to achieve the TRV values of table 13 for the load circuit, it is permissible to transfer part of the load-side impedance to the source side of the starter, provided that the impedance on the source side does not exceed 30 % of the total circuit impedance.

For a starter producing an emission of flame or metallic particles, the tests shall be made with metallic screens placed in the vicinity of the live parts and separated from them by a clearance distance which the manufacturer shall specify. The screens, frame and other normally earthed parts shall be insulated from earth, but connected thereto by a suitable device to indicate leakage current to earth.

6.106.2 Test quantities

Where a tolerance is not specified, tests shall be carried out at values not less severe than the specified values; the upper limits are subject to the consent of the manufacturer.

6.106.2.1 Applied voltage before short-circuit making tests

The average value of the applied voltage between phases shall be equal to the rated operational voltage. The difference between this average and the applied voltage between each pair of phases shall not exceed 5 %.

6.106.2.2 Prospective current

The r.m.s. value of the a.c. component of the prospective short-circuit current shall be measured one half-cycle after the initiation of the short circuit in the prospective current test.

The r.m.s. value of the a.c. component in any phase shall not vary from the average by more than 10 % of the average.

6.106.2.3 Breaking current

Shall be the r.m.s. value of the a.c. component measured at the instant of initiation of the interruption process.

6.106.2.4 Transient recovery voltage (TRV)

The prospective TRV of the test circuit shall be determined by such a method as will produce and measure the oscillation without materially influencing it, and shall be measured at the terminals to which the apparatus under test will be connected, with all necessary test measuring devices, such as voltage dividers, included.

For three-phase circuits, the TRV refers to the first pole to clear, i.e. the voltage across one open pole with the other two poles closed, with the appropriate test circuit arranged in accordance with 6.106.1.4.

The prospective TRV curve of a test circuit is represented by its envelope drawn as shown in figure 6 and by its initial portion.

The prospective TRV wave of the test circuit shall comply with the following two requirements:

Requirement a)

Its envelope shall at no time be below the specified reference line.

NOTE It is stressed that the extent by which the envelope may exceed the specified reference line requires the consent of the manufacturer.

Requirement b)

Its initial portion shall not cross the delay line where specified.

When the prospective test TRV is not a single-frequency wave, it shall be evaluated by the method of four parameters (figure 7). The straight lines OBAC obtained in this way shall be above the area bounded by the time axis and the reference line of the specified TRV (figure 8).

6.106.2.5 Power frequency recovery voltage

The power frequency recovery voltage shall be maintained across the terminals of the combination for at least 0,3 s after interruption.

The power frequency recovery voltage of a three-phase test circuit shall be the average value of the power frequency recovery voltage in all phases measured after interruption. It shall be determined in accordance with 6.106.2.6.

6.106.2.6 Power frequency recovery voltage measurements

The power frequency recovery voltages of the test circuit shall be measured between the terminals of each pole of the combination in each phase of the test circuit.

Oscillograms of the power frequency recovery voltage shall be measured one cycle after interruption in accordance with figure 9.

6.106.3 Test duties

The combination under test shall be arranged as specified in 6.106.1. The test quantities shall be in accordance with 6.106.2, except that 6.106.2.4 does not apply to test duties A and B.

6.106.3.1 Test duty A – 100 % break test

One break test shall be made with the combination connected to a supply capable of delivering maximum prospective current equal to the rated short-circuit current of the combination, with a tolerance of $^{+5}_{0}$ %.

The power factor shall not exceed 0,15 inductive load.

The power frequency recovery voltage shall be equal to the rated voltage divided by $\sqrt{3}$.

NOTE For this test, the combination is closed as in normal service and the short circuit will be applied by external means (see 6.106.1.1 for control circuit parameters).

6.106.3.2 Test duty B – 100 % make test

One make test shall be made with the combination connected to a supply capable of delivering maximum prospective current equal to the rated short-circuit current of the combination, with a tolerance of $^{+5}_{0}$ %.

The power factor shall not exceed 0,15 inductive load.

NOTE For this test, the mechanical switching device will close on the fault (for control circuit parameters, see 6.106.1.1).

6.106.3.3 Test duty C – Breaking tests near the take-over point

Three breaking tests shall be made to prove the protection coordination offered by the combination. The interval between tests shall not exceed 3 min, or such minimum longer time as is necessary to change fuse-links.

For this test duty, the value of the breaking current shall be equal to, or greater than, the maximum take-over current as determined by the coordination curves of maximum rated SCPD and overload relay characteristics for a given combination with a minimum of seven times the rated operational current (I_e) of the combination (see figure 10).

These tests shall be made with the SCPD replaced by solid links of negligible impedance and shall be made in a three-phase circuit. In this case, the test current used may exceed seven times I_e.

The tolerance on the specified breaking current is $^{+5}_{0}$ % and the d.c. component of any phase at contact separation shall not exceed 20 %.

The power factor of the circuit, determined in accordance with 6.106.1.3, shall be

0,2 to 0,3 inductive load if the breaking current exceeds 400 A, or

0,3 to 0,4 inductive load if the breaking current is equal to or less than 400 A.

The power frequency recovery voltage shall be equal to the rated operational voltage divided by $\sqrt{3}$ whilst the prospective transient recovery voltage shall be in accordance with table 13 and 6.106.2.4.

Table 13 – Transient recovery voltage characteristics

Rated voltage U_r	TRV peak value u_c	Time coordinate t_3	Rate of rise u_c/t_3
kV	kV	µs	kV/µs
2,5	4,3	70	0,061
3,6	6,2	80	0,077
5,0	8,6	90	0,096
7,2	12,4	104	0,119
12,0	20,6	120	0,172

NOTE When a combination is installed for instance in the vicinity of a large transformer bank, and conditions may occur in which there are no parallel loads, the TRV may be more severe than the values of table 13 for currents lower than the specified breaking current. Such conditions of application should be referred to the manufacturer.

6.106.4 Behaviour of starter during tests

During the tests, there shall be no earth faults nor excessive emission of flame or gases from enclosed starters which could endanger an operator.

For a starter that is intended for open mounting or to be mounted with other apparatus in an enclosure having large dimensions with respect to the volume of the starter, arc and flames must not extend beyond the safety area stated by the manufacturer.

Any replacements during test duties A or B shall only be those permitted by classification type a, b or c as stated in 4.107.3.

6.106.5 Condition of starter after test

The condition of the starter after test duties A and B will be the basis for assigning the classification of the starter into type a, b or c as described in 4.107.3.

After test duty C, there shall be no material damage as described in 4.107.3.

6.107 Electrical endurance tests

Electrical endurance tests are included as special type tests and sufficient tests need only be carried out to provide a wear curve that can be reliably extrapolated, since the power requirements and time for a complete test are prohibitive.

The making and breaking currents and the test voltages are those given in table 14.

