

INTERNATIONAL STANDARD



**Low-voltage fuses –
Part 4: Supplementary requirements for fuse-links for the protection of
semiconductor devices**

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Low-voltage fuses –
Part 4: Supplementary requirements for fuse-links for the protection of
semiconductor devices

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LOW-VOLTAGE FUSES –

**Part 4: Supplementary requirements for fuse-links
for the protection of semiconductor devices**

FOREWORD

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This commented version (CMV) of the official standard IEC 60269-4:2024 edition 6.0 allows the user to identify the changes made to the previous IEC 60269-4:2009+AMD1:2012+AMD2:2016 CSV edition 5.2. Furthermore, comments from IEC SC 32B experts are provided to explain the reasons of the most relevant changes, or to clarify any part of the content.

A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text. Experts' comments are identified by a blue-background number. Mouse over a number to display a pop-up note with the comment.

This publication contains the CMV and the official standard. The full list of comments is available at the end of the CMV.

IEC 60269-4 has been prepared by subcommittee 32B: Low-voltage fuses, of IEC technical committee 32: Fuses. It is an International Standard.

This sixth edition cancels and replaces the fifth edition published in 2009, Amendment 1:2012 and Amendment 2:2016. This edition constitutes a technical revision.

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

- a) the introduction of voltage source inverter fuse-links, including test requirements.
- b) coverage of the tests on operating characteristics for AC, by the breaking capacity tests.
- c) the updating of examples of standardised fuse-links for the protection of semiconductor devices.

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

Draft	Report on voting
32B/746/FDIS	32B/753/RVD

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

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

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

This part is to be used in conjunction with IEC 60269-1:2024, *Low-voltage fuses – Part 1: General requirements*.

This Part 4 supplements or modifies the corresponding clauses or subclauses of Part 1.

Where no change is necessary, this Part 4 indicates that the relevant clause or subclause applies.

Tables and figures which are additional to those in Part 1 are numbered starting from 101.

Additional annexes are lettered AA, BB, etc.

A list of all parts of the IEC 60269 series, under the general title: *Low-voltage fuses*, can be found on the IEC website.

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

- reconfirmed,
- withdrawn, or
- revised.

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LOW-VOLTAGE FUSES –

Part 4: Supplementary requirements for fuse-links for the protection of semiconductor devices

1 ~~General Scope~~ 1

IEC 60269-1 applies with the following supplementary requirements.

Fuse-links for the protection of semiconductor devices shall comply with all requirements of IEC 60269-1, if not otherwise indicated hereinafter, and shall also comply with the supplementary requirements laid down below.

~~1.1 Scope and object~~

These supplementary requirements apply to fuse-links for application in equipment containing semiconductor devices for circuits of nominal voltages up to 1 000 V AC or 1 500 V DC ~~and also, in so far as they are applicable, for circuits of higher nominal voltages~~. For some fuse-links higher rated voltages can be used. 2

~~NOTE 1~~ Such fuse-links are commonly referred to as "semiconductor fuse-links".

~~NOTE 2~~ In most cases, a part of the associated equipment serves the purpose of a fuse base. Owing to the great variety of equipment, no general rules can be given; the suitability of the associated equipment to serve as a fuse base should be subject to agreement between the manufacturer and the user. However, if separate fuse bases or fuse holders are used, they should comply with the appropriate requirements of IEC 60269-1.

~~NOTE 3~~ IEC 60269-6 (Low-voltage fuses – Part 6: Supplementary requirements for fuse-links for the protection of solar photovoltaic energy systems) is dedicated to the protection of solar photovoltaic energy systems.

~~NOTE 4~~ These fuse links are intended for use on systems employing the standardized voltages and tolerances of IEC 60038. Tests carried out on fuse links in accordance with previous editions of this standard shall remain valid until such time as complementary equipment has evolved to the standardized voltages and tolerances of IEC 60038. 3

The object of these supplementary requirements is to establish the characteristics of semiconductor fuse-links in such a way that they can be replaced by other fuse-links having the same characteristics, provided that their dimensions are identical. For this purpose, this standard refers in particular to

- a) the following characteristics of fuses:
 - 1) their rated values
 - 2) their temperature rises in normal service
 - 3) their power dissipation
 - 4) their time-current characteristics
 - 5) their breaking capacity
 - 6) their cut-off current characteristics and their I^2t characteristics
 - 7) their arc voltage characteristics
- b) type tests for verification of the characteristics of fuses
- c) the markings on fuses
- d) availability and presentation of technical data (see Annex BB).

2 Normative references 4

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

IEC 60269-1:2024, *Low-voltage fuses – Part 1: General requirements*

IEC 60269-2:2013, *Low-voltage fuses – Part 2: Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application) – Examples of standardized systems of fuses A to K*

IEC 60269-2:2013/AMD1:2016

IEC 60269-2:2013/AMD2:2024

~~IEC 60269-3, *Low-voltage fuses – Part 3: Supplementary requirements for fuses for use by unskilled persons (fuses mainly for household and similar applications) – Examples of standardized systems of fuses A to F*~~

IEC TR 60269-5:2014, *Low-voltage fuses – Part 5: Guidance for the application of low-voltage fuses*

IEC TR 60269-5:2014/AMD1:2020

~~IEC 60269-6, *Low-voltage fuses – Part 6: Supplementary requirements for fuse links for the protection of solar photovoltaic energy systems*~~

IEC 60417, *Graphical symbols for use on equipment*

~~IEC 60664-1:2000, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*~~

ISO 3, *Preferred numbers – Series of preferred numbers*

3 Terms and definitions

IEC 60269-1 applies with the following supplementary definitions.

3.2 General terms

3.2.101

semiconductor device

device whose essential characteristics are due to the flow of charge carriers within a semiconductor.

[SOURCE: IEC 60050-521:2002, 521-04-01]

3.2.102

semiconductor fuse-link

current-limiting fuse-link capable of breaking, under specific conditions, any current value within the breaking range (see 8.4)

3.2.103

signalling device

device forming part of the fuse and signalling the fuse operation to a remote place

Note 1 to entry: A signalling device consists of a striker and an auxiliary switch. Electronic devices may also be used.

3.2.104

voltage source inverter

VSI

a voltage stiff inverter

Note 1 to entry: Also referred to as a voltage stiff inverter i.e. an inverter that supplies current without any practical change in its output voltage.

[SOURCE: IEC 60050-551:1998, 551-12-11] **5**

3.2.105

voltage source inverter fuse-link

VSI fuse-link

current-limiting fuse-link capable of breaking, under specified conditions, the short circuit current supplied by the discharge of a DC-link capacitor in a voltage source inverter

Note 1 to entry: The abbreviation "VSI fuse-link" is used in this document.

Note 2 to entry: A VSI fuse-link usually operates under a short circuit current supplied by the discharge of a DC-link capacitor through a very low inductance, in order to allow high frequency in normal operation. This short circuit condition leads to a very high rate of rise of current equivalent to a very low value of time constant, typically 3 ms or less. The supply voltage is DC, even though the applied voltage decreases as the current increases during the short circuit.

Note 3 to entry: In some multiple AC drive applications, individual output inverters may be remote from the main input rectifier. In these cases, the associated fault circuit impedances may influence the operation of the fuse-links. – the associated time constant and the size of the capacitors need to be considered when choosing the appropriate short circuit protection.

4 Conditions for operation in service

IEC 60269-1 applies with the following supplementary requirements.

Fuses must be only used according to their rated values. **6**

4.5 Voltage

4.5.1 Rated voltage

For AC, the rated voltage of a fuse-link is related to the applied voltage; it is based on the RMS value of a sinusoidal AC voltage. It is further assumed that the applied voltage retains the same value throughout the operation of the fuse-link. All tests to verify the ratings are based on this assumption.

~~NOTE In many applications, the applied voltage will be sufficiently close to the sinusoidal form for the significant part of the operating time, but there are many cases where this condition is not satisfied.~~

~~The performance of a fuse-link subjected to a non-sinusoidal applied voltage can be evaluated by comparing, for the first approximation, the arithmetic mean values of the non-sinusoidal and sinusoidal applied voltages.~~ **7**

For DC and VSI fuse-links, the rated voltage of a fuse-link is related to the applied voltage. It is based on the mean value. When DC is obtained by rectifying AC, the ripple is assumed not to cause a variation of more than 5 % above or 9 % below the mean value.

4.5.2 Applied voltage in service

Under service conditions, the applied voltage is that voltage which, in the fault circuit, causes the current to increase to such proportions that the fuse-link will operate.

For AC, consequently, the value of the applied voltage in a single-phase AC circuit is usually identical to the power-frequency recovery voltage. For all cases other than the sinusoidal AC voltage, it is necessary to know the applied voltage as a function of time.

For a unidirectional voltage and for VSI fuse-links, the important values are:

- the average value over the entire period of the operation of the fuse-link;
- the instantaneous value near the end of the arcing period.

4.6 Current

The rated current of a semiconductor fuse-link is based on the RMS value of a sinusoidal AC current at rated frequency.

For DC, the RMS value of current is assumed not to exceed the RMS value based on a sinusoidal AC current at rated frequency.

NOTE The thermal response time of the fuse-element may be so short that it cannot be assumed that operation under conditions which deviate much from sinusoidal current can be estimated on the basis of the RMS current alone. This is so, in particular at lower frequency values and when the current presents salient peaks separated by appreciable intervals of insignificant current; for example, in the case of frequency converters and traction applications.

4.7 Frequency, power factor and time constant

4.7.1 Frequency

The rated frequency refers to the frequency of the sinusoidal current and voltage that form the basis of the type tests.

~~NOTE In particular, where service frequency deviates significantly from rated frequency the manufacturer should be consulted.~~

4.7.3 Time constant (τ)

For DC, the time constants expected in practice are considered to correspond to those in Table 105.

~~NOTE 1 Some service conditions may be found which exceed the specified performance shown in the table as regards time constant. In such a case, a design of fuse link which has been tested and marked accordingly should be used or the suitability of such a fuse link be subject to agreement between manufacturer and user. In some service conditions, the time constant is significantly lower than the values stated in the table. In such a case, the applied voltage can be higher than the rated voltage defined according to Table 105.~~ **8**

For VSI fuse-links, equivalent time constants expected in practice are considered to correspond to those in Table 106.

NOTE 2 The high rate of rise of short circuit current is due to the low inductance, which is considered to be equivalent to a low time constant.

NOTE 3 Instead of time constant di/dt can be used in case of short circuit condition.

$$di/dt = E/L.$$

E = voltage value of the DC power source,

L = total inductance of the capacitor discharge circuit.

~~3.10 Temperature inside an enclosure~~ **9**

~~Since the rated values of the fuse-links are based on specified conditions that do not always correspond to those prevailing at the point of installation, including the local air conditions, the user may have to consult the manufacturer concerning the possible need for re-rating.~~

5 Classification

IEC 60269-1 applies.

6 Characteristics of fuses

IEC 60269-1 applies with the following supplementary requirements.

6.1 Summary of characteristics

6.1.3 Fuse-links

- a) Rated voltage (see 6.2)
- b) Rated current (see 6.3 of IEC 60269-1:2024)
- c) Kind of current and frequency (see 6.4 of IEC 60269-1:2024)
- d) Rated power dissipation (see 6.5 of IEC 60269-1:2024)
- e) Time-current characteristics (see 6.6)
- f) Breaking range (see 6.7.1 of IEC 60269-1:2024)
- g) Rated breaking capacity (see 6.7.2 of IEC 60269-1:2024)
- h) Cut-off current characteristics (see 6.8.2)
- i) I^2t characteristics (see 6.8.3)
- j) Dimensions or size (if applicable)
- k) Arc voltage characteristics (see 6.9)
- l) Fuse-links may only be used with the fuse-base and/or fuse-holder assigned by the manufacturer and defined in the manufacturer's instructions **10**

6.2 Rated voltage

For rated AC voltages up to 690 V and DC voltages up to 750 V, IEC 60269-1 applies; for higher voltages, the values shall be selected from the R 5 series or, where not possible, from the R 10 series of ISO 3.

A fuse-link shall have an AC voltage rating or a DC voltage rating or a VSI voltage rating. It may have one or more of these voltage ratings.

6.4 Rated frequency

The rated frequency is that frequency to which the performance data are related.

6.5 Rated power dissipation of the fuse-link and rated acceptable power dissipation of a fuse-holder **11**

In addition to the requirements of IEC 60269-1, the manufacturer shall indicate the power dissipation as a function of current for the range 50 % to 100 % of the rated current ~~or for 50 %, 63 %, 80 % and 100 % of the rated current.~~ **12**

NOTE—In cases where the resistance of the fuse-link is of interest, this resistance should be determined from the functional relation between the power dissipation and the associated value of current.

6.6 Limits of time-current characteristics

6.6.2 Time-current characteristics, time-current zones

6.6.2.1 General requirements

The time-current characteristics depend on the design of the fuse-link, and, for a given fuse-link, on the ambient air temperature and the cooling conditions.

The manufacturer shall provide time-current characteristics based on an ambient temperature of 20 °C to 25 °C in accordance with the conditions specified in 9.3. The time-current characteristics of interest are the pre-arcing characteristic and operating characteristics.

For AC, the time-current characteristics are stated at rated frequency and for pre-arcing or operating times longer than 0,1 s.

For DC, they are stated for time constants according to Table 105 and for pre-arcing or operating times longer than 15τ .

For the higher values of prospective current (shorter times), the same information shall be presented in the form of I^2t characteristics (see 6.8.2).

6.6.2.2 Pre-arcing time-current characteristics

For AC, the pre-arcing time-current characteristic shall be based on a symmetrical AC current of a stated value of frequency (rated frequency).

For DC, the pre-arcing time-current characteristic is of particular significance for times exceeding 15τ for the relevant circuit, and is identical to the AC pre-arcing time-current characteristic in this zone.

NOTE 1 Because of the wide range of circuit time constants likely to be experienced in service, the information for times shorter than 15τ is conveniently expressed as a pre-arcing I^2t characteristic.

NOTE 2 The value of 15τ has been chosen to avoid the effects which different rates of rise of current have on the pre-arcing time-current characteristic at shorter times.

6.6.2.3 Operating time-current characteristics

For AC with times longer than 0,1 s and for DC with times longer than 15τ , the arcing period is negligible compared to the pre-arcing time. The operating time is then equivalent to the pre-arcing time.

6.6.3 Conventional times and currents

6.6.3.1 Conventional times and currents for "aR" fuse-links

See 8.4 and Table 101. **13**

6.6.3.2 Conventional times and currents for "gR" and "gS" fuse-links

The conventional times and currents are given in Table 101.

Table 101 – Conventional time and current for "gR" and "gS" fuse-links 14

Rated current A	Conventional time h	Conventional current			
		Type "gR"		Type "gS"	
		I_{nf}	I_f	I_{nf}	I_f
$I_n \leq 4$	1	$1,1 I_n$	$2,1 I_n$	$1,5 I_n$	$2,1 I_n$
$4 < I_n < 16$	1	$1,1 I_n$	$1,9 I_n$	$1,5 I_n$	$1,9 I_n$
$I_n \leq 63$ $16 \leq I_n \leq 63$	1				
$63 < I_n \leq 160$	2	$1,1 I_n$	$1,6 I_n$	$1,25 I_n$	$1,6 I_n$
$160 < I_n \leq 400$	3				
$400 < I_n$	4				
^aIn Annex CC, some examples specify the requirements for $I_n \leq 16$.					
NOTE For explanation of gR and gS see 5.7.1.					
NOTE The conventional times also apply for "aR" – fuses					

6.6.4 Gates

Not applicable.

