

Australian Standard™

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



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STANDARDS AUSTRALIA

RECONFIRMATION

OF

AS 60470—2001

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

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Technical Committee EL-007 has reviewed the content of this publication and in accordance with Standards Australia procedures for reconfirmation, it has been determined that the publication is still valid and does not require change.

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NOTES

Australian Standard™

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

Originated as part of AS 1864—1976 and AS 2232.1—1979.
AS 1864—1976 and AS 2232.1—1979 revised, amalgamated and
redesignated as AS 60470—2001.

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee EL-007, Power Switchgear, to supersede AS 1864—1976 and AS 2232.1—1979.

This Standard is the result of a consensus among representatives on the Joint Committee to produce it as an Australian Standard.

The objective of this Standard is to state the characteristics of contactors, starters and associated equipment, the conditions with which contactors or starters shall comply, the tests intended for confirming that these conditions have been met and the methods to be adopted for these tests and the information to be given with the equipment or in the manufacturer's literature.

This Standard is identical in technical content with and has been reproduced from IEC 60470:2000, *High-voltage alternating current contactors and contactor-based motor-starters*.

An informative Australian only Annex ZA has been added to inform the reader of items to be agreed between manufacturer and user. Annex ZA has been shaded to emphasize that it is additional information.

This Standard differs from AS 1864—1976 and AS 2232.1—1979 in the following areas:

- (a) Vacuum and SF6 contactors are included.
- (b) Additional utilization categories.
- (c) Conditions for construction and operation in service.
- (d) Type and routine tests.
- (e) Requirements for transport, storage, erection, operation, maintenance and safety.
- (f) Guide to the selection of contactors and motor-starters for service.

A reference to an International Standard identified in the Normative References Clause by strikethrough (~~example~~) is replaced by a reference to the Australian or Australian/New Zealand Standard(s) listed immediately thereafter and identified by shading (**example**). Where the struck-through referenced document and the referenced Australian or Australian/New Zealand Standard are identical, this is indicated in parenthesis after the title of the latter.

As this Standard is reproduced from an International Standard, the following applies:

- (a) Its number does not appear on each page of text and its identity is shown only on the cover and title page.
- (b) In the source text 'this standard' should read 'this Australian Standard'.
- (c) A full point should be substituted for a comma when referring to a decimal marker.

The terms 'normative' and 'informative' have been used in this Standard to define the application of the annex to which they apply. A 'normative' annex is an integral part of a Standard, whereas an 'informative annex' is only for information and guidance.

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STANDARDS AUSTRALIA

Australian Standard**High-voltage alternating current contactors and contactor-based motor-starters**

Any IEC table, figure or passage of text that is struck-through is not part of this Standard. Any Australian table, figure or passage of text that is added (and identified by shading) is part of this Standard.

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 less 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.

References to International Standards that are struck through in this Clause are replaced by references to equivalent Australian or Australian/New Zealand Standards that are listed immediately thereafter and identified by shading. Any Australian or Australian/New Zealand Standard that is identical to the International Standard it replaces is appropriately identified.

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~~

AS 1852.441, *International Electrotechnical Vocabulary, Part 441: Switchgear controlgear and fuses* (identical to IEC 60050(441):1984)

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

AS 2006, *High voltage a.c. switchgear and controlgear—Circuit-breakers for rated voltages above 1000 V*

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

AS 2374.2, *Power transformers, Part 2: Temperature rise*

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

AS 1306, *High voltage a.c. switchgear and controlgear—Disconnectors (isolators) 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~~

AS/NZS 60265.1, *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~~

AS 1033.2, *High voltage fuses (for rated voltages exceeding 1000 V), Part 2: Current-limiting (powder filled) type*

~~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)~~

AS 2086, *A.C. metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 72.5 kV, (identical to IEC 60298:1990)*

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

AS 1104 (all parts), *Informative symbols for use on electrical and electronic equipment*

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~~

AS/NZS 2650, *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~~

AS/NZS 3947.5.1, *Low-voltage switchgear and controlgear, Part 5.1: Control circuit devices and switching elements—Electromechanical control circuit devices* (identical to IEC 60947-5-1:1997 and including IEC Amendment 1:1999 and IEC Amendment 2:1999)

~~IEC 61233:1994, High-voltage alternating current circuit-breakers—Inductive load switching~~

AS 4372, *High-voltage alternating current circuit-breakers—Inductive load switching* (identical to IEC 61233:1994)

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, SF₆, oil.

3.4.103**disconnecter**

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

NOTE A disconnecter 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 disconnecter 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**SF₆ contactor**

a contactor in which the main contacts open and close within an SF₆ 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:

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

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
<i>(A) Rated characteristics</i>				
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
<i>(B) Characteristics to be given on request</i>				
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
<i>(C) Characteristics dependent on starter type</i>				
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				