The majority of the electrical endurance tests may, however, be carried out at any convenient voltage above the arc voltage with the device switching at the current and power factor given in table 14. At this reduced voltage, it shall be shown that the arc duration is consistent with that measured during the corresponding full voltage test. A minimum of five tests shall be made at full voltage at the end of the test series to confirm that the performance is substantially unchanged. Oscillographic or equivalent records, in accordance with annex A, shall be made of these final tests and included in the test report.

After the test, the device shall fulfil the operating conditions specified in 6.101.1 and withstand the dielectric tests of 6.2, but limited to the application of a voltage not exceeding the levels specified in 6.2.11 of IEC 60694.

Table 14 – Verification of the number of on-load operating cycles – Conditions for making and breaking corresponding to the several utilization categories

Category	Make			Break		
	I_m/I_e [1]	U_r	cos φ [2]	I_c/I_e	U_{rec}/U_r	cos φ [2]
AC-1	1	1	0,95	1	1	0,95
AC-2	2,5	1	0,65	2,5	1	0,65
AC-3	6	1	0,35	1	0,17	0,35
AC-4 [3]	6	1	0,35	6	1	0,35

I_e Rated operational current (see 4.101)
I_m Making current
I_c Breaking current
U_r Rated voltage (see 4.1)
U_{rec} Recovery voltage

[1] The conditions for making are expressed in r.m.s. 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 (see note of 4.103.1.1).

[2] Tolerance for cos φ: ±0,05 %.

[3] In the case of re-acceleration or plug braking, it should be noted that, at the instant of making, the voltage and current may be doubled.

6.108 Motor switching tests

Refer to Section 3 of IEC 61233.

7 Routine tests

Clause 7 of IEC 60694 is applicable with the following addition.

The routine tests also comprise operating tests in accordance with 7.101 and tests dependent on starter type in accordance with 7.102.

7.1 Dielectric test on the main circuit

Subclause 7.1 of IEC 60694 is applicable.

7.2 Dielectric test on auxiliary and control circuits

Subclause 7.2 of IEC 60694 is applicable.

7.3 Measurement of the resistance of the main circuit

Subclause 7.3 of IEC 60694 is applicable.

7.4 Tightness test

Subclause 7.4 of IEC 60694 is applicable with the following addition.

The manufacturer may use an alternative test that can be demonstrated to be at least as effective.

7.5 Design and visual checks

Subclause 7.5 of IEC 60694 is applicable.

7.101 Operating tests

Tests are carried out to verify operation within the limits specified in 4.8. As the main contacts are in a new condition, an adjustment may be necessary to the figure for minimum drop-out voltage which is specified for worn contacts.

During these tests, it shall be verified, in particular, that the contactors open and close correctly when their operating devices are energized. It shall also be verified that operation will not cause any damage. SCPDs (for example fuses), if any, of maximum mass and dimensions shall be fitted.

For all combination starters, the following test shall be carried out where applicable:

a) with the action of one fuse striker of minimum energy simulated: five operations to test the reliability of the fuse-blown indicator;

b) at the specified maximum supply voltage: five operating cycles;

c) at the specified minimum supply voltage: five operating cycles;

d) for release-operated combinations only, at rated supply voltage: five operating cycles with a tripping circuit energized by the closing of the main contacts.

Tests a), b) and c) shall be made without current passing through the main circuit.

For combinations fitted with overcurrent releases, the releases shall be set at the minimum calibration mark on the overcurrent scale.

During test d), it shall be shown that the overcurrent releases operate correctly with a current passing through the main circuit not exceeding 110 % of the setting value on the over-current scale.

This current may be supplied from a suitable low-voltage source.

During all the foregoing routine tests, no adjustments shall be made and the operation shall be faultless. The closed and open positions shall be attained during each operating cycle of tests a), b) and c).

After the tests, the combination shall be examined to determine that no parts have sustained damage and that all parts are in a satisfactory condition.

Tests shall be made to verify the calibration of overload relays. In the case of a thermal or time-delay magnetic overload relay, this may be a single test with all poles equally energized at a multiple of the current setting to check that the tripping time conforms (within tolerances) to the curves supplied by the manufacturer; in the case of an instantaneous magnetic overload relay, the test shall be carried out at 1,1 times the current setting.

NOTE In the case of a time-delay magnetic overload relay comprising a time-delay device working with a fluid dashpot, the test may be carried out with the dashpot empty at a percentage of the current setting indicated by the manufacturer and capable of being justified by a special test.

7.102 Tests dependent on starter type

7.102.1 For rheostatic rotor starters

Tests shall be performed to verify the proper operation of time-delay relays and the calibration of any other devices used for controlling the rate of starting.

The value of the starting resistors shall be verified for each step, with a tolerance of ±10 %.

It shall also be verified that the rotor switching devices cut out the steps of resistors in the correct sequence.

7.102.2 For two-step auto-transformer starters

It shall be verified that the open-circuit voltages on the tapping terminals of the auto-transformer are in accordance with the design figures and that the phase sequence at the motor terminals is correct in both STARTING and RUN positions of the starter.

7.102.3 For two-step reactor starters

It shall be verified that the impedance of the tapping terminals of the reactor is in accordance with the design figures and that the phase sequence at the motor terminals is correct in both the STARTING and RUN positions of the starter.

8 Guide to the selection of contactors and motor-starters for service

8.101 General

A contactor or starter, including a combination starter, suitable for a given duty in service is best selected by considering the individual rated values required by load conditions and fault conditions.

The complete list of rated characteristics is given in clause 4. The following individual ratings are dealt with in this clause:

– rated voltage (U_r)	8.102.1
– rated insulation level	8.102.2
– rated frequency (f_r)	8.102.3
– rated short-circuit breaking current (I_{sc})	8.102.4

For rated characteristics not dealt with in this clause reference should, if applicable, be made to clause 4 as follows.

Rated characteristics for all contactors and starters

– rated short-time withstand current (I_k)	4.5
– rated peak withstand current (I_p)	4.6
– rated duration of short circuit (t_k)	4.7
– rated supply voltage of operating devices, and of auxiliary and control circuits (U_a)	4.8
– rated supply frequency of operating devices and of auxiliary circuits	4.9
– rated operational current (I_e) or rated operational power	4.101
– rated duties	4.102
– rated load and overload characteristics	4.103
– utilization category	4.104
– mechanical endurance	4.105

Characteristics given on request

– thermal current (I_{th})	8.102.5
– electrical endurance	4.106
– coordination with short-circuit protective devices	4.107
– motor switching characteristics	6.108

Characteristics dependent on starter type

– automatic change-over devices and automatic acceleration control devices	4.108
– starting auto-transformer characteristics	4.109
– starting reactor characteristics	4.109
– starting resistor characteristics for rheostatic rotor starters	4.110

Other parameters to be considered when selecting contactors or motor starters are, for example:

– local atmospheric and climatic conditions	8.102.6
– use at high altitudes	8.102.7
– coordination with current-limiting fuses such as the SCPD	8.102.8
– degree of protection for the enclosure and partitions	IEC 60298
– type of metal-enclosed controlgear	IEC 60298

8.102 Selection of ratings and characteristics for service conditions

8.102.1 Selection of rated voltage

The rated voltage of the equipment should be chosen so as to be at least equal to the highest voltage of the system at the point where it is to be installed.