5.6.4 Overload curves 15

5.6.4.1 Verified overload capability

~~The manufacturer shall indicate sets of coordinate points along the time-current characteristics (see 5.6.1) for which the overload capability has been verified in accordance with the procedure indicated in 8.4.3.4.~~

~~The number and the location of the sets of coordinate points for which the overload capability shall be verified shall be selected at the discretion of the manufacturer. The time coordinates for the verification of the overload capability shall be selected within the range of 0,01 s to 60 s. Further sets of the coordinate points may be added according to agreement between manufacturer and user.~~

5.6.4.2 Conventional overload curve

~~The conventional overload curve is formed of straight line sections emanating from the coordinate points of verified overload capability. From each set of coordinate points, two lines are drawn:~~

- ~~— one from the verified point and following points of constant values of current towards shorter times;~~
- ~~— the other from the verified point and following points of constant values of I^2t towards longer times.~~

~~These line sections, ending at the line representing rated current, form the conventional overload curve (see Figure 101).~~

~~NOTE For practical applications, a few points of verified overload capability are sufficient. As the number of points of verified overload capability increases, the conventional overload curve becomes more precise.~~

6.7 Breaking range and breaking capacity

6.7.1 Breaking range and utilization ~~category~~ class

The first letter shall indicate the breaking range:

- "a" fuse-links (partial-range breaking capacity, see 8.4);
- "g" fuse-links (full-range breaking capacity).

The second letter "R" and "S" shall indicate the utilization ~~category~~ class for fuse-links complying with this standard for the protection of semiconductor devices.

The type "R" is typically faster acting than type "S" and gives lower I^2t values. **16**

The type "S" generally has lower power dissipation and gives enhanced utilization of cables compared to type "R".

For example:

- aR indicates fuse-links with partial range breaking capacity for the protection of semiconductor devices;
- gR indicates fuse-links with full-range breaking capacity for general application and semiconductor protection, optimised to low I^2t values;
- gS indicates fuse-links with full range breaking capacity for general application and semiconductor protection, optimised to low power dissipation.

Some aR fuse-links are used to protect voltage source inverters. Even though they are common aR fuses on AC, they must be tested differently under VSI DC short-circuit conditions. For these reasons, their designation is still "aR" but their DC characteristics must be clearly stated "for VSI protection" in the manufacturer's data sheets.

6.7.2 Rated breaking capacity

A breaking capacity of at least 50 kA for AC and ~~8~~ 20 kA for DC is ~~recommended~~ required. **17**

For AC, the rated breaking capacity is based on type tests performed in a circuit containing only linear impedance and with a constant sinusoidal applied voltage of rated frequency.

For DC, the rated breaking capacity is based on type tests performed in a circuit containing only linear inductance and resistance with mean applied voltage.

For VSI, the rated breaking capacity is based on type tests performed in a circuit ~~containing very low inductance and resistance with d.c. or capacitor discharged applied voltage~~ with low time constant. The time constant for tests is defined in Table 106. The required rated maximum breaking capacity of VSI fuses is at least 20 kA. **18**

NOTE The addition in practical applications of non-linear impedances and unidirectional voltage components may significantly influence the breaking severity either in a favourable or unfavourable direction.

6.8 Cut-off current and I^2t characteristics

6.8.2 Cut-off current characteristics

The manufacturer shall provide the cut-off current characteristics which shall be given, according to the example shown in Figure 4 of IEC 60269-1:2024, in a double logarithmic presentation with the prospective current as abscissa and, if necessary, with applied voltage and/or frequency as a parameter.

For AC, the cut-off current characteristics shall represent the highest values of current likely to be experienced in service. They shall refer to the conditions corresponding to the test conditions

of this standard, for example, given voltage, frequency and power-factor values. The cut-off current characteristics may be defined by the tests specified in 9.6.

For DC, the cut-off current characteristics shall represent the highest values of current likely to be experienced in service in circuits having a time constant specified in Table 105 for aR, gS and gR fuse-links, or in Table 106 for aR fuse-links in VSI applications. For aR, gS and gR fuse-links, these values will be exceeded in circuits of smaller time constants than those of Table 105. The manufacturer shall provide the relevant information to enable the determination of these higher cut-off current characteristics.

NOTE The cut-off current characteristic varies with the circuit time constant. The manufacturer should provide the relevant information to enable these variations to be determined at least for time constants of 5 ms and 10 ms.

6.8.3 I^2t characteristics

6.8.3.1 Pre-arcing I^2t characteristic

For AC, ~~the pre-arcing I^2t characteristic shall be~~ the manufacturer shall provide the pre-arcing I^2t characteristic based on a symmetrical AC current at a stated frequency value (rated frequency). **19**

For DC, the manufacturer shall provide the pre-arcing I^2t characteristic ~~shall be~~ based on RMS DC current at a time constant specified in Table 105 for aR, gS and gR fuse-links or in Table 106 for aR fuse-links in VSI applications.

~~NOTE For aR and gR and gS fuse links, the pre-arcing I^2t characteristic varies with the circuit time constant. The manufacturer should provide the relevant information to enable these variations to be determined at least for time constants of 5 ms and 10 ms.~~

For DC, the pre-arcing I^2t value represents the lowest value likely to be experienced in service. It shall be based on RMS DC current as defined in the test requirements of test No.1 of the breaking capacity.

6.8.3.2 Operating I^2t characteristics

For AC, the manufacturer shall provide the operating I^2t characteristics ~~shall be~~ given with applied voltage as a parameter and for a stated power-factor value. In principle, they shall be based on the moment of current initiation that leads to the highest operating I^2t value (see 9.7). The voltage parameters shall include at least 100 %, and 50 % ~~and 25 %~~ of rated voltage.

For DC, the manufacturer shall provide the operating I^2t characteristics ~~shall be~~ given with the applied voltage as a parameter and for a time constant specified in the Table 105 for aR, gS and gR fuse-links, or Table 106 for aR fuse-links in VSI applications. The voltage parameters shall include at least 100 % and 50 % of rated voltage. It is permitted to determine the operating I^2t characteristics at lower voltages from tests in accordance with Table 105 or Table 106 according to their DC. application or VSI application.

The I^2t at reduced voltages may be calculated using the method described in IEC 60269-1:2024, Clause B.3. **20**

6.9 Arc voltage characteristics

Arc voltage characteristics provided by the manufacturer shall give the highest (peak) value of arc voltage as a function of the applied voltage of the circuit in which the fuse-link is inserted and, in the case of AC, for power factors as stated in Table 104 and, in the case of DC at time constants specified in Table 105 or in Table 106 according to their DC application or VSI application.

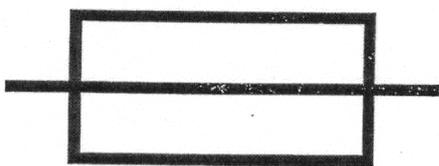
7 Markings

IEC 60269-1 applies with the following supplementary requirements.

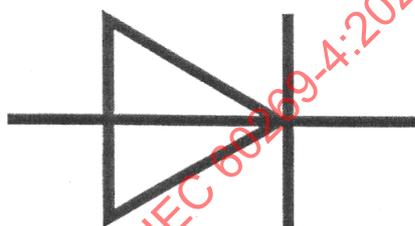
7.3 Marking of fuse-link

Subclause 7.3 of IEC 60269-1:2024 applies with the following addition:

- manufacturer's identification reference and/or symbols enabling all the characteristics listed in 6.1.3 of IEC 60269-1:2024 to be found;
- utilization ~~category~~ class, "aR" or "gR" or "gS";
- a combination of symbols of IEC 60417 of a fuse (5016) and a rectifier (5186) as shown below:



Symbol IEC 60417-5016 (2002-10)



Symbol IEC 60417-5186 (2002-10)

For VSI rated fuse-links an additional mark, e.g. "1 200V DC VSI" with the voltage rating value must be stated on the product. **21**

8 Standard conditions for construction

IEC 60269-1 applies with the following supplementary requirements.

8.3 Temperature rise and power dissipation of the fuse-link and acceptable power dissipation of a fuse-holder **22**

Fuse-links shall be so designed and proportioned as to carry, when tested in accordance with 9.3, the rated current without exceeding,

- the temperature rise limit of the hottest upper metal part of the fuse-link indicated by the manufacturer instructions (see Figure 101 and Figure 102). **23**
- the power dissipation at the rated current indicated by the manufacturer instructions.

8.4 Operation

The fuse-link shall be so designed and proportioned as to carry continuously any value of current up to its rated current.

"aR" fuse-links shall operate and break the circuit for any current value not exceeding the rated breaking capacity and not less than ~~a current sufficient to interrupt the fuse-link specified by the manufacturer~~ the current I_{2a} (see Table 104 and Table 105). **24**

For "gR" and "gS" fuse-links within the conventional time and at currents defined in Table 101:

- it ~~does~~ shall not operate, when it carries any current not exceeding the conventional non-fusing current (I_{nf});
- it ~~operates~~ shall operate when it carries any current equal to, or exceeding, the conventional fusing current (I_f) and equal to or lower than the rated breaking capacity.

8.5 Breaking capacity

A fuse-link shall be capable of breaking, at a voltage not exceeding ~~the voltage specified in 8.5~~ its rated voltage **25**, any circuit having a prospective current between a current according to 8.4 and the rated breaking capacity:

- ~~— for a.c. at power factors not lower than those in Table 104 appropriate to the value of the prospective current;~~
- ~~— for d.c., at time constants not greater than the values specified in Table 105;~~
- ~~— for VSI applications, the fuse-link shall be capable of breaking a current specified in 8.5 at time constants not greater than the value specified in Table 106.~~
- for AC, test parameters are given in Table 104;
- for DC, test parameters are given in Table 105;
- for VSI applications, test parameters are given in Table 106.

8.7 I^2t characteristics

The values of operating I^2t determined as described in 9.7 shall not exceed those stated by the manufacturer. The values of pre-arcing I^2t determined as described in 9.7 shall be not less than the values stated (see 6.8.2.1 and 6.8.2.2).

8.15 Arc voltage characteristics

The arc voltage values measured as described in 9.7.5 shall not exceed those stated by the manufacturer (see 6.9).

~~7.16 Special operating conditions~~

~~Special operating conditions, such as high value of acceleration, shall be subject to agreement between manufacturer and user. **26**~~

9 Tests

IEC 60269-1 applies with the following supplementary requirements.

~~8.1 General~~

9.1.5 Arrangement of the fuse-link and dimensions

The fuse-link shall be mounted open in free air in draught-free surroundings free from draughts and, unless otherwise specified, in a vertical position (see 9.3.1). Examples of test arrangements are given in Figure 101 and Figure 102. Test arrangements for other kinds of fuse-links are given in IEC 60269-2 and IEC 60269-3.

9.1.6 Testing of fuse-links

9.1.6.2 Complete tests

The complete tests on fuse-links are listed in Table 102. The internal resistance of all fuse-links shall be determined and recorded in the test report(s).

A fuse-link shall have an AC breaking capacity or a DC breaking capacity or a VSI breaking capacity. It may have one or more of these breaking capacities.

Table 102 – List of complete tests 27

Test according to subclause		Number of fuse-links to be tested
9.3	Temperature rise and power dissipation	1
9.4.3.1 a)	Conventional non-fusing current	1
9.4.3.1 b)	Conventional fusing current	1
9.4.3.2	Verification of rated current	1
9.4.3.5	Conventional cable overload test (for "gR" and "gS" fuse-links only)	1
For AC:		
9.5	No 5 "gR" and "gS" breaking capacity and operating characteristics	1
	No. 2a "aR" breaking capacity and operating characteristics	1
	No. 2 Breaking capacity and operating characteristics ^a	3
	No. 1 Breaking capacity and operating characteristics ^a	3
8.4.3.4	Verification of overload capability ^b	4
For DC:		
9.5	No. 13 "gR" and "gS" breaking capacity and operating characteristics	1
	No.12a "aR" breaking capacity and operating characteristics	1
	No.12 Breaking capacity and operating characteristics	3
	No.11 Breaking capacity and operating characteristics	3
For VSI fuse-links:		
9.5	No. 21 Breaking capacity and operating characteristics	3
^a Valid for pre-arcing I^2t characteristics, if ambient air temperature is between 10 °C and 30 °C.		
^b The number of points at which the overload capability is verified should be at the manufacturer's discretion.		

9.1.6.3 Testing of fuse-links of a homogeneous series

Fuse-links having intermediate values of rated current of a homogeneous series are exempted from type tests if the fuse-link of the largest rated current has been tested to the requirements of 9.1.6.2 and if the fuse-link of the smallest rated current has been submitted to the tests indicated in Table 103.

Table 103 – Survey of tests on fuse-links of the smallest rated current of a homogeneous series

Test according to subclause		Number of fuse-links to be tested
8.3	Temperature rise and power dissipation	1

9.3 Verification of temperature rise limits and power dissipation

9.3.1 Arrangement of the fuse-link

Only one fuse-link shall be used for the test. The fuse-link shall be mounted vertically in the conventional test arrangement. Examples are given in Figure 101 and Figure 102.

The current density of the copper conductors forming part of the conventional test arrangement shall be not less than 1 A/mm² and not more than 1,6 A/mm², these values being based on the rated current of the fuse-link. The ratio of width to thickness of these conductors shall not exceed

- 10 for current ratings less than 200 A;
- 5 for current ratings 200 A and above.

The ambient air temperature during this test shall be between 10 °C and 30 °C.

When conducting the temperature-rise tests, the cross-sectional areas of the conductors connecting the conventional test arrangement to the supply are important. The cross-sectional area shall be selected in accordance with Table 18 of IEC 60269-1:2024, excluding the note, and the conductors on either side of the fuse-link shall be at least 1 m long.

For fuse-links intended to be used in separate fuse-bases, the test may be performed in these fuse-bases with conductors according to Table 18 of IEC 60269-1:2024; in other cases, the test shall be performed in the manner described in these requirements.

For special fuse-links or special applications that cannot be accommodated in the conventional test arrangement, or for which this test arrangement is not applicable, special tests shall be performed according to the manufacturer's instructions and all pertinent data shall be recorded in the test report.

9.3.3 Measurement of power dissipation of the fuse-link

In addition to 9.3.3 of IEC 60269-1:2024, the following applies: the power dissipation test shall be made successively at least at 50 % and at 100 % of rated current. This test may be performed with either AC or DC.

9.3.4 Test method

The cross-sectional area of copper conductors for high current ratings tests corresponding to Subclauses 9.3 and 9.4 is defined in Table 107.

Table 107 – Cross-sectional area of copper conductors for high current ratings tests

Rated current (I_N)	Cross-sectional area
A	(mm × mm)
1 600	2 × 100 × 5
2 000	3 × 100 × 5
2 500	4 × 100 × 5
3 150	3 × 100 × 10
≥ 4 000	$I_N \times \text{mm}^2 / \text{A}^a$
^a For currents ≥ 4 000 A the cross-sectional area is defined with a current density = 1 A/mm ² .	

9.3.5 Acceptability of test results

The temperature rise and the power dissipation of the fuse-link shall ~~not exceed~~ be given in the ~~values specified by the manufacturer~~ manufacturer's documentation. **28**

9.4 Verification of operation

9.4.1 Arrangement of the fuse-link

The arrangement of the fuse-link for the verification of operation shall be as described in 9.1.5 and 9.3.1.