The rated voltage should be selected from the standard values given in 4.1.

In selecting the rated voltage, the corresponding insulation levels specified in 4.2 should also be taken into account (see also 8.102.2).

8.102.2 Insulation coordination

The rated insulation level should be selected according to 4.2. The values in these tables apply to both indoor and outdoor equipment.

8.102.3 Rated frequency

The manufacturer should be consulted if a contactor, or motor starter, is to be used at any frequency other than rated frequency (see 4.3).

8.102.4 Rated short-circuit breaking current

As stated in 4.107, the rated short-circuit breaking current is the highest prospective short-circuit current which the combination shall be capable of breaking under the conditions of use and behaviour prescribed in this standard in a circuit having a power-frequency recovery voltage corresponding to the rated voltage of the combination.

The rated short-circuit breaking current of a combination is largely determined by that of the SCPD and shall be equal to or greater than the maximum expected fault current level of the point in the distribution system at which the combination is to be located. When forming a switchboard incorporating both circuit-breakers and starters, the rated short-circuit breaking current of the complete board should have one value, namely that of the lowest rated circuit. This rating then forms the basis for type testing of the short-circuit withstand capability of the main circuit conductors of the combination, i.e. the busbars and connections upstream of the SCPD.

8.102.5 Thermal current

Reference should be made to IEC 60282-1 where comment is made on the rated normal current of fuses and its selection, and on how it may be affected by the mounting of the fuses in an enclosure.

The thermal current of a switch-fuse combination is assigned by the combination manufacturer on the basis of information gained from temperature-rise tests and will depend on the type and ratings of the contactor and the fuses. It may have to be reduced where the ambient temperature in service exceeds the prescribed ambient temperature (see 2.1 and 2.2 of IEC 60694).

NOTE The thermal current of a combination is generally less than, but should not be in excess of, the rated current of the fuses as assigned by the fuse manufacturer.

8.102.6 Local atmospheric and climatic conditions

It should be specified in the enquiry whether the equipment is to be of indoor or outdoor type. For outdoor installation, it is assumed that the equipment will be mounted in a suitable enclosure. Inside the enclosure, normal indoor conditions are considered to prevail. If necessary, appropriate measures shall be taken, such as air-conditioning, so that common indoor components may be used. This does not apply to gas-filled compartments.

8.102.7 Use at high altitudes

The normal service conditions specified in clause 2 of IEC 60694 provide for controlgear intended for use at altitudes not exceeding 1 000 m.

Installation at altitudes of 2 000 m and 3 000 m is also recognized in this standard (2.2.1), but it may be necessary for the manufacturer to take account of variations in the design for higher altitudes, for example temperature rise, insulation level and mechanical parameters and to make any necessary setting adjustments.

8.102.8 Coordination with current-limiting fuses such as the SCPD

The object of this part of the guide, taken in conjunction with that for fuses (IEC 60282-1), is to specify criteria for the selection of a combination of contactor and SCPD which will assure safe operation, using the parameter values established by tests in accordance with IEC 60282-1, IEC 60644 and this standard.

IEC 60644 applies primarily to fuse-links, complying with the requirements of IEC 60282-1, used with motors started direct-on-line and intended to withstand normal service conditions, and to the selection of fuse-links with particular reference to the *K* factor under repetitive starting conditions.

The test duties specified in this standard, together with the associated guidance as to the application of these tests to other combinations, cover most users' requirements. However, some cases, for example to support the use of a back-up fuse by type tests done on the combination using so-called full-range fuses from another manufacturer, may require additional combination testing. Such testing should be subject to agreement between the manufacturer and user.

8.102.8.1 Take-over current

The value of the take-over current of a combination is dependent upon both the release initiated opening time of the contactor and the time-current characteristic of the fuse. As its name implies, it is the value of overcurrent above which the fuses take over the function of current interruption from the release and contactor.

From a practical standpoint, the maximum take-over current for a given application is determined as follows.

Superimpose upon the maximum pre-arcing time-current characteristic (based on a current tolerance of +6,5 %) of the fuse (see figure 10) a time equal to the minimum opening time, or minimum response time if operated by an overcurrent relay and/or time delay device. The associated current is the value of the take-over current, and shall not be greater than the rated take-over current which is the current determined by the fuse manufacturer and used on test duty C (see 6.106.3.3).

NOTE In this subclause, a current tolerance ±6,5 % is used (i.e. ±2 σ of ±10 %). This is based on current practice.

8.102.8.2 Extension of the validity of making and breaking type tests

As it is recognized that it may well be impractical to test all combinations of contactor and fuses, and to carry out repeat tests on combinations whenever the fuse is altered, this standard specifies conditions whereby the validity of the making and breaking type tests may be extended to cover combinations of contactor and fuses other than that (those) tested.

The fuse manufacturer or the user can, on his own responsibility, avail himself of this extension and decide which other types of fuses can validly be used in the combination.

The principles on which the conditions for extending the validity of the making and breaking type tests are based are as follows:

a) any fuse or modified fuse used in a combination shall have been certified to its relevant standard. This is necessary not only to prove the fuse but also to provide cut-off current and operating I^2t data;

b) the cut-off current and operating I^2t of the fuse shall be no greater than those of the fuse tested in the combination in order to ensure that the contactor contacts cannot be subjected to unproven conditions;

c) the same type of fuse striker (energy output) as that fitted to the fuse tested in the combination shall be used in order to give assurance that the contactor will be released without damage (see also 5.104).

8.102.8.3 Fuse operation

a) The three fuses fitted in a given combination shall be all of the same type and current rating, otherwise the breaking performance of the combination could be adversely affected.

b) It is vital, for the correct operation of the combination, that the fuses are inserted with the strikers correctly located.

c) When a combination has operated as a result of a three-phase fault, it is possible for

   1) only two out of the three fuses to have operated;

   2) all three fuses to have operated, but for only one out of the three strikers to have ejected.

   Such partial operation of one fuse can occur under three-phase service conditions and is not to be considered abnormal.

d) Where a combination has opened without any obvious signs of a fault on the system, examination of the operated fuse or fuses may give an indication as to the type of fault current and its approximate value. Such an investigation is best carried out by the fuse manufacturer who is usually prepared to offer such a service to users.

e) It is advisable to discard and replace all three fuses when the fuse(s) in one or two poles of a combination has(have) operated, unless it is definitely known that no over-current has passed through the unmelted fuse(s).

f) Before removing or replacing fuses, the operator should satisfy himself that the fuse-mount is electrically disconnected from all parts of the combination which could still be electrically energized. This is especially important when the fuse-mount is not visibly isolated.

g) It is considered good practice, especially for lower damage classification categories, to check that the contactor has not been subjected to contact welding.

9 Information to be given with enquiries, tenders and orders

9.101 Information to be given with enquiries and orders

When enquiring for or ordering a contactor, or motor starter, the following particulars should be supplied by the enquirer.

a) Particulars of systems, i.e. nominal and highest voltages, frequency, number of phases, and details of neutral earthing.

   If the equipment is to be used in installations exposed to lightning and/or switching over-voltages.

b) Service conditions, including minimum and maximum ambient temperatures, the latter if greater than the normal value; altitude class; and any special conditions likely to exist or arise, for example unusual exposure to water vapour, moisture, fumes, explosive gases, excessive dust or salt air (see 8.102.6 and 8.102.7).

   If the equipment may be fitted to a moving device, if its support may be capable of assuming a sloping position either permanently or temporarily (for example devices fitted aboard ships), or if the equipment may be exposed in service to abnormal shocks or vibrations.

   The enquirer should provide information of the type and dimensions of any special electrical connections with other apparatus, in order to enable enclosures and terminals meeting the conditions of installation and temperature rise prescribed by this standard to be provided. Attention should be drawn to any special need for silent operation.

   If the equipment may be used for applications not clearly within the scope of this standard, for example the switching of capacitors or transformers.

c) Characteristics, as appropriate and listed in table 1, should be given.

9.102 Information to be given for coordination with current-limiting fuse SCPDs

The combination manufacturer shall give, apart from the rated quantities, the following information:

a) maximum acceptable power dissipation of the combination (see d) of 6.5.3);

b) maximum cut-off current that the contactor has been proven to be able to deal with (see 8.102.8.2);

c) maximum I^2t that the fuse has been proven to be able to deal with (see 8.102.8.2);

d) fuse-initiated opening time of the contactor and also, where applicable, the minimum release-initiated opening time of the contactor (see 8.102.8.1);

e) types and dimensions of the fuses which can be used in the combination;

f) type of fuse striker (medium or heavy);

g) filling medium (type and amount), where applicable;

Where a user wishes to use a fuse of a type different from those listed under e) above but of the same dimensions, he should, in addition to referring to the application guide (clause 8), request the following information from the fuse manufacturer in accordance with IEC 60282-1:

h) I^2t characteristic (according to IEC 60282-1);

j) cut-off current characteristic;

k) rated short-circuit breaking current;

l) rated minimum breaking current;

m) power dissipation at rated current;

n) pre-arcing time-current characteristic;

o) type of fuse striker (medium or heavy).

10 Rules for transport, storage, erection, operation and maintenance

Clause 10 of IEC 60694 is applicable with the following addition.

High-voltage fuses, although robust in external appearance, may have fuse elements of relatively fragile construction. Fuses should, therefore, be kept in their protective packaging until ready for installation and should be handled with the same degree of care as a relay, meter or other similar item. Where fuses are already fitted in a combination, they should be temporarily removed while the unit is manhandled into position.

11 Safety

Clause 11 of IEC 60694 is applicable.