9.4.3 Test method and acceptability of test results

The following tests may be performed by AC or DC source. 29

9.4.3.1 Verification of conventional non-fusing and fusing current

"aR" fuse-links:

Not applicable.

"gR" and "gS" fuse-links:

~~It is permissible to make The following tests at a reduced voltage:~~

The following test must be made but can be performed with reduced voltage. 30

- the fuse-link is subjected to its conventional non-fusing current (I_{nf}) for a time equal to the conventional time specified in Table 101. It shall not operate during this time;
- the fuse-link, after having cooled down to ambient temperature, is subjected to the conventional fusing current (I_f). It shall operate within the conventional time as specified in Table 101. The fuse-link shall operate without external effects or damage.

9.4.3.2 Verification of rated current (see AA.3.3)

The fuse-link is tested under the same test conditions as indicated in 9.3.1.

It is subjected to 100 test cycles, each consisting of an "on" period of 0,1 times the conventional time as specified in Table 101 at rated current and an "off" period of the same duration. After test, the fuse-link must not have changed its resistance by more than 10 %. 31

NOTE Conventional time for "gR" in Table 101 also applies for "aR". 32

9.4.3.3.1 Time-current characteristics

The time-current characteristics may be verified on the basis of the results obtained from the oscillographic records taken during the performance of the tests according to 9.5.

The pre-arcing period is determined from the instant of closing the circuit until the instant when the voltage measurement shows the beginning of the arc.

The value of pre-arcing time so determined, referred to the abscissa corresponding to the value of the prospective current, shall be within the time-current zone indicated by the manufacturer.

For AC prospective currents heading to actual pre-arcing time values of less than 10 cycles of rated frequency and up to current values where the melting is adiabatic, the currents shall be initiated in such a manner that the prospective current will be symmetrical.

For DC, the time-current characteristics determined for AC are applicable for times longer than 15τ for the relevant circuit.

When, for the fuse-links of a homogeneous series (see 9.1.6.3), the complete test according to 9.5 is made only on the fuse-link having the largest rated current, it shall be sufficient to verify only the pre-arcing time for the fuse-link having the smallest rated current.

Pre-arcing time-current characteristics can be determined at any convenient voltage value and on any linear circuit. Tests to determine operating time-current characteristics require the proper voltage values and circuit characteristics.

8.4.3.4 Overload 33

~~The fuse-link is tested under the same test conditions as indicated in 8.3.1.~~

~~It is subjected to 100 load cycles, each cycle having a total duration of 0,2 times the conventional time, the "on" period with a current value and a duration corresponding to the coordinates of the overload capability to be verified, the "off" period forming the rest of the cycle. The conventional time is that specified in Table 101.~~

~~NOTE These tests are deemed to verify the overload capability of the fuse on d.c. for pre-arcing times greater than 15 τ for the relevant circuit.~~

9.4.3.5 Conventional cable overload protection test (for "gR" and "gS" fuse-links only)

"gR" and "gS" fuse-links: IEC 60269-1 applies.

9.4.3.6 Operation of indicating devices and striker, if any

The correct operation of indicating devices is verified in combination with the verification of breaking capacity (see 9.5.5).

For verifying the operation of strikers, if any, an additional test sample shall be tested:

- at a current of I_{2a} (see Table 104 and Table 105);
- at a recovery voltage of 20 V.

The value of the recovery voltage may be exceeded by 10 %.

The striker shall operate during all tests.

However, if, during one of these tests, the indicating device or striker fails, the test shall not be considered negative on this account, if the manufacturer can furnish evidence that such failure is not typical of the fuse type but is due to a fault on the individual tested sample. If such a failure occurs, then twice the number of samples shall be tested for the particular test duty, without further failure.

The characteristics and the verification of the characteristics of indicating devices or strikers are subject to an agreement between the manufacturer and user.

9.5 Verification of the breaking capacity

9.5.1 Arrangement of the fuse

In addition to the conditions of 9.1.4 and 9.3.1, the following applies.

For breaking-capacity tests, the fuse-link shall be mounted in a manner resembling its practical use, in particular with respect to the location of the conductors. In cases where the fuse-link can be used rigidly supported at one end only, it shall be so mounted for the test. Fuse-links intended to be always rigidly supported at both ends shall be so tested.

9.5.5 Test method

9.5.5.1 In order to verify that the fuse-link satisfies the conditions of 8.5 for AC, test Nos. 1 to 2a for "aR" fuse-links and tests numbers 1, 2 and 5 for "gR" and "gS" fuse-links, as described below, shall be made, ~~unless otherwise specified~~, with the values stated in Table 104 (see 9.5.5.2) for each of these tests. For DC tests, numbers 11 to 12a for "aR" fuse-links and numbers 11, 12 and 13 for "gR" and "gS" fuse-links shall be made, unless otherwise specified, with the values stated in Table 105. For VSI fuse-links, test no 21 shall be made with the values stated in Table 106. Test voltages are given in Tables 104, 105 and 106.

Test Nos. 1 and 2 for AC; or 11 and 12 for DC or 21 for VSI fuse-links: for each of these tests, three fuse-links shall be tested in succession. If, during test No. 1, the requirements of test No. 2 are met on one or more tests, then these tests need not be repeated as part of test No. 2. The same applies for tests numbers 11 and 12 for DC.

Test Nos. 2a and 5 for AC and 12a and 13 for DC: for AC, the values of test current are specified in Table 104. For DC, the values of test current are specified in Table 105. For AC tests, the closing of the circuit in relation to the passage of the applied voltage through zero may be effected at any instant. If the testing arrangement does not permit the current to be maintained at the full voltage during all of the time required, the fuse may be pre-heated at reduced voltage by applying a current approximately equal to the value of the test current. In this case, switching over to the test circuit according to 9.5.2 shall take place before the arc is initiated, and the switching time T_1 (interval without current) shall not exceed 0,2 s. The time interval between re-application of the current and beginning of arcing shall be not less than three times T_1 .

The following text replaces the text of 9.5.5.2 of IEC 60269-1:2024 with the exception of the resistance test: **34**

9.5.5.2 For one of the tests of No. 2 and for test No. 2a or 5 for AC, and one of the tests of No. 12 and for tests 12a or 13 for DC, and for one test of 21 for VSI, the recovery voltage shall be maintained at a value of:

- for AC, ~~110~~ 105% + 5 %/-0 % of the rated voltage
- for DC, ~~100~~ 105% + 10 %/-0 % of the rated voltage
- for VSI, ~~100~~ 105% + 10 %/-0 % of the rated voltage

The tolerance +xx %/-xx % is to be used by testing bodies as tolerance in testing. The practical use of the fuse should be only to 100 % of the rated voltage, unless the manufacturer gives his consent to a higher value. **35**

For at least:

- 30 s after operation of fuse-links not containing organic materials in their body or filler;
- 5 min after operation of the fuse-links in all other cases, switching over to another source of supply being permitted after 15 s if the switching time (interval without voltage) does not exceed 0,1 s.

For all other tests, the recovery voltage shall be maintained at the same value for 15 s after operation of the fuse.

In a lapse of time of at least 6 min and maximum 10 min after the operation, the resistance between the contacts of the fuse-link shall be measured (see 9.5.8) and noted. With the manufacturer's consent, shorter times are possible if the fuse-link does not contain organic materials in its body or filler.

Table 104 – Values for breaking-capacity tests on AC fuses 36

	Tests according to 9.5.5.1			
	No. 1	No. 2	No. 2a	No. 5
Power-frequency recovery voltage ^c	$110 \frac{+2}{-3}$ % of the rated voltage^a $110 \frac{+5}{0}$ % for other rated voltages^a 105+5%/-0% of the rated voltage ^a			
Prospective test current	I_1	I_2	I_{2a} "aR"	$I_5 = 1,25 I_f$ "gR" and "gS"
Tolerance on current	$\frac{+10}{0}$ % ^a	Not applicable		$\frac{+20}{0}$ %
Power factor	0,2 to 0,3 for prospective current up to and including 20 kA 0,1 to 0,2 for prospective current above 20 kA		0,3 to 0,5 ^b	
Making angle after voltage zero	Not applicable	$0 \frac{+20}{-0}$	Not specified	
Initiation of arcing after voltage zero	65° to 90°	Not applicable		
<p>I_1 is the current which is used in the designation of the rated breaking capacity (see 6.7.2).</p> <p>I_2 is the current which shall be chosen in such a manner that the test is made under conditions which approximate those giving maximum arc energy.</p> <p>NOTE This condition may be deemed to be satisfied if the current at the beginning of arcing (instantaneous value) has reached a value between $0,6\sqrt{2}$ (=0,85) and $0,75\sqrt{2}$ (=1,06) times the prospective current (for AC, the RMS value of the AC component).</p> <p>As a guide for practical application, Informative: The value of current I_2 may be found between three and four times the current which corresponds to a pre-arcing time of one half-cycle of rated frequency on the time-current characteristic.</p> <p>I_{2a} is the minimum value of the breaking capacity of the fuse-link in the overcurrent range specified by the manufacturer (see 8.4).</p> <p>I_5 is the test current deemed to verify that the fuse is able to operate satisfactorily in the range of small overcurrents.</p>				
<p>^a The positive tolerance may be exceeded with the manufacturer's consent.</p> <p>^b Power factors lower than 0,3 may be permitted with the manufacturer's consent.</p> <p>^c For single-phase circuits, the RMS value of the applied voltage is for all practical purposes equal to the RMS value of the power-frequency recovery voltage.</p>				

Table 105 – Values for breaking-capacity tests on DC fuses 37

	Tests according to 9.5.5.1			
	No. 11	No. 12	No. 12a	No. 13
Mean value of recovery voltage ^a	115-105 % +10 % -0 % of the rated voltage ^b			
Prospective test current	I_1	I_2	I_{2a} "aR"	$I_5 = 1,25 I_f$ "gR" and "gS"
Tolerance on current	+10 0 %	Not applicable		+20 0 %
Time constant ^c	Where prospective test current is greater than 20 kA: 10 ms to 15 ms Where prospective test current I is equal to, or less than, 20 kA: 0,5 (I) ^{0,3} ms with a tolerance of +20 % ^b (value of I in A)			
<p>I_1 is the current which is used in the designation of the rated breaking capacity (see 6.7.2).</p> <p>I_2 is the current which shall be chosen in such a manner that the test is made under conditions which approximate those giving maximum arc energy.</p> <p>NOTE This condition may be deemed to be satisfied if the current, at the beginning of arcing, has reached a value between 0,5 and 0,8 times the prospective current.</p> <p>I_{2a} is the minimum value of the breaking capacity of the fuse-link in the overcurrent range specified by the manufacturer (see 8.4).</p> <p>I_5 is the test current deemed to verify that the fuse is able to operate satisfactorily in the range of small overcurrents.</p> <p>^a This tolerance includes ripple.</p> <p>^b The upper limit may be exceeded with the manufacturer's consent.</p> <p>^c In some practical applications, time-constant values may be found which are shorter than those indicated in the tests and which may result in a more favourable fuse performance. Time constants which are considerably longer than those indicated will in most cases significantly affect the performance, in particular with respect to the rated voltage. For such applications, further information may be available from the manufacturer.</p>				

Table 106 – Values for breaking-capacity tests on VSI fuse-links 38

	Tests according to 9.5.5.1	
	No. 21	
Mean value of recovery voltage ^a	110 $\frac{+2}{-3}$ % 105 +10%/-0% of the rated voltage ^b	
Prospective test current	I_1	
Tolerance on current	+10 -0 %	
Time constant	Less than 3 ms ^c	
<p>I_1 is the current which is used in the designation of the rated breaking capacity (see 6.7.2).</p> <p>^a This tolerance includes ripple.</p> <p>^b The upper limit may be exceeded with the manufacturer's consent.</p> <p>^c Prospective current with high di/dt instead of low time constant may be utilized with the manufacturer's consent. The time constant can be higher with the manufacturers' consent.</p>		

9.5.8 Acceptability of test results 39

~~Fuse links shall be deemed not to comply with this standard if, during the tests, one or more of the following failures occur:~~

~~— ignition of the fuse link, excluding any paper labels or the like used as indicating devices;~~

- ~~— mechanical damage to the conventional test arrangement;~~
- ~~— mechanical damage to the fuse-link;~~

~~NOTE Thermal cracking which leaves the fuse-link in one piece is accepted.~~

- ~~— burning or melting of end caps;~~
- ~~— significant movement of end caps.~~

Part 1 of IEC 60269 applies.

9.6 Verification of the cut-off current characteristics

9.6.1 Test method

For AC, tests shall be made as specified in Table 104.

For DC, tests shall be made as specified in Table 105.

For VSI fuse-links, tests shall be made as specified in Table 106.

Tests conducted in accordance with 9.5 shall be used for evaluation according to 9.6.2. The tests may be used to prove the characteristics of all fuse-links of a homogeneous series.

9.6.2 Acceptability of test results

For AC, cut-off characteristics shall be verified from tests Nos. 1 and 2 in Table 104.

For DC, cut-off current characteristics shall be verified from tests Nos. 11 and 12 in Table 105.

For VSI fuse-links, cut-off characteristics shall be verified from test No. 21 in Table 106.

9.7 Verification of the I^2t characteristics and overcurrent ~~discrimination~~ selectivity

9.7.1 Test method

The test method is that specified in 9.6.1.

9.7.2 Acceptability of test results

For AC, the I^2t characteristics shall be verified from tests Nos. 1 and 2 according to Table 104.

For DC, the I^2t characteristics shall be verified from tests Nos. 11 and 12 according to Table 105.

For VSI fuse-links, the I^2t characteristics shall be verified from tests No. 21 according to Table 106.

The values of the pre-arcing I^2t at each prospective current shall be not less than the values stated by the manufacturer.

The values of operating I^2t at each prospective current shall not exceed the values indicated by the manufacturer for the stated applied voltage.

9.7.3 Verification of compliance for fuse-links at 0,01 s

Not applicable.

9.7.4 Verification of overcurrent-discrimination selectivity 40

Not applicable.