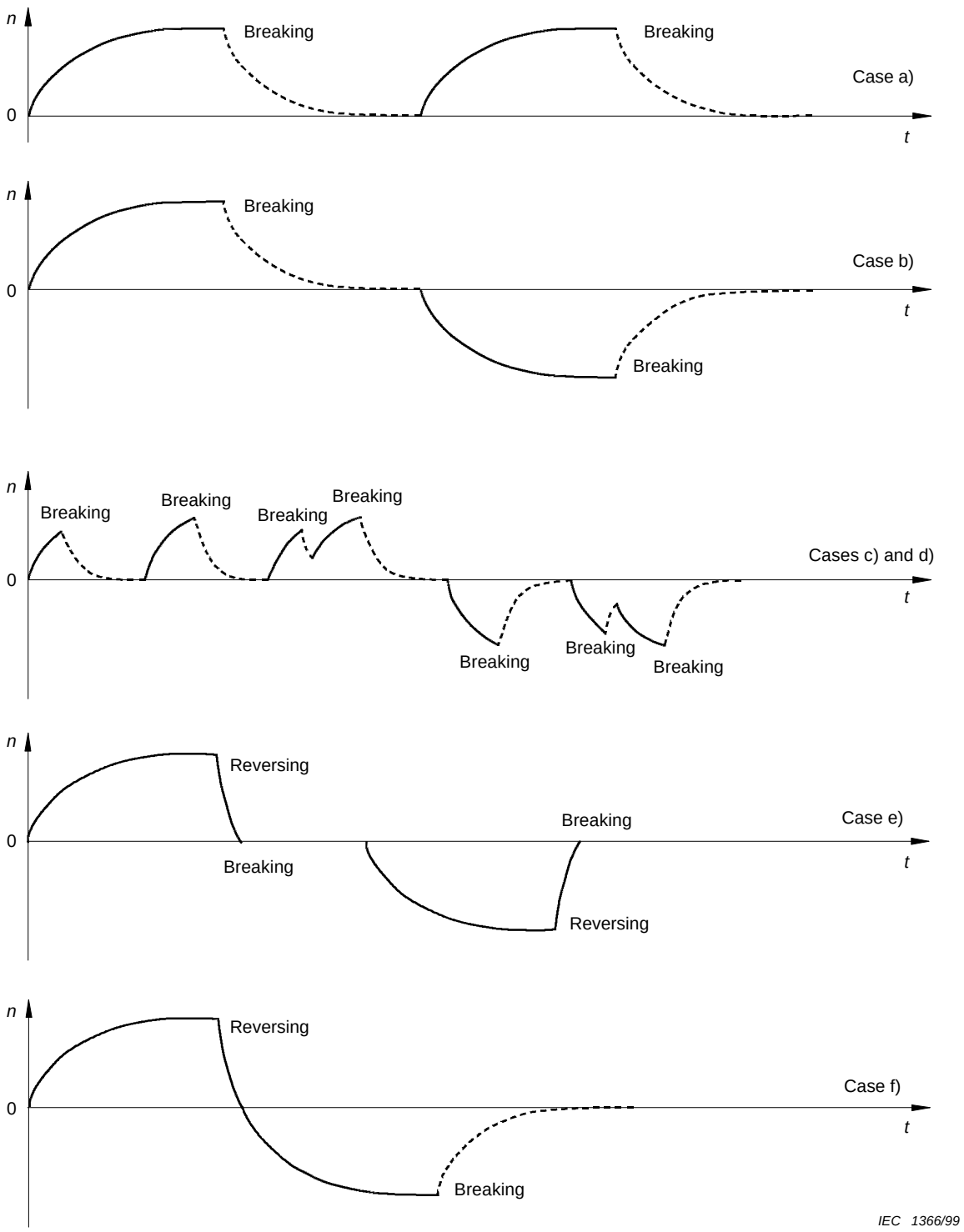

Figure 1 – Examples of speed/time curves

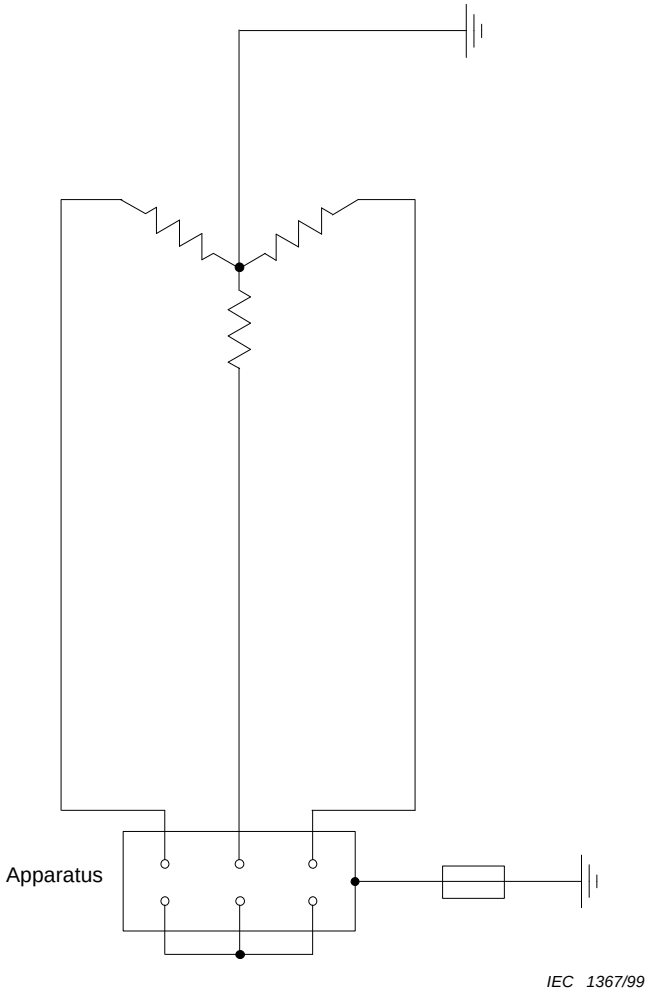

Figure 2 – Test duties A and B – preferred earth point

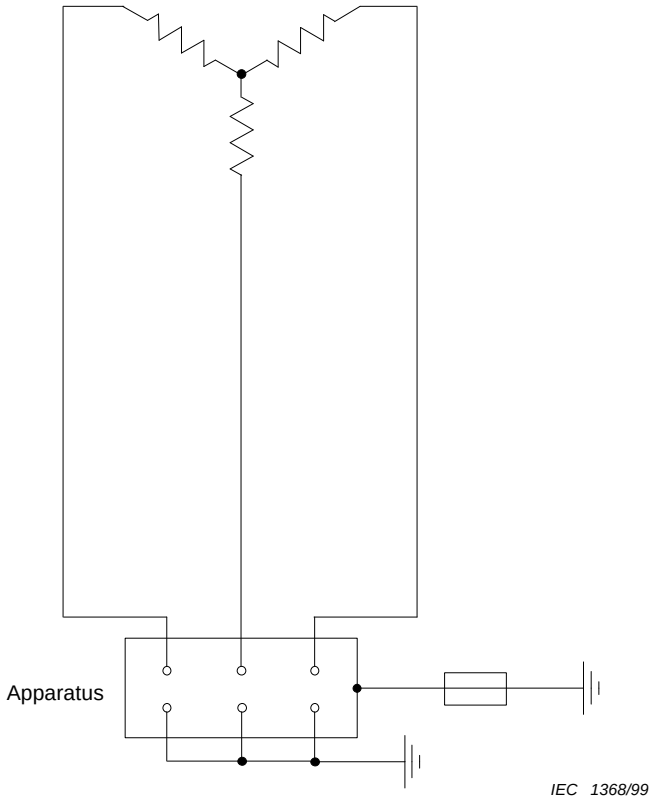

Figure 3 – Test duties A and B – alternative earth point

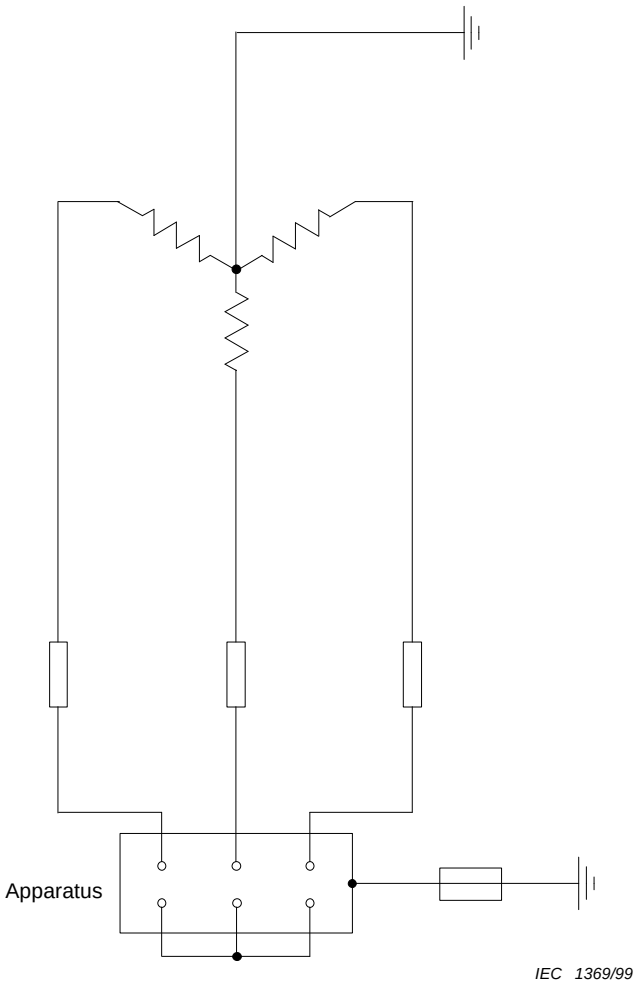

Figure 4 – Test duty C – preferred earth point

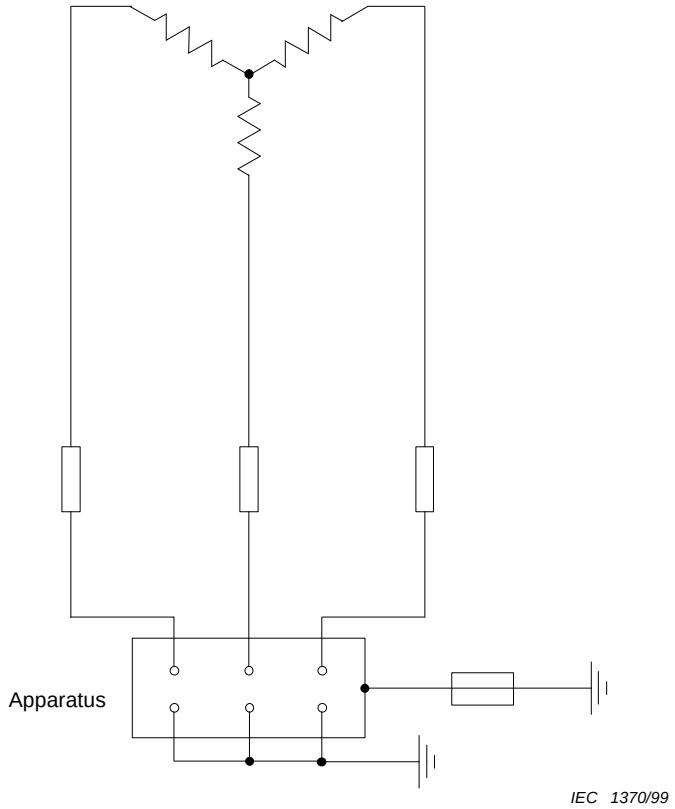