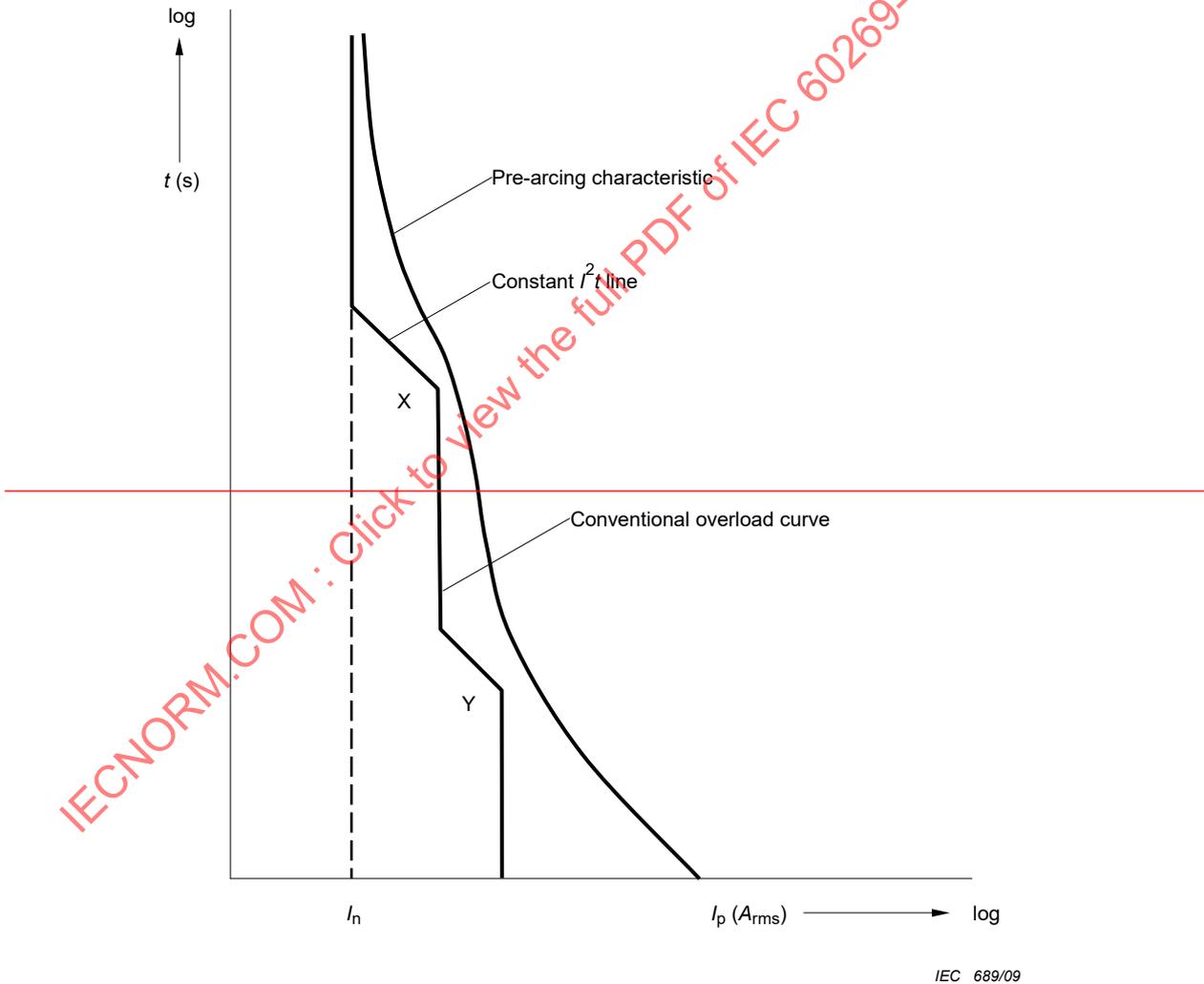
9.7.5 Verification of arc voltage characteristics and acceptability of test results

The highest values of arc voltage derived from each of the following tests shall not exceed those indicated by the manufacturer.

For AC, the arc voltage characteristics shall be verified from tests Nos. 1 and 2 in Table 104.

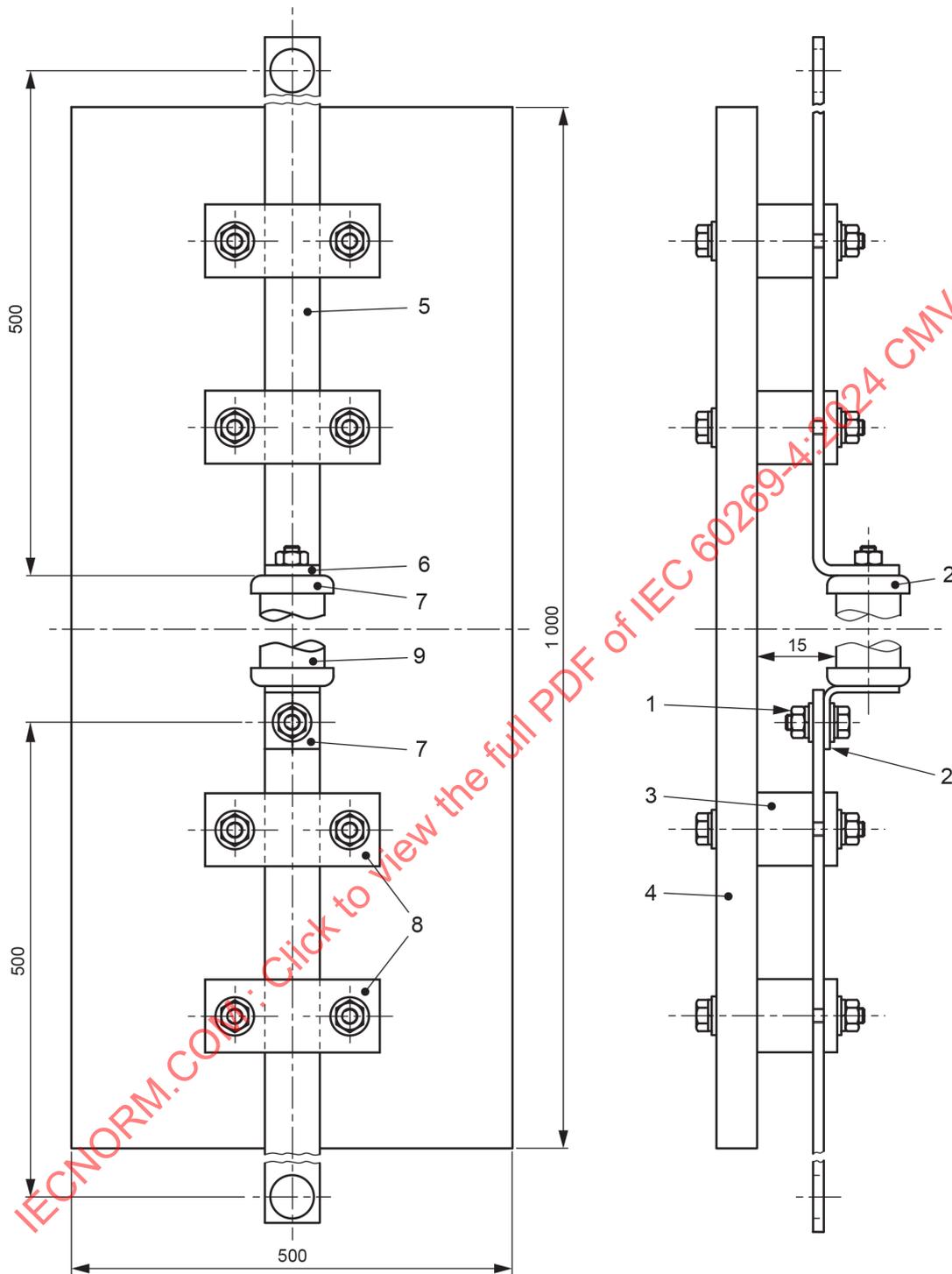
For DC, the arc voltage characteristics shall be verified from tests Nos. 11 and 12 in Table 105.

For VSI fuse-links, the arc voltage characteristics shall be verified from tests No. 21 in Table 106.



**Figure 101 — Conventional overload curve (example)
(X and Y are points of verified overload capability)**

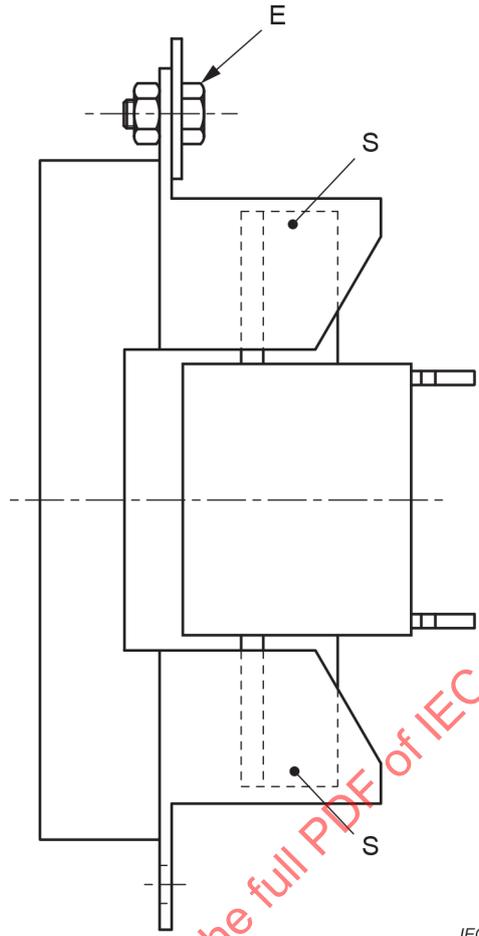
Dimensions in millimetres

**Key**

- 1 fixing bolts
- 2 alternative points of measurement of voltage for determination of power dissipation
- 3 insulating blocks (for example, wood)
- 4 insulated base panel (for example, 16 mm plywood)
- 5 matt black finish
- 6 position of thermocouple fixed to hottest upper metal part of the fuse-link, indicated by the manufacturer or otherwise specified
- 7 contact surface to be tin-plated
- 8 insulated clamps. Where necessary, the two upper clamps may be left loose.
- 9 the body of the fuse-link can be round or rectangular

Figure 101 – Example of a conventional test arrangement for bolted fuse-links

IEC



IEC

Key

Points of measurement:

E temperature rise

S power dissipation

Figure 102 – Example of a conventional test arrangement for blade contact fuse-links

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Annex AA (informative)

Guidance for the coordination of fuse-links with semiconductor devices 41

NOTE The full content of this annex can be read in the user guide IEC TR 60269-5:2014+AMD1:2020 and therefore is not copied here.

AA.1 General

~~This annex is limited to the use of fuse-links in circuits having the characteristics generally found in converters based on semiconductors.~~

~~It deals with the performance of fuse-links under the conditions covered but it does not deal with the adequacy of fuse-links with respect to converters.~~

~~NOTE Attention is drawn to the fact that fuse-links intended for use on a.c. are not necessarily suitable for use on d.c. The manufacturer should be consulted on all cases of d.c. applications. It should be noted in particular that the relationship between rated voltage a.c. versus rated voltage d.c. cannot be stated in a general form. The few references in this guide to d.c. operations are not complete and do not cover all of the important factors related to such use.~~

~~It is the object of this annex to explain the performance to be expected from the fuse-links in terms of their ratings and in terms of the characteristics of the circuits of which they form a part, in such a manner that this may form the basis for the selection of the fuse-links.~~

AA.2 Terms and definitions

~~For the purposes of this annex, the following terms and definitions apply. See also the terms and definitions of Clause 2.~~

AA.2.1

~~**pulsed current** (in a semiconductor fuse-link)~~

~~unidirectional current, the instantaneous value of which varies in a cyclic manner and includes intervals of zero or insignificantly small values of current for times significant in relation to the total cycle~~

~~NOTE A typical pulsed current is the current in a single arm of a bridge-connected rectifier.~~

AA.2.2

~~**pulsed load** (in a semiconductor fuse-link)~~

~~load where the r.m.s. value of the current varies in a cyclic manner and includes intervals of zero current or insignificantly small values of current for times significant in relation to the total load cycle~~

~~NOTE In a rectifier circuit, a pulsed load may be caused by cyclic making and breaking of the d.c. circuit current; for instance, by the starting and stopping of a motor.~~

AA.3 Current-carrying capabilities

AA.3.1 Rated current

~~The rated current of a semiconductor fuse-link is assigned by the manufacturer and verified in particular by the temperature-rise test (see 8.3) and by the repetitive duty test as described in 8.4.3.2.~~

~~NOTE The ability to carry current without deterioration is closely related to the temperature variations. The data given by the manufacturer relate to the test conditions (see 8.1.4 and 8.3). The cooling conditions depend on the physical properties of the fuse-link, the flow of the cooling medium, the type and temperature of the connections and of adjacent hot bodies.~~

~~Guidance on the influence of these factors may be obtained from the manufacturer.~~

~~AA.3.2 — Continuous duty current~~

~~For most kinds of fuse-links for semiconductor devices, the continuous duty current is identical with the rated current (see AA.3.1). However, fuse-links designed for applications not requiring the carrying of rated current continuously are to be de-rated for continuous duty.~~

~~AA.3.3 — Repetitive duty current~~

~~The tests for rated current verify that the fuse-link is able to withstand, under the test conditions, repetition of the rated current load at least 100 times. The expected life in the number of repetitions will increase as the value of the actual load current is reduced in relation to the rated current.~~

~~The manufacturer's advice should be sought on the suitability of a given fuse-link for a required repetitive duty, since the specified tests establish minimum life expectancy requirements only.~~

~~AA.3.4 — Overload current~~

~~The overload capability (see 5.6.4.1) indicated by the manufacturer is based on one or more coordinates of time and current for which the overload capability has been verified under conditions identical with those indicated for the rated current (see 8.4.3.4). The conventional overload characteristic based on these verified points is a conservative estimate of the overload capability (see 5.6.4.2 and Figure 101).~~

~~As the actual overload rarely shows the same function of time as the conventional overload, it shall be transformed into an equivalent conventional one as follows:~~

- ~~— the maximum value of the actual overload is equated to the maximum value of an equivalent conventional overload;~~
- ~~— the duration of the equivalent conventional overload shall be such that its I^2t becomes equal to the I^2t of the actual load integrated over a time of 0,2 times the conventional time of the fuse-link.~~

~~Any value of the load which approaches 0,2 times the conventional time shall be considered to be a continuous load with respect to the fuse-link.~~

~~However, as the verification of the overload capability is based on 100 overload cycles, the practical cases of repetitive overload may necessitate a de-rating. The manufacturer's advice should be sought.~~

~~AA.3.5 — Peak current (cut-off current)~~

~~The highest value of peak current is obtained when the fuse-link operates under adiabatic conditions.~~

~~Under conditions where the rate of rise of the current is essentially constant, the instantaneous value of the current reached at the end of the pre-arcing period increases as the cube root of the rate of rise. For many fuse-links, this is essentially the peak value. For fuse-links reaching the peak value of current significantly later (in the arcing period), no general statement can be made and information should be obtained from the manufacturer.~~

AA.4 Voltage characteristics

AA.4.1 Rated voltage

The rated voltage (see 5.2) of the fuse-link for the protection of semiconductor devices is a value of sinusoidal applied voltage of rated frequency (or, in some cases, d.c.) assigned by the manufacturer. Information on the fuse-link is related to the rated voltage. Comparison between fuse-links of different manufacture on the basis of the voltage rating alone is insufficient.

AA.4.2 Applied voltage in service

The applied voltage is the voltage in the fault circuit that causes the fault current to flow. In most cases, it is possible to consider the no-load voltage in the fault circuit as the applied voltage, since the influence of the voltage drop can usually be disregarded.

NOTE The applied voltage may be affected by any commutation which takes place during the operation of the fuse-link or by the arc voltage of another fuse-link.

During the pre-arcing period, the applied voltage and the self-inductance of the circuit determine the rate of rise of the fault current (in general, it increases from zero to almost its peak value). In a given circuit, i.e. for a given self-inductance, it is the value of I^2t that determines the end of the pre-arcing period, and it is the integral of the applied voltage during that period that determines the instantaneous value of the current reached by the end of the pre-arcing period.

During the arcing period, the difference between the arc voltage and the applied voltage determines the rate of change of the current. Generally, it is a decrease from the peak value to zero. The zero value is reached in that instant where the integral of this difference becomes equal to the integral of the applied voltage over the pre-arcing period. For the time in which the arc voltage is less than the applied voltage, the current continues to increase; but, in most cases, this time is short and the associated current increase negligible.