Figure 5 – Test duty C – alternative earth point

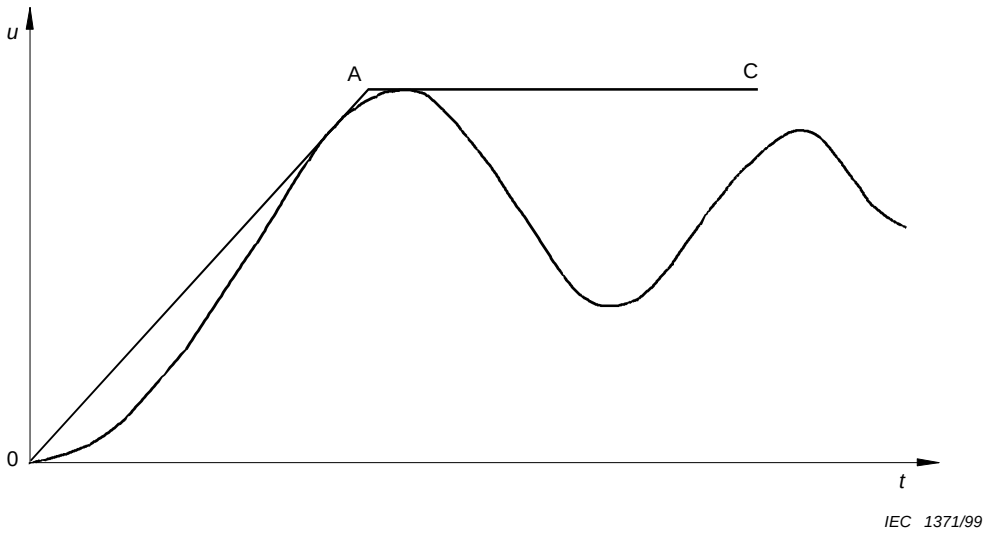

Figure 6 – Representation by two parameters of a prospective TRV of a circuit

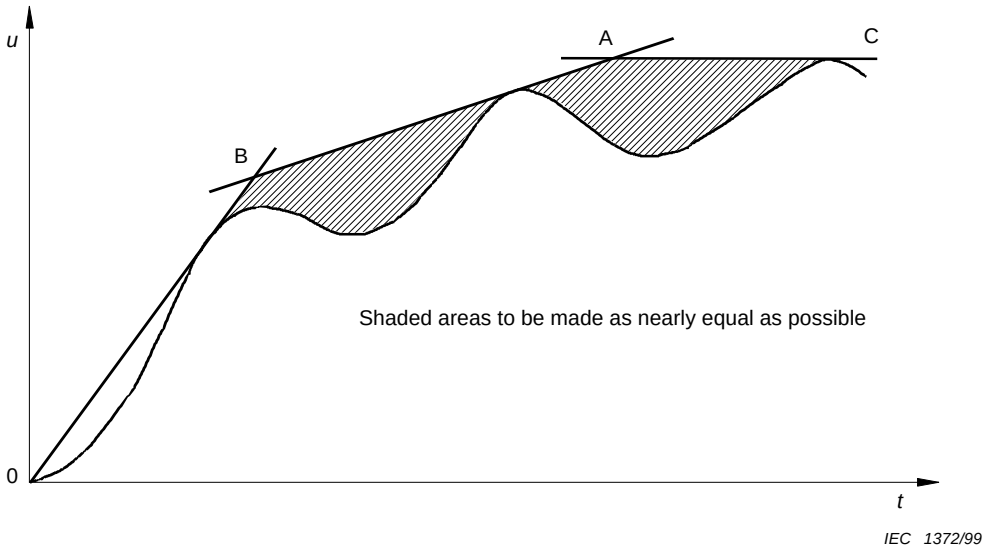

Figure 7 – Representation by four parameters of a prospective TRV of a circuit

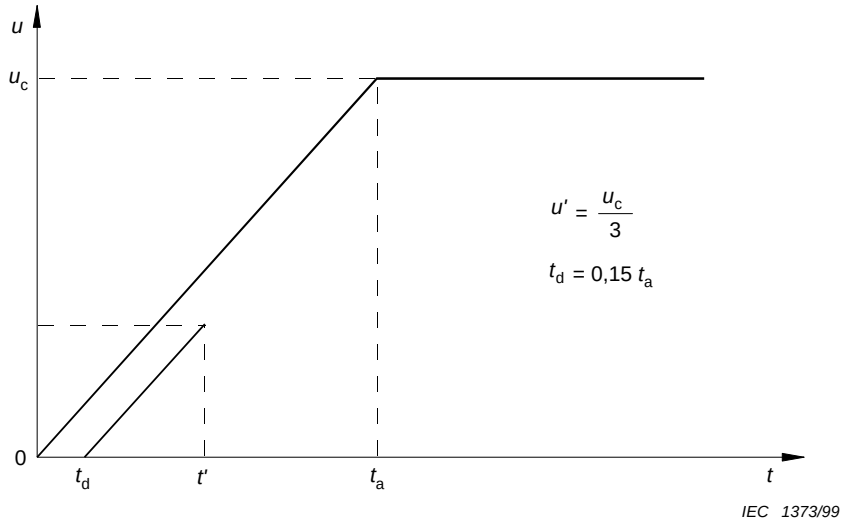

Figure 8 – Representation of the specified TRV by a two-parameter reference line and a delay line