For a fuse-link operating in the adiabatic or near-adiabatic zone, the pre-arcing I^2t is a well-defined quantity. The arcing I^2t can assume very different values, even for the same arcing time. It becomes a minimum when the excess arc voltage reaches its maximum during the early part of the arcing period.

AA.4.3 Arc voltage

The peak value of the arc voltage indicated by the manufacturer is that obtained under the most unfavourable conditions. The arc voltage characteristic is given as a function of the applied voltage. The peak value of the arc voltage should be limited to that which can be withstood by the semiconductor device.

AA.5 Power dissipation characteristics

AA.5.1 Rated power dissipation

The rated power dissipation is based on the rated current and on the standard test conditions (see 8.1.4 and 8.3.1). The temperature coefficient of the resistance of the fuse-link causes an increase in power dissipation at a higher rate than the square of the current.

For this reason, the manufacturer provides information about the relation between current and power dissipation either in the form of a power dissipation characteristic or in the form of discrete points.

The power dissipation characteristic may deviate from the rated value because of installation conditions different from those of the test (see 8.3).

AA.5.2 — Factors influencing power dissipation

Because of the significant influence on power dissipation of the relation between the actual current and the rated current, it may be desirable to use fuse links of larger current ratings than those determined by repetitive duty and overload. However, the higher current ratings imply a larger value of I^2t . The use of a fuse link of the highest current rating consistent with reasonable protection may at the same time reduce power dissipation and solve the problems of repetitive duty and overload.

The use of a fuse link of a higher voltage rating inherently leads to higher values of power dissipation. If its use is possible in spite of higher values of arc voltage, a reduction in the arcing I^2t will be obtained which may permit the selection of a fuse link having a higher current rating, resulting in a reduction in power dissipation.

Fuse links having iron parts may show a significant increase in power dissipation when used at frequencies higher than rated frequency.

AA.5.3 — Mutual influence

A very short electrical connection between the fuse link and the associated semiconductor device provides a significant thermal coupling between the two.

Thus, any reduction in the power dissipation of the fuse link may improve the current loading of the semiconductor device.

AA.6 — Time-current characteristics

AA.6.1 — Pre-arcing characteristic

A pulsed current, as it appears in the arms of rectifiers or invertors, cannot be dealt with solely on the basis of its r.m.s. value. In marginal cases, it is necessary to make sure that a single pulse alone cannot damage the fuse element. For instance, if a short-time overload (for example, below 0,1 s) is considered in accordance with 8.4.3.4, the peak of the actual overload is not the maximum value of the r.m.s. value, but the peak of the highest pulse.

Any current of frequency higher than rated frequency has practically no influence on the pre-arcing I^2t characteristic, except in the region mentioned above. For values of prospective current where the pre-arcing time at rated frequency is less than one quarter cycle, the tendency at higher frequencies is towards shorter pre-arcing times. For frequencies lower than rated frequency, the effect is the opposite of that mentioned above. However, attention is drawn to the fact that the increase in pre-arcing time can be even more significant, particularly towards the higher values of prospective current.

For lower values of prospective current, the only influence of an asymmetrical current (a.c. with a transient d.c. component) is to give a slight increase in the r.m.s. value of the current.

In the adiabatic zone, the influence is best considered as an increase or decrease in the rate of rise, replacing the actual current by that symmetrical current that has the same (or similar) rate of rise during the pre-arcing period.

In the critical zone, where the pre-arcing I^2t characteristic leaves the adiabatic zone, a distinction has to be made between an asymmetry beginning with a major loop and one beginning with a minor loop. The major loop will give a decrease in the pre-arcing I^2t value, the minor loop will give an increase.

When considering the ability of the fuse link to withstand an asymmetrical current, the peak of the asymmetry shall be taken into account.

~~In case of operation with d.c., the pre-arcing I^2t characteristic based on a.c. may not be applicable at all, or be only partly applicable, depending on the circuit parameters.~~

~~If the time constant of the circuit is smaller than the shortest time being considered, the prospective current is the applied voltage divided by the resistance.~~

~~If the circuit contains a significant amount of self-inductance, the adiabatic zone of the pre-arcing I^2t characteristic can be used provided the abscissa refers to rate of rise instead of prospective current, i.e. the rate of rise of d.c. is determined as the applied voltage divided by the self-inductance. It is further to be assumed that the value of the prospective current (the applied voltage divided by the resistance) is significantly higher (three times or more) than the cut-off current at the rate of rise considered.~~

~~For the remaining cases of d.c. operation, it is very difficult to draw any significant conclusions about the pre-arcing time to be expected from the normal pre-arcing I^2t characteristic based on a.c., and the manufacturer should be consulted. However, the majority of practical cases are covered by the consideration of the rate-of-rise equivalence.~~

~~The normal pre-arcing I^2t characteristic does not give much information on the behaviour in the case of a non-sinusoidal current unless it is either a case where the rate of rise is predominant (i.e. for very large currents) or where the current is of such low value that the long time involved permits the use of the r.m.s. value.~~

AA.6.2—Operating I^2t characteristic

~~For a given prospective current, the difference between the pre-arcing I^2t characteristic and the operating I^2t characteristic is the maximum value of the arcing I^2t which is possible under the conditions for which the operating I^2t is drawn. The data presented by the manufacturer are based on a low value of power factor (i.e. below 0,3) and the r.m.s. value of the applied voltage.~~

~~The worst case is reached when the instantaneous value of applied voltage is as large as possible both throughout the pre-arcing period and the arcing period. Since such a situation seldom occurs, advantage may be taken of this fact.~~

~~For the same applied voltage and the same prospective short-circuit current, a higher frequency implies a lower value of self-inductance, so the arcing time decreases and within practical limits it is inversely proportional to the frequency.~~

~~For the same applied voltage and the same prospective short-circuit current, a lower frequency implies a higher value of self-inductance, so the arcing time increases and within practical limits it is inversely proportional to the frequency.~~

~~NOTE—Because of the longer arcing time and the resulting energy released, it is not certain that fuse-links are suitable for use at a frequency below rated frequency. The manufacturer should be consulted whenever operating frequency below rated frequency is contemplated.~~

~~The influence of asymmetrical current shall be taken into account in the selection of the maximum value of the arcing time.~~

~~In all cases of d.c. (see Note in AA.1) where the pre-arcing I^2t is judged on the basis of the rate of rise (see AA.6.1), and if the cut-off current is reached at the end of the pre-arcing period, the operating I^2t is also valid provided that the voltage parameter (which is based on r.m.s. values) is so chosen that the applied d.c. voltage is less than the average a.c. voltage (90 % of the r.m.s. value). All other cases require special consideration or additional information should be obtained from the manufacturer.~~

AA.7 Breaking capacity

Within the rating, breaking capacity for non-sinusoidal a.c. is rarely critical for fuse links for the protection of semiconductor devices.

For the higher values of voltage (high-voltage fuse links), the task of breaking small values of current may be a problem, but this problem normally lies outside the range of currents which is of interest here (see 7.4).

The breaking capacity is not impaired by frequencies higher than rated frequency as long as the maximum value of rate of rise of the current for rated frequency is not exceeded. At frequencies lower than rated frequency, the energy released in the fuse link is larger than at rated frequency. Additional information should be obtained from the manufacturer, which may include a test at the lower frequency according to 8.5.5.1.

For breaking capacity on d.c. (see Note in AA.1), the energy released in the fuse link is in many cases greater than at rated frequency. Often, satisfactory operation can be ensured only by using a fuse link having an a.c. rated voltage appreciably higher than the d.c. supply voltage. Additional information should be obtained from the manufacturer.

AA.8 Commutation

Short-circuit currents in semiconductor installations normally involve circuits having several arms between which commutation can take place during the operation of the fuse link. Such commutation can be caused by the cyclic change in the voltage of the a.c. source, by the firing of thyristors or by the arc voltage of another fuse link.

The commutations influence the operation of the fuse link by altering the circuit configuration, the circuit constants and by changing the applied voltage (for example, by adding an arc voltage).

Another form of unintentional commutation which may seriously affect the duty of the fuse link is that caused by the appearance of a secondary fault.

Annex BB (normative)

Survey on information to be supplied by the manufacturer in his literature (catalogue) or on request 42 for a fuse designed for the protection of semiconductor devices

The following information ~~shall~~ should be given separately for AC and, where applicable, for DC.

- a) Name of the manufacturer (trade mark)
- b) Type or list reference of the manufacturer
- c) Rated voltage (see 4.4.1)
- d) Rated current (see 4.5)
- e) Rated frequency or frequencies (see 6.4)
- f) Rated breaking capacity (at rated voltage and at different applied voltages) (see 6.7.2 and 9.5)
- g) Pre-arcing and operating time-current characteristics (diagrams) and application class (symbol), where applicable (see 6.6.1 and 9.4.3.3.1)
- h) Pre-arcing I^2t characteristic (see 6.8.2.1 and 9.7.2)
- i) Operating I^2t characteristic in relation to the voltage with indication of the power factor or time constant (see 6.8.2.2 and 9.7.2)
- j) Arc voltage characteristic (see 6.9 and 9.7.5)
- k) Cut-off current characteristic (see 6.8.1 and 9.6)
- l) Temperature rise at rated current under conventional test conditions and indication of a defined measuring point (see 7.3 and 9.3.5)
- m) Power dissipation for at least 50 % and 100 % of the rated current, at fixed points or in the form of a diagram for that range (additional parameters may be 63 % and 80 %) (see 8.3 and 9.3.3)
- n) Required minimum operating voltage of the indicator (see 9.4.3.6)
- o) Permissible current as a function of the ambient temperature (diagram) (see 9.4.3.2)
- p) Instructions for mounting, where necessary, with respect to the dimensions (sketch)
- q) Current carrying ability under special conditions of mounting (for example, cross-sectional area of connected conductors, inadequate cooling, additional heat sources, etc.)

~~NOTE In the case of special conditions, the manufacturer should be consulted.~~

Annex CC (normative)

Examples of standardized fuse-links for the protection of semiconductor devices 43

CC.1 General

This annex is divided into seven specific examples of standardised dimensions:

- system of fuse-links with bolted connections, type A – British
- system of fuse-links with bolted connections, type B – DIN
- system of fuse-links with bolted connections, type C – North American
- system of fuse-links with flush end connections, type A
- system of fuse-links with flush end connections, type B – North American
- system of fuse-links with cylindrical contact caps, type A – North American
- system of fuse-links with cylindrical contact caps, type B – French

Fuse-links for the protection of semiconductor devices may also have the same dimensions as fuse-links according to:

- IEC 60269-2: system of fuses A, B, F and H;
- IEC 60269-3: system of fuses A.

In addition to meeting the requirements of this standard, the power dissipation of the fuse-link shall not exceed the acceptable power dissipation of the associated fuse bases or fuse-holders. Where the power dissipation of the fuse-link exceeds the acceptable power dissipation of the standardised fuse base or fuse-holder, de-rating values shall be given by the manufacturer.

CC.2 System of fuse-links with bolted connections, type A – British

CC.2.1 Scope

The following supplementary requirements apply to fuse-links having bolted connections, whose dimensions comply with the requirements given in Figure CC.1 to Figure CC.3. Their rated voltages and currents are as follows:

- 230 V AC up to 900 A;
- 690 V AC up to 710 A.

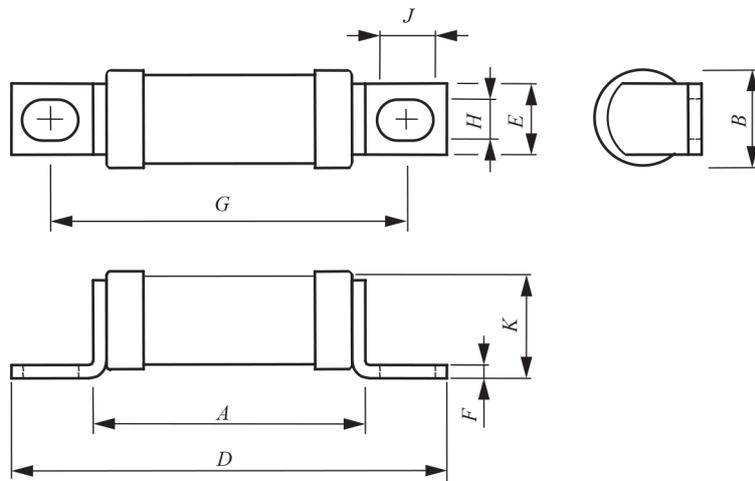
CC.2.2 Mechanical design (see 8.1 of IEC 60269-1:2024)

The standardized dimensions of the fuse-links are given in Figure CC.1 to Figure CC.3.

CC.2.3 Construction of a fuse-link

For indication of operation, a striker fuse-link may be used. The standardised dimensions of the striker fuse-links are given in Figure CC.4.

Dimensions in millimetres

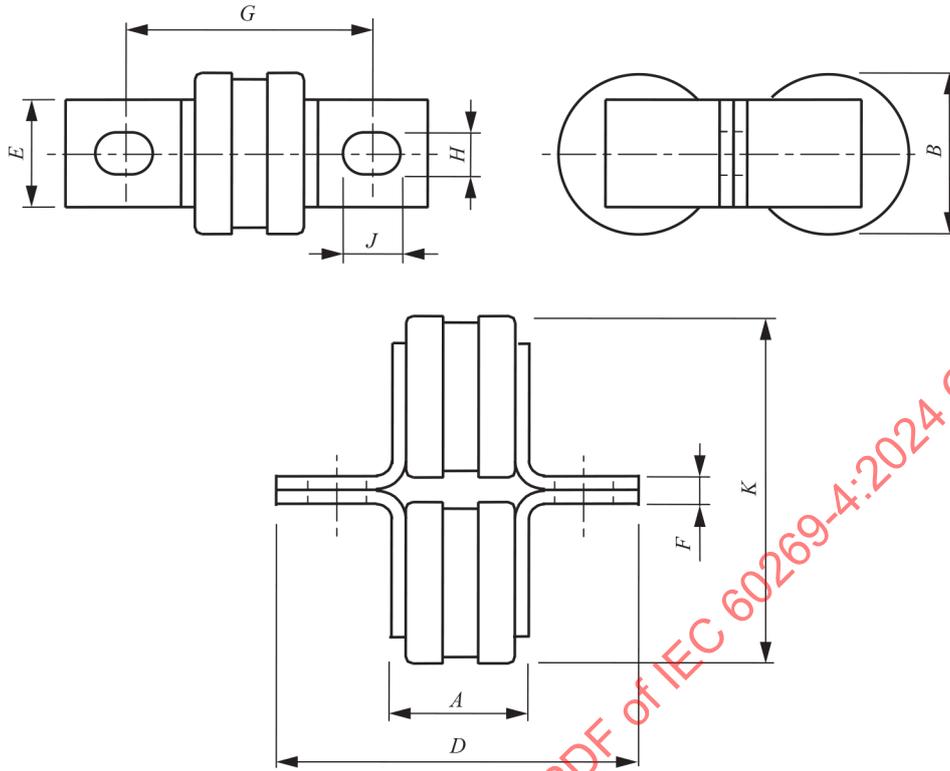
**Key**

Typical voltage rating V AC	Preferred maximum current rating A	<i>A</i> max.	<i>B</i> max.	<i>D</i> max.	<i>E</i> nom.	<i>F</i> max.	<i>G</i> nom.	<i>H</i> nom.	<i>J</i> min.	<i>K</i> max.
230	20	29	8,7	47,6	6,4	0,9	38	4	4,8	8,8
690	20	55	8,7	75	6,4	0,9	64,5	4	4,8	8,8
230	180	29,2	17,7	58,4	12,7	2,5	42	6,4	7,9	19,3
690	100	50,6	17,7	79,8	12,7	2,5	63,5	6,4	7,9	19,3
230	450	32,6	38,2	85	25,4	3,3	59	10,3	13	41,5
690	355	60	38,2	114	25,4	3,3	85	10,3	13	41,5

NOTE For DC and VSI voltage ratings consult the manufacturer.

Figure CC.1 – Single body fuse-links

Dimensions in millimetres



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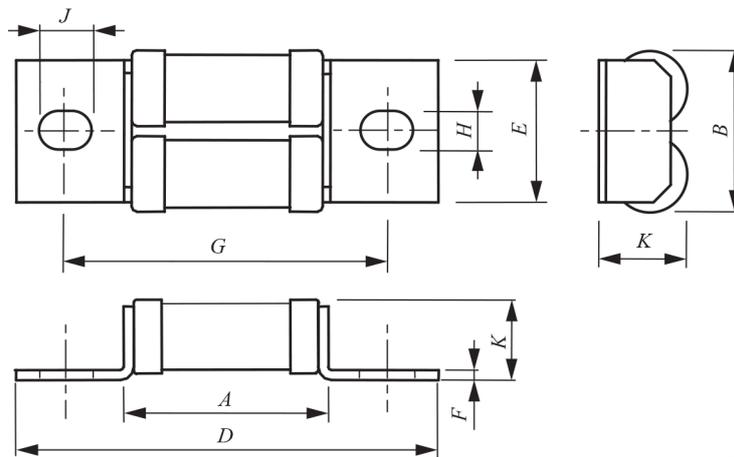
Key

Typical voltage rating	Preferred maximum current rating	A	B	D	E	F	G	H	J	K
V AC	A	max.	max.	max.	nom.	nom.	nom.	nom.	min.	max.
230	900	32,6	38,2	85	25,4	6,4	59	10,3	13	83
690	710	60	38,2	114	25,4	6,4	85	10,3	13	83

NOTE For DC and VSI voltage ratings consult the manufacturer.

Figure CC.2 – Double body fuse-links

Dimensions in millimetres

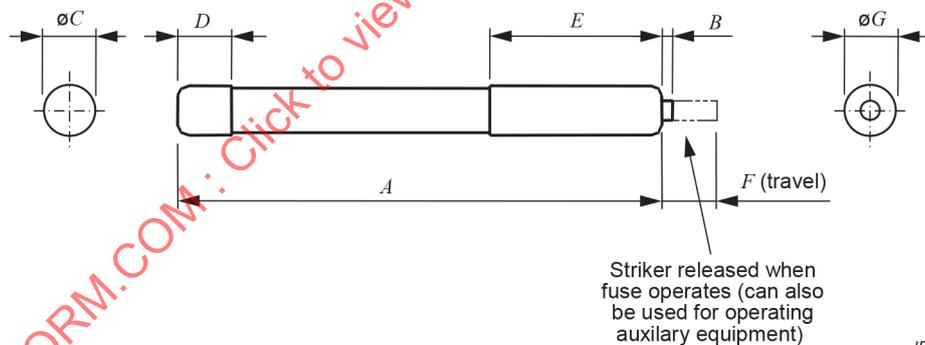
**Key**

Typical voltage rating V AC	Preferred maximum current rating A	A	B	D	E	F	G	H	J	K
690	200	max.	max.	max.	nom.	max.	nom.	nom.	min.	max.
		50,6	37	95	32	1,6	70	8,7	10,3	19,9

NOTE For DC and VSI voltage ratings consult the manufacturer.

Figure CC.3 – Twin body fuse-links

Dimensions in millimetres

**Key**

Typical voltage rating V AC	A	B	øC	D	E	F	øG
230	max.	nom.	nom.	max.	nom.	nom.	max.
690	48	0,8	6,4	5,6	19	5,6	7,9
	62	0,8	6,4	5,6	19	5,6	7,9

NOTE For DC and VSI voltage ratings consult the manufacturer.

Figure CC.4 – Striker fuse-links

CC.3 System of fuse-links with bolted connections, type B – DIN

CC.3.1 Scope

The following supplementary requirements apply to fuse-links having bolted connections, whose dimensions comply with the requirements given in Figure CC.5 and Figure CC.6. They have rated currents up to 1 250 A and rated voltages up to 1 250 V AC.

CC.3.2 ~~Conventional times and currents for “gR” and “gS” fuse-links (see Table CC.1)~~

Table CC.1 – Conventional time and current for “gR” and “gS” fuse-links

Rated current A	Conventional time h	Conventional current			
		Type “gR”		Type “gS”	
		I_{nf}	I_f	I_{nf}	I_f
$I_n \leq 4$	1	$1,1 I_n$	$2,1 I_n$	$1,5 I_n$	$2,1 I_n$
$4 < I_n \leq 16$	1	$1,1 I_n$	$1,9 I_n$	$1,5 I_n$	$1,9 I_n$
$16 \leq I_n \leq 63$	1				
$63 < I_n \leq 160$	2				
$160 < I_n \leq 400$	3	$1,1 I_n$	$1,6 I_n$	$1,25 I_n$	$1,6 I_n$
$400 < I_n$	4				

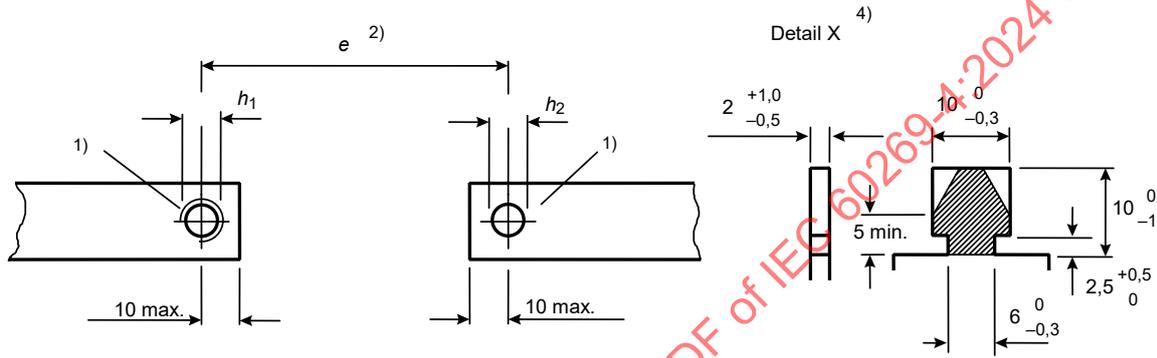
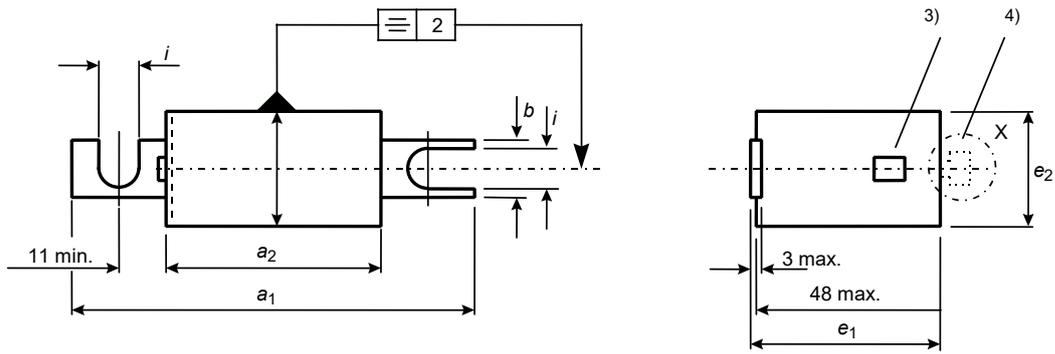
CC.3.2 Mechanical design (see 8.1 of IEC 60269-1:2024)

The standardized dimensions of the fuse-links are given in Figure CC.5 and Figure CC.6.

Fuse-links with other fixing dimensions, for example elongated holes, longitudinal or cross-slots, shall be agreed between manufacturer and user.

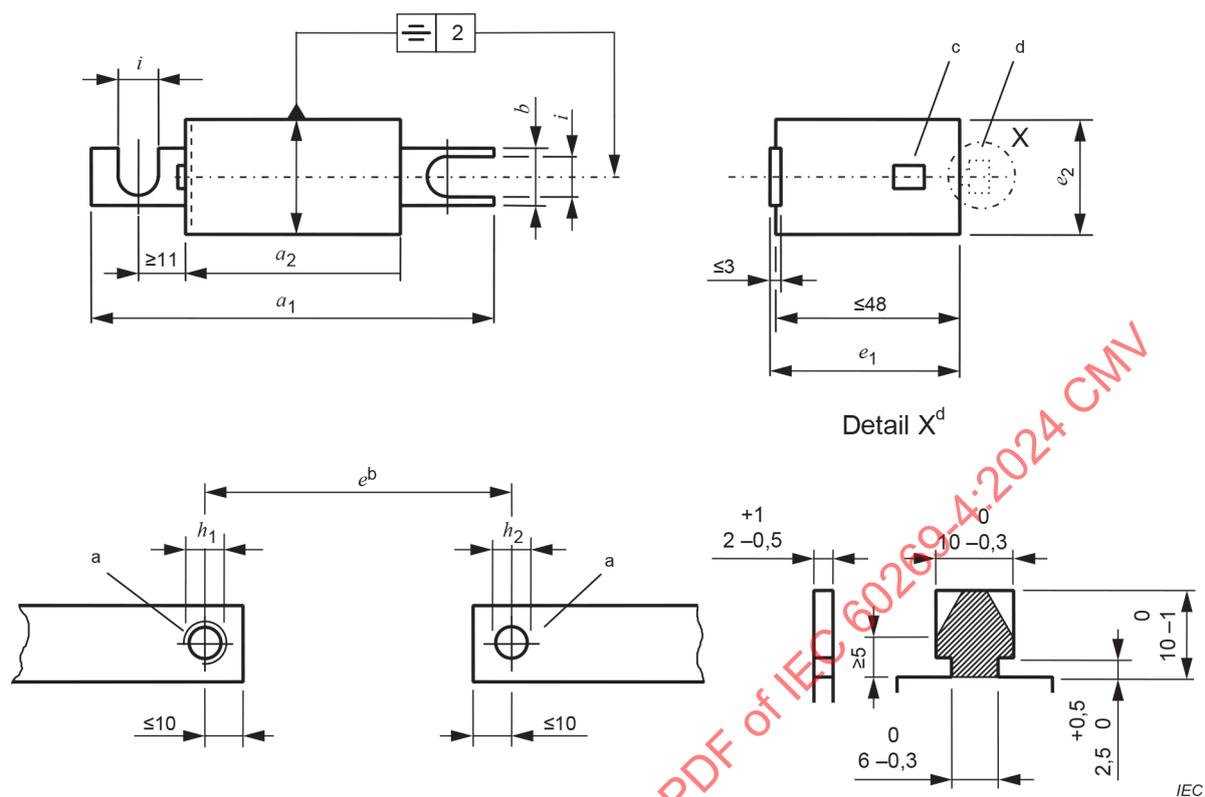
CC.3.3 Construction of a fuse-link

If the fuse-link is provided with an indicator or striker, then its position has to be agreed between the manufacturer and user.



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Dimensions in millimetres



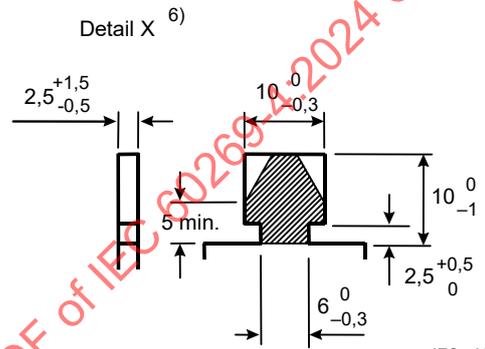
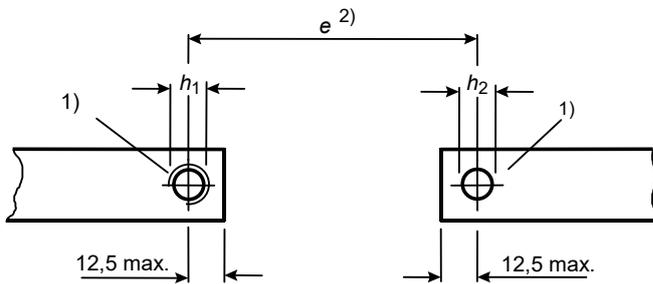
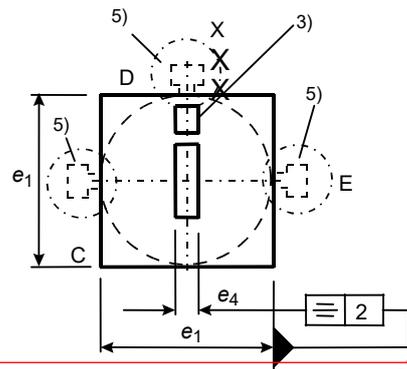
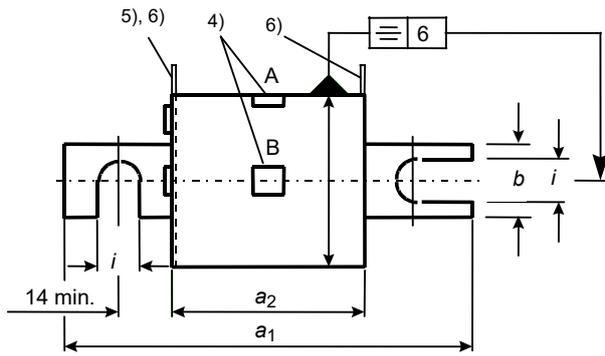
Key

Body size	e ± 2	$a1$ max.	$a2$ max.	b min.	$e1$ max.	$e2$ max.	$h1$	$h2$ $+0,3$ 0	i 0 $-0,5$
000	80	105	56	20	51	21	M8	9	9
00	80	105	56	20	51	30	M10	11	11
	110	140	86						

- a Thread or corresponding through-hole for flat terminations
- b Distance of terminals
- c Indicator or striker (if required)
- d Lug for signalling device (if required)