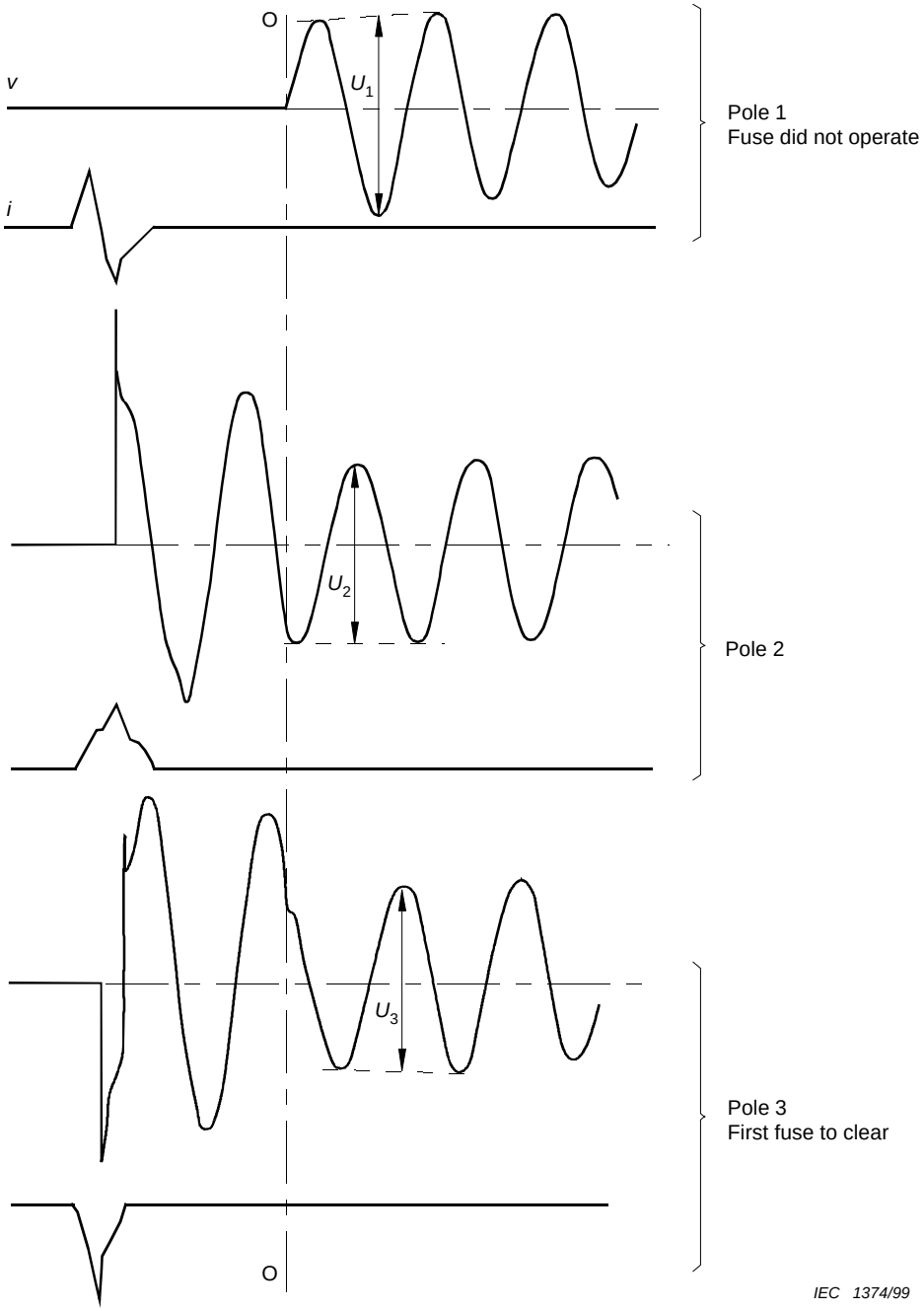

Figure 9 – Determination of power frequency recovery voltage

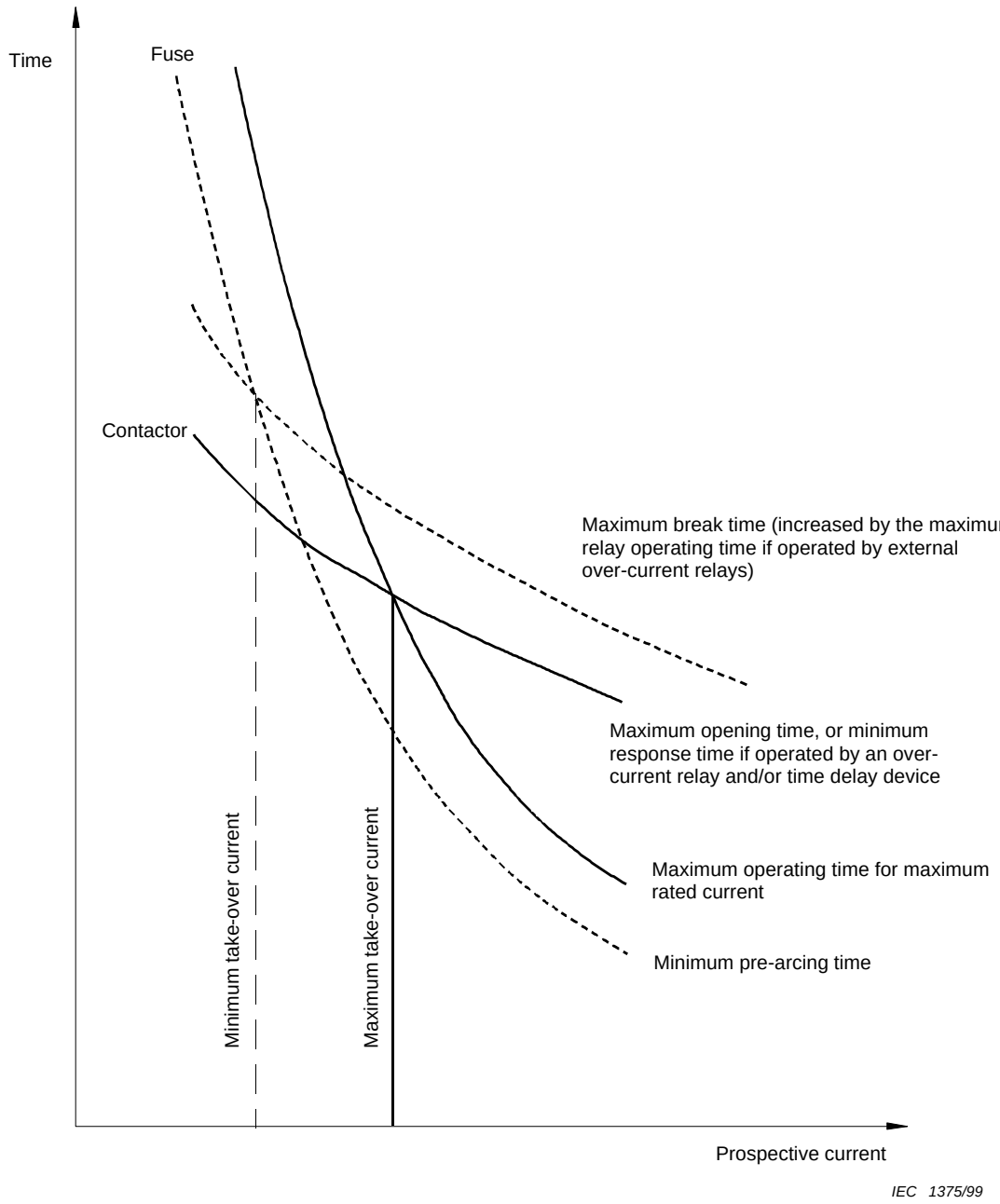

Figure 10 – Characteristics for determining take-over current

Annex A
(normative)

Records and reports of type tests for making, breaking and short-time current performance

A.1 Information and results to be recorded

All relevant information and results of making, breaking and short-time current tests shall be included in the type-test reports.