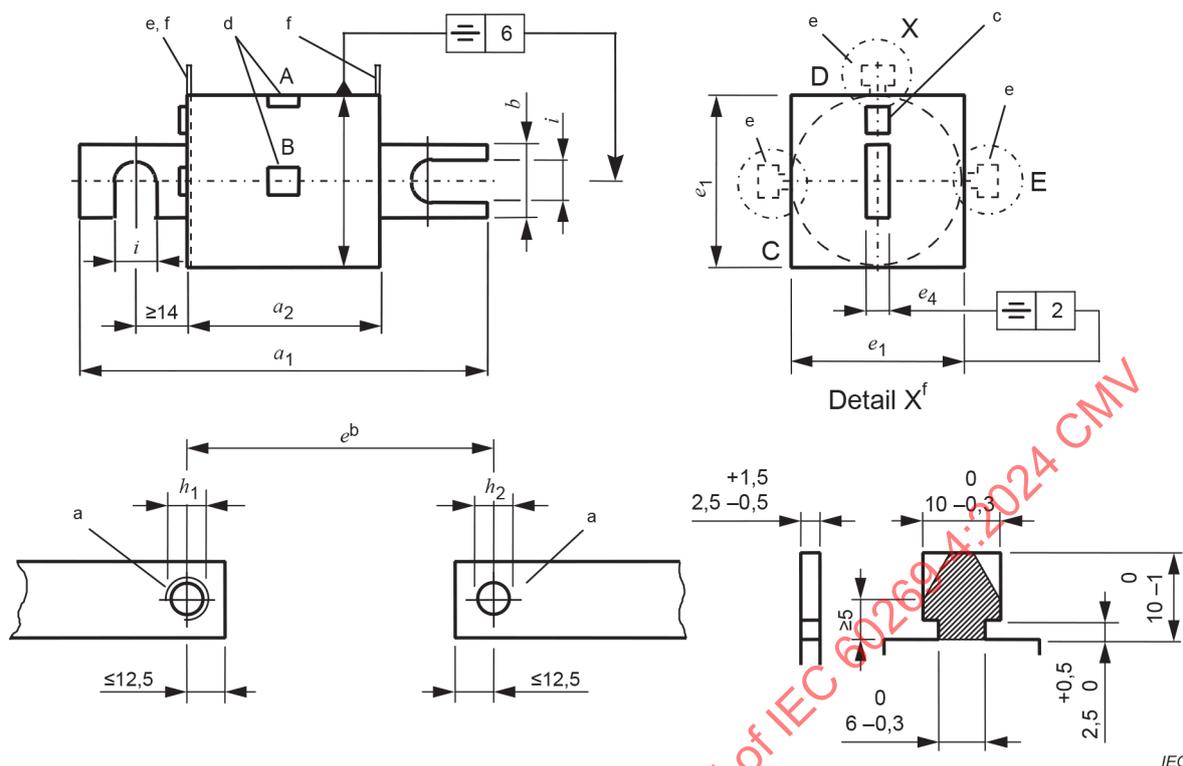
Figure CC.5 – Fuse-links with bolted connections, type B, body sizes 000 and 00

Dimensions in millimetres



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Key

Body size	e ± 2	a_1 max.	a_2 max.	b min.	e_1 max.	e_4 max.	h_1	h_2 $+0,3$ 0	i 0 $-0,5$
0	80 110	110 150	50 80	19	45	6,5	M10	11	11
1	80 110	110 150	50 80	24	53	6,5	M10	11	11
2	80 110	110 150	50 80	24	61	6,5	M10	11	11
3	80 110 170 210	110 150 210 250	50 80 140 180	29	76	6,5	M12 7)	13	13 8)

- 1) Thread or corresponding through-hole for flat terminations
- 2) Distance of terminals
- 3) Indicator or striker (if required)
- 4) Indicator or striker, position A or B (if required)
- 5) Alternative positions C, D and E for lug for signalling device (if required)
- 6) Gripping lugs, dimensions according to Figure 101 of IEC 60269-2: 2013/AMD2:2024 (if required)
- 7) M10 also possible
- 8) 11 also possible for M10

Figure CC.6 – Fuse-links with bolted connections, type B, body sizes 0, 1, 2 and 3

CC.4 System of fuse-links with bolted connections, type C – North American

CC.4.1 Scope

The following supplementary requirements apply to fuse-links having bolted connections, whose dimensions comply with the requirements given in Figure CC.7. Their AC rated voltages (see CC.4.3) and currents are as follows:

- 130/150 V AC up to 1 000 A;
- 250/300 V AC up to 800 A;
- 500 V AC up to 1 200 A;
- 700 V AC up to 600 A;
- 1 000 V AC up to 800 A.

For DC voltage ratings, see CC.4.4.

CC.4.2 Mechanical design (see 8.1 of IEC 60269-1:2024)

The standardized dimensions of the fuse-links are given in Figure CC.7.

CC.4.3 Table 104

The power-frequency recovery voltage shall be:

$$U_{\text{Test}} = 100 \begin{matrix} +5 \\ -0 \end{matrix} \% \text{ of the rated voltage.}$$

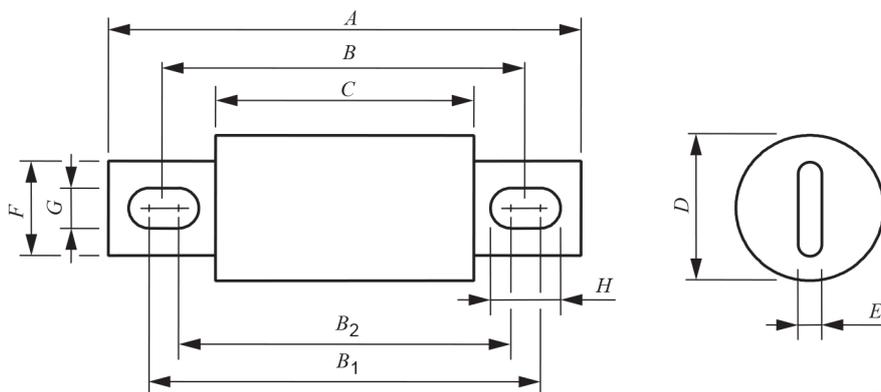
CC.4.4 Table 105

The mean value of the recovery voltage shall be:

$$100 \begin{matrix} +5 \\ -9 \end{matrix} \% \text{ of the rated voltage.}$$

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Dimensions in millimetres



Key

Typical voltage rating V AC.	Preferred current rating A	<i>A</i>	<i>B</i>	<i>B</i> ₁	<i>B</i> ₂	<i>C</i>	<i>D</i>	<i>E</i>	<i>F</i>	<i>G</i>	<i>H</i>
		max.	nom.	max.	min.	max.	max.	max.	min.	max.	max.
150	50 to 450	69,1	52,4	57,5	45	31	29,1	5,2	22,6	8,3	20,9
	500 to 1 000	90,6	62,0	67	47,5	33,4	40,9	6,8	25,8	10,7	30,2
250/300	35 to 60	82,6	61,9	67,5	55,5	42,9	21	3,6	19,5	9,1	21,1
	65 to 200	81,1	60,3	64	54	42,9	31,8	5,2	25,8	9,1	19,1
	225 to 800	99,2	70,6	79	55,5	42,1	51,2	6,8	25,4	12,3	25,6
500	35 to 60	92,6	62,7	75	54	54,1	25,4	3,6	19,5	9,1	30,1
	65 to 100	93,5	73,0	79	66,5	55,6	25,8	3,7	19,5	9,3	21,8
	110 to 200	93,8	73,0	76,5	66,5	55,7	31,4	5,2	25,8	9,1	19,1
	225 to 400	111,9	83,3	89	68	54,8	38,5	6,8	25,8	11,4	32,4
	450 to 600	115,6	86,5	91,5	69	58	51,2	6,8	38,5	12,3	33,8
	700 to 800	166	110,0	128	85,5	58	63,9	10,1	51,2	15,9	58,4
	900 to 1 200	178,6	127,0	140	110	84,2	77,4	11,5	60,7	17,9	47,9
700	35 to 60	112,6	92,1	100	72	74,6	25,8	5,2	19	10,7	38,7
	65 to 100	113,6	92,1	95,5	72	74,6	31,4	5,2	19	10,7	34,2
	110 to 200	131	102,4	108	72	73,8	38,5	6,8	25,8	12,3	48,3
	225 to 400	131	102,4	111	73	73,8	51,2	6,8	38,5	14,7	52,7
	450 to 600	181,6	129,4	147	81	73,9	63,9	10,1	38,5	16,3	82,3
1 000	35 to 60	128,6	108,0	111	98	90,5	25,8	5,2	19,5	8,3	21,3
	65 to 100	128,6	108,0	111	104	90,5	31,4	5,2	25,8	9,3	16,3
	110 to 200	146,9	118,4	123	104	89,7	39,3	6,8	25,8	11,7	29,7
	225 to 400	148,1	118,4	124	104	90,5	51,2	6,8	38,5	11,4	31,4
	450 to 800	197,7	150,8	154	117	101,6	89,8	10,1	51,2	16,3	53,3

NOTE For DC and VSI voltage ratings consult the manufacturer.

Figure CC.7 – Bolted fuse-links, type C

CC.5 System of fuse-links with flush end connections type A

CC.5.1 Scope

The following supplementary requirements apply to fuse-links having flush end connections whose dimensions comply with the requirements given in Figure CC.8. They have rated currents up to 5 000 A and rated voltages up to 1 250 V AC.

CC.5.2 ~~Conventional times and currents for "gR" and "gS" fuse-links (see Table CC.2)~~

Table CC.2 – Conventional time and current for "gR" and "gS" fuse-links

Rated current A	Conventional time h	Conventional current			
		Type "gR"		Type "gS"	
		I_{nf}	I_f	I_{nf}	I_f
$I_n \leq 4$	1	$1,1 I_n$	$2,1 I_n$	$1,5 I_n$	$2,1 I_n$
$4 < I_n \leq 16$	1	$1,1 I_n$	$1,9 I_n$	$1,5 I_n$	$1,9 I_n$
$16 \leq I_n \leq 63$	1				
$63 < I_n \leq 160$	2	$1,1 I_n$	$1,9 I_n$	$1,25 I_n$	$1,6 I_n$
$160 < I_n \leq 400$	3				
$400 < I_n$	4				

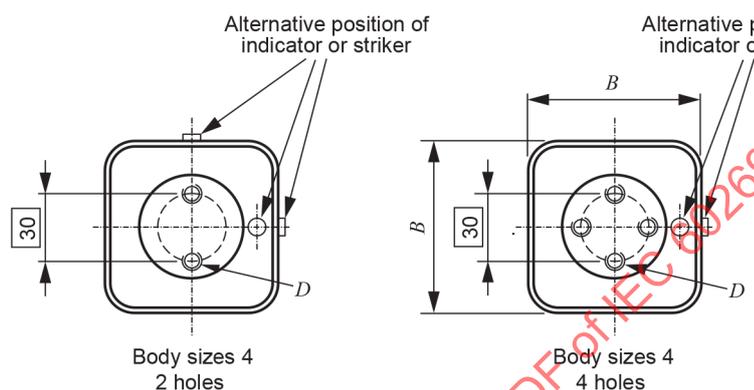
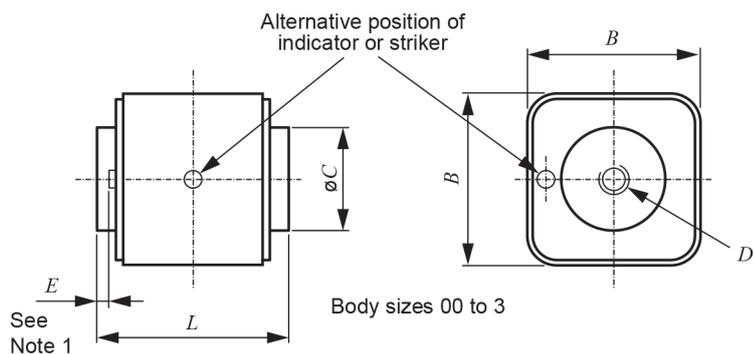
CC.5.2 Mechanical design (see 8.1 of IEC 60269-1:2024)

The standardized dimensions of the fuse-links are given in Figure CC.8.

CC.5.3 Construction of a fuse-link

The fuse-links may have indicators or strikers, and if they are fitted, the standardised positions are shown in Figure CC.8.

Dimensions in millimetres



IEC

Key

Body size	Typical voltage rating V AC	Preferred maximum current rating A	L max.	B max.	C min.	D		E
						Thread	Minimum depth	
00	690	400	65	30×48	15	M8	5	0,2
01	690	630	53	45	17	M8	5	0,2
01	1 000	500	77	45	17	M8	5	0,2
01	1 250	400	82	45	17	M8	5	0,2
1	690	1 000	53	53	19	M8	8	0,3
1	1 000	800	77	53	19	M8	8	0,3
1	1 250	630	82	53	19	M8	8	0,3
2	690	1 600	53	61	23	M10	9	0,4
2	1 000	1 250	77	61	23	M10	9	0,4
2	1 250	1000	82	61	23	M10	9	0,4
3	690	2 500	53	76	28	M12	9	0,5
3	1 000	2 000	93	76	28	M12	9	0,5
3	1 250	1 600	99	76	28	M12	9	0,5
4 hole								
4	690	5 000	67	120	50	M10	9	2,0
4	1 000	4 000	89	120	50	M10	9	2,0
4	1 250	3 150	110	120	50	M10	9	2,0
2 hole								
4	690	5 000	94	120	50	M12	10	2,0
4	1 000	4 000	100	120	50	M12	10	2,0
4	1 250	3 150	120	120	50	M12	10	2,0

NOTE 1 Minimum distance between mounting face and other fuse features.

NOTE 2 Alternative shapes of the end contact are permitted provided the surface area is not less than those shown.

NOTE 3 For DC and VSI voltage ratings consult the manufacturer.

Figure CC.8 – Flush end fuse-links, type A

CC.6 System of fuse-links with flush end connections, type B – North American

CC.6.1 Scope

The following supplementary requirements apply to fuse-links having flush end connections, whose dimensions comply with the requirements given in Figure CC.9. Their AC rated voltages (see CC.6.3) and currents are as follows:

- 130/150 V or 150 V AC up to 6 000 A;
- 250/300 V AC up to 4 500 A;
- 600 V AC up to 2 000 A.

For DC voltage ratings see CC.6.4.

CC.6.2 Mechanical design (see 8.1 of IEC 60269-1:2024)

The standardized dimensions of the fuse-links are given in Figure CC.9.

CC.6.3 Table 104

The power-frequency recovery voltage shall be:

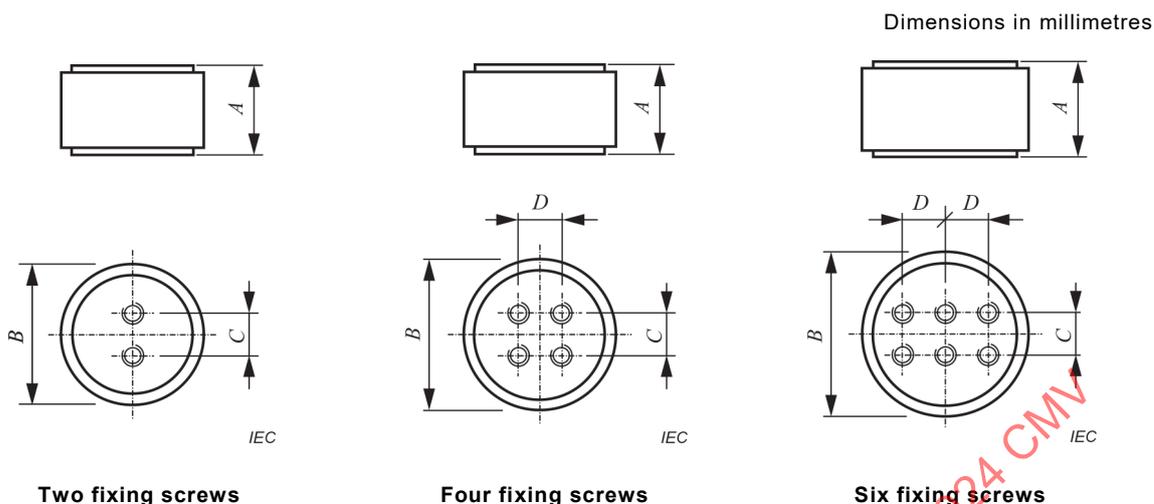
$$U_{\text{Test}} = 100 \begin{matrix} +5 \\ -0 \end{matrix} \% \text{ of the rated voltage.}$$

CC.6.4 Table 105

The mean value of the recovery voltage shall be:

$$100 \begin{matrix} +5 \\ -9 \end{matrix} \% \text{ of the rated voltage.}$$

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Key

Typical voltage rating V AC	Preferred current rating A	A max.	B max.	C max.	D max.	Thread inches ^a	Fixing screws
130/150	1 000 to 2 000	49,2	51,2	25,8		3/8"-24 × 1/2"	2
	2 500 to 3 000	49,2	76,6	38,5		1/2"-20 × 1/2"	2
	3 500 to 4 000	49,2	89,5	38,5	38,5	1/2"-20 × 1/2"	4
	5 000 to 6 000	61,9	146,5	38,5	38,5	1/2"-20 × 1/2"	6
250/300	800 to 1 200	67,4	76,6	38,5		3/8"-24 × 1/2"	2
	1 500 to 2 500	67,4	89,5	38,5	38,5	3/8"-24 × 1/2"	4
	3 000 to 4 500	67,4	114,7	38,5	38,5	1/2"-20 × 1/2"	4
600	700 to 800	103,2	76,6	38,5		3/8"-24 × 1/2"	2
	1 000 to 1 200	103,2	89,5	38,5	38,5	3/8"-24 × 1/2"	4
	1 500 to 2 000	103,2	114,7	38,5	38,5	1/2"-20 × 1/2"	4

^a Diameter – threads per inch × depth.