Except where otherwise specified, oscillographic or equivalent records in accordance with clause A.2 shall be made of all operations and included in the type-test reports.

The uncertainty of each measurement by oscillograph or similar means, including associated equipment, of the quantities which determine the ratings (for example short-circuit current, applied voltage and recovery voltage) shall be within ±5 %.

Photographs should be taken to illustrate the condition of the contactor before and after a series of tests.

The type test reports shall include a statement of the performance of the contactor during each test duty and of the condition of the contactor after each test duty, insofar as an examination is made, and at the end of the series of test duties. The statement shall include the following particulars:

a) condition of contactor giving details of any replacements or adjustments made and condition of contacts, arc control devices, gas (including any quantity lost), statement of any damage to arc shields, enclosures, insulators and bushings;
b) description of performance during test duty, including observations regarding emission of gas or flame.

A.2 Information to be included in reports

A.2.1 General

a) Date of tests
b) Reference or report number
c) Test numbers
d) Oscillogram numbers

A.2.2 Apparatus tested

a) Type or list number
b) Description (by the manufacturer), including number of poles
c) Manufacturer
d) Photograph numbers
e) Drawing numbers

A.2.3 Ratings assigned by manufacturer

a) Rated voltage
b) Rated operational current or rated operational power
c) Rated frequency
d) Breaking current:
   1) r.m.s. value of the a.c. component of current
   2) percentage d.c. component
e) Minimum opening time
f) Transient recovery voltage: peak value and rate of rise
g) Making current (peak value)
h) Short-time withstand current, and duration
i) Rated duty
j) Operating gas pressure range

A.2.4 Test conditions (for each series of tests)

a) Number of poles
b) Power factor
c) Frequency
d) Generator neutral (earthed or isolated)
e) Transformer neutral (earthed or isolated)
f) Short-circuit point or load-side neutral (earthed or isolated)
g) Diagram of test circuit, including connection(s) to earth

A.2.5 Breaking and making tests

a) Operating sequence and time intervals
b) Applied voltage
c) Making current (peak value)
d) Breaking current:
   1) r.m.s. value of a.c. component for each phase and average
   2) percentage d.c. component
e) Power frequency recovery voltage
f) Prospective transient recovery voltage:
   1) compliance with requirement a) of 6.104.5.1 of IEC 60056; voltage and time coordinates may be quoted
   2) compliance with requirement b) of 6.104.5.1 of IEC 60056
g) Arcing time
h) Opening time
j) Break time

   Where applicable, break times up to the instant of extinction of the arc shall be given.
k) Physical behaviour:
   1) emission of flame, gas, etc.
   2) behaviour, conditions and remarks

A.2.6 Short-time current test

a) Current:
   1) r.m.s. value
   2) peak value
b) Duration
c) Physical behaviour

A.2.7 No-load operation

a) Before making and breaking tests
b) After making and breaking tests

A.2.8 Oscillographic and other records

Oscillograms, or equivalent, shall record the whole of the operation. The following quantities shall be recorded. Certain of these quantities may be recorded separately from the oscillograms, and several oscillographs with different time scales may be necessary.

a) Applied voltage
b) Current in each pole
c) Recovery voltage
d) Current in closing coil
e) Current in opening coil
f) Suitable timing scale
g) Travel of moving contacts (if practicable)

All cases in which the requirements of this standard are not strictly complied with, and all deviations, shall be explicitly mentioned at the beginning of the test report.

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Annex ZA (normative)

Normative references to international publications with their corresponding European publications

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

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

Publication	Year	Title	EN/HD	Year
IEC 60034-11	1978	Rotating electrical machines Part 11: Built-in thermal protection -- Chapter 1: Rules for protection of rotating electrical machines	-	-
IEC 60050-441	1984	International Electrotechnical Vocabulary (IEV) Chapter 441: Switchgear, controlgear and fuses	-	-
IEC 60056 (mod)	1987	High-voltage alternating-current circuit-breakers	HD 348 S7[1)]	1998
IEC 60076-2 (mod)	1993	Power transformers Part 2: Temperature rise	EN 60076-2	1997
IEC 60129	1984	Alternating current disconnectors and earthing switches	EN 60129	1994
IEC 60255-8 (mod)	1990	Electrical relays Part 8: Thermal electrical relays	EN 60255-8	1998
IEC 60265-1	1983	High-voltage switches Part 1: High-voltage switches for rated voltages above 1 kV and less than 52 kV	HD 355.1 S3[2)]	1995
IEC 60282-1	1994	High-voltage fuses Part 1: Current-limiting fuses	EN 60282-1 + corr. December	1996 1997
IEC 60298	1990	A.C. metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV	EN 60298[3)] + A11	1996 1999

1) HD 348 S7 includes A3:1996 to IEC 60056.

2) HD 355.1 S3 is superseded by EN 60265-1:1998, which is based on IEC 60265-1:1998.

3) EN 60298 includes corrigendum April 1995 + A1:1994.

Publication	Year	Title	EN/HD	Year
IEC 60417	Series	Graphical symbols for use on equipment	EN 60417	Series
IEC 60644	1979	Specification for high-voltage fuse-links for motor circuit applications	EN 60644	1993
IEC 60694	1996	Common specifications for high-voltage switchgear and controlgear standards	EN 60694 + corr. May	1996 1999
IEC 60726 (mod)	1982	Dry-type power transformers	HD 464 S1[4)]	1988
IEC 60947-5-1	1997	Low-voltage switchgear and controlgear Part 5-1: Control circuit devices and switching elements - Electromechanical control circuit devices	EN 60947-5-1 + A12	1997 1999
IEC 61233	1994	High-voltage alternating current circuit-breakers - Inductive load switching	-	-
IEC 61812-1	1996	Specified time relays for industrial use Part 1: Requirements and tests	EN 61812-1 + A11 + corr. February	1996 1999 1999

4) HD 464 S1includes A1:1986 to IEC 60726.

BS EN 60470:2001
IEC 60470:2000

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