NOTE For DC. and VSI voltage ratings consult the manufacturer.

Figure CC.9 – Flush end fuse-links, type B

CC.7 System of fuse-links having cylindrical contact caps, type A – North American

CC.7.1 Scope

The following supplementary requirements apply to fuse-links having cylindrical contact caps whose dimensions comply with the requirements given in Figure CC.10. Their AC. rated voltages (see CC.7.3) and currents are as follows:

- 150 V AC ~~up~~ 35A to 60A;
- 600 V AC ~~up~~ 1 to 30 A;
- 1 000 V AC ~~up~~ 1 to 30 A.

For DC voltage ratings see CC.7.4.

CC.7.2 Mechanical design (see 8.1 of IEC 60269-1:2024)

The standardized dimensions of the fuse-links are given in Figure CC.10.

~~NOTE Dimensions of fuse-links having cylindrical contact caps are also standardized in IEC 60269-2, System of fuses F:~~

~~sizes — 10 × 38;
14 × 51;
22 × 58.~~

CC.7.3 Table 104

The power-frequency recovery voltage shall be:

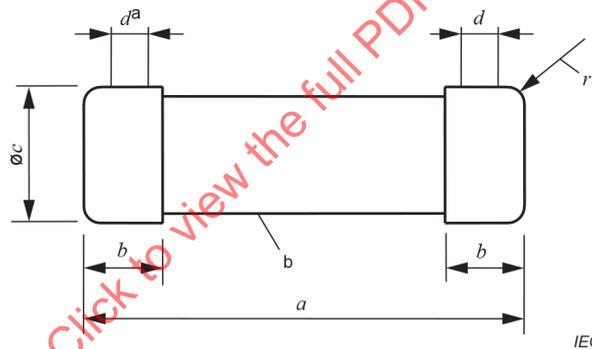
$$U_{\text{Test}} = 100 \begin{matrix} +5 \\ -0 \end{matrix} \% \text{ of the rated voltage.}$$

CC.7.4 Table 105

The mean value of the recovery voltage shall be:

$$U_{\text{Test}} = 100 \begin{matrix} +5 \\ -0 \end{matrix} \% \text{ of the rated voltage.}$$

Dimensions in millimetres



IEC

Key

Typical voltage rating V AC	Preferred maximum current rating A	<i>a</i>	<i>b</i> max.	<i>c</i>	<i>d</i> min.	<i>r</i>
150	35-60	$51 \begin{matrix} +0,6 \\ -1 \end{matrix}$	15,9	$20,6 \pm 0,2$	6	2 ± 1
600	1-30	$127 \begin{matrix} +0,6 \\ -3 \end{matrix} \pm 2$	16,2	$20,6 \pm 0,2$	11	2 ± 1
1 000	1-30	$66,7 \begin{matrix} +0,6 \\ -2 \end{matrix}$	16,2	$14,5 \pm 0,2$	11	2 ± 1

NOTE For DC, and VSI voltage ratings consult the manufacturer.

^a Cylindrical part within which the specified tolerances shall not be exceeded.

^b The diameter of the cartridge between the end caps shall not exceed diameter *c*.

Figure CC.10 – Fuse-links with cylindrical contact caps, type A

CC.8 System of fuse-links having cylindrical contact caps, type B – French

CC.8.1 Scope

The supplementary requirements apply to fuse-links having cylindrical contact caps whose dimensions comply with the requirements given in Figure CC.11 and Figure CC.12. The preferred rated voltages and corresponding rated currents are as follows (see Table CC.1):

Table CC.1 – Typical rated voltages and preferred maximum rated currents

Typical voltage rating V AC.	Preferred maximum current rating A	Size
600	63	14 × 51
600	125	22 × 58
690	32	10 × 38
690	50	14 × 51
690	100	22 × 58
690	250	27 × 60
800	100	27 × 60
1 500	63	20 × 127
1 500	63	22 × 127
1 500	100	36 × 127
2 500	25	20 × 127
3 000	63	20 × 190
3 000	100	36 × 190

NOTE For DC and VSI voltage ratings consult the manufacturer.

CC.8.2 Conventional times and currents for “gR” and “gS” fuse-links (see Table CC.4)

Table CC.4 – Conventional time and current for “gR” and “gS” fuse-links

Rated current A	Conventional time h	Conventional current			
		Type “gR”		Type “gS”	
		I_{nf}	I_f	I_{nf}	I_f
$I_n \leq 4$	1	$1,1 I_n$	$2,1 I_n$	$1,5 I_n$	$2,1 I_n$
$4 < I_n \leq 16$	1	$1,1 I_n$	$1,9 I_n$	$1,5 I_n$	$1,9 I_n$
$16 \leq I_n \leq 63$	4				
$63 < I_n \leq 160$	2	$1,1 I_n$	$1,6 I_n$	$1,25 I_n$	$1,6 I_n$
$160 < I_n \leq 400$	3				
$400 < I_n$	4				

CC.8.2 Mechanical design (see 8.1 of IEC 60269-1:2024)

The standardized dimensions of the fuse-links are given in Figure CC.11 and Figure CC.12.

~~NOTE – Dimensions of fuse-links having cylindrical caps are also standardized in~~

~~– IEC 60269-2, System of fuses F;~~

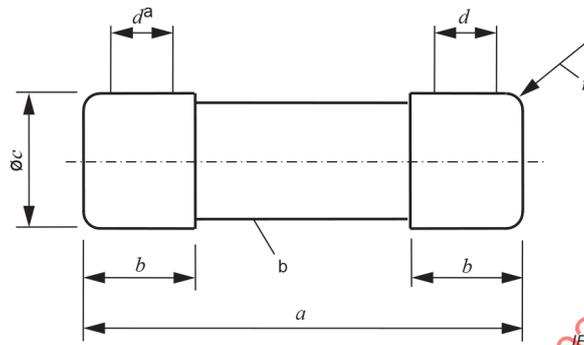
~~– sizes 10 × 38;~~

~~– 14 × 51;~~

~~– 22 × 58;~~

~~– IEC 60269-2, System of fuses H.~~

Dimensions in millimetres



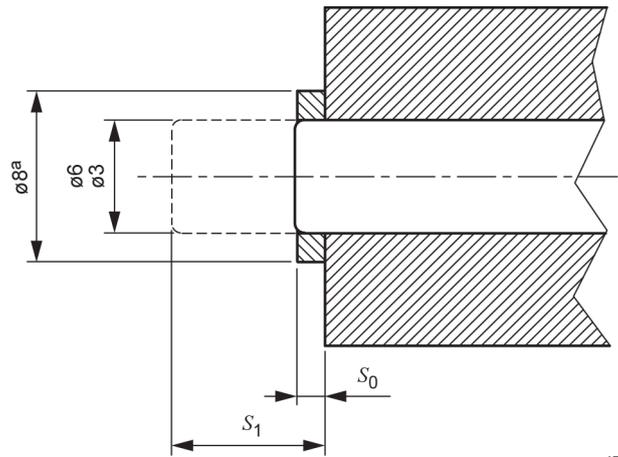
The drawings are not intended to govern the design of fuse-links except as regards the notes and dimensions shown.

Size	a	b max.	c	d min.	r
10 × 38	38 ^{+0,9} _{-0,6}	10,5	10,3 ± 0,1	6	1,5 ± 0,5
14 × 51	51 ^{+0,6} ₋₁	13,8	14,3 ± 0,1	7,5	2 ± 1
22 × 58	58 ^{+0,1} ₋₂	16,2	22,2 ± 0,1	11	2 ± 1
27 × 60	60,3 ± 0,8	16,3	27 ± 0,2	14	1,7 ± 1
20 × 127	127 ± 1	16,2	20,6 ± 0,2	10,8	2 ± 1
20 × 190	188 ± 2 ³⁾	16,2	20,6 ± 0,2	10,8	2 ± 1
22 × 127	127 ± 2 ³⁾	16,2	22,2 ± 0,1	11	2 ± 1
36 × 127	127 ± 1	27	36,3 ± 1	24,7	2 ± 1
36 × 190	188 ± 2 ³⁾	27	36,3 ± 1	24,7	2 ± 1

- a Cylindrical part within which the specified tolerances shall not be exceeded.
 b The diameter of the cartridge between the end caps shall not exceed diameter c.
 c For striker versions, the tolerance is ± 1.

Figure CC.11 – Fuse-links with cylindrical contact caps, type B

Dimensions in millimetres



Key

S_0 1 mm maximum

S_1 7 mm to 10 mm

^a Diameter of cylinder in which the striker must stay

NOTE The overall length a (see Figure CC.11) does not include S_0

The drawing is not intended to govern the design of fuse-links except as regards the notes and dimensions shown.

**Figure CC.12 – Fuse-links with cylindrical contact caps with striker, type B
(additional dimensions for all sizes except 10 × 38)**

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Bibliography

IEC 60050-521, *International Electrotechnical Vocabulary (IEV) – Part 521: Semiconductor devices and integrated circuits*

IEC 60050-551, *International Electrotechnical Vocabulary (IEV) – Part 551: Power electronics*

~~IEC /TR 60269-5, *Low-voltage fuses – Guidance for the application of low-voltage fuses*~~

IEC 60269-6:2010, *Low-voltage fuses – Part 6: Supplementary requirements for fuse-links for the protection of solar photovoltaic energy systems*

IEC 60269-6:2010/AMD1:2021

IEC 60269-7:2021, *Low-voltage fuses – Part 7: Supplementary requirements for fuse-links for the protection of batteries and battery systems*

IEC 60664-1:2020, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

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List of comments

- 1 This is the first of many changes requested by the HAS consultants to ensure CENELEC compliance, when they reviewed the committee draft for vote (CDV).
If other changes are not otherwise commented then the changes were also the result of the HAS review.
The largest changes required are to the introduction and the scope.
These changes should not have changed the “spirit” of the wording.
- 2 There was debate around this change. The standards for fuses above 1 000 V AC and 1 500 V DC are all based around distribution systems (or traction systems). This wording is likely to be changed when an additional standard for the higher voltages is published, a joint working group is close to finishing this new standard.
- 3 These notes are considered to be covered elsewhere in the standard or are not required.
- 4 Changes are to align the details to specific editions or they are not referred to later in the standard.
- 5 The date is added for clarity.
- 6 This paragraph is added for clarity.
- 7 Deleted as the committee could not see the value of the notes, or indeed, know what the meaning was.
- 8 The statement is not totally clear and is deemed to confuse the users (and manufacturers) and as an application comment it should be in IEC 60269-5.
- 9 Subclause 3.10 is removed as this is an application comment.
- 10 l) is added to ensure a user will use an appropriate fuse-base or fuse-holder.
This is not totally clear regarding fixing of the fuse-link to a busbar, but as the tests are mostly performed on busbars then one could assume that mounting to busbars is appropriate for fuse-links to this standard. The wording will be improved during the next maintenance.
- 11 This is added for clarification.
- 12 Deleted as the range 50 % to 100 % covers the range.
- 13 Added as details are now in the table.
- 14 Table 101 is added here to remove the need for the table to be included in each fuse system described in the annexes. Consequently, the tables in the annexes are now removed.
- 15 The testing and production of the overload curves is removed completely. To produce this curve takes considerable test effort and the committee did not believe the curve added value to the information for users. The test points could be selected to be a boundary condition or could be chosen to simply produce a curve which would then have no value. Overload capabilities are given in producers documentation.
- 16 Words added to be none specific as performance between manufacturers can vary.
- 17 “recommended” needed strengthening and it should be noted that the minimum breaking capacity for DC in this standard has been increased.
- 18 This is clarification and is more specific to define a minimum current for the VSI test.
- 19 The comments on pre-arcing characteristics are to clarify the characteristics a manufacturer should provide if requested.
- 20 This points the user to where to find a method for calculation of $I2t$ at lower voltages.
- 21 This is new to this edition in that previously the manner to mark VSI fuse-links was not specifically defined.
- 22 This is added for clarification.

- 23 This is added for clarification.
 - 24 This is less wordy and is specific.
 - 25 This change is to clarify the wording.
 - 26 This is an application problem and is been deleted form the standard as inappropriate.
 - 27 The overload test is deleted, hence removed from the table.
 - 28 Wording is changed for clarification.
 - 29 Where possible the use of AC or DC for testing is included to give more flexibility for manufacturers and test authorities.
 - 30 Wording is changed for clarification.
 - 31 A pass/fail condition is now defined.
 - 32 Until this edition the conventional times were not defined for aR fuse-links. They were assumed by manufacturers and test authorities to be the same as for gR but they are now defined.
 - 33 As with the overload curve the test for overload is removed from the standard. This was a generalised test introduced in earlier standards but has little relevance to applications. The test takes considerable time and the committee concluded that it could be removed without detriment to products.
 - 34 The voltages in IEC 60269-4 will be differently defined to those in other parts. This is in part as the tolerances on the test voltages (see later tables) are also differing.
 - 35 This is added for clarification.
 - 36 The testing voltages are standardised so tolerances are common, rather than differing for 690 V specifically.
 - 37 The testing voltage tolerances are adjusted.
 - 38 The test voltages are clarified, as VSI test could be performed with batteries or capacitors the tolerance based on ripple of rectified.
 - 39 Historically the acceptability of results was differing across the standards. Unless specific parts require differing acceptabilities, it is better placed in IEC 60269-1.
 - 40 For some time the former term discrimination has been referred to as selectivity.
 - 41 Guidance was added as informative many years ago, since IEC 60269-5 was developed this annex is superfluous. IEC 60269-5 has a more extensive section on application of fuse-links for the protection of semiconductor devices.
 - 42 This change means the manufacturer does not have to formally publish the information but must have it available if a user requests it.
 - 43 Note the tables for conventional times and currents are deleted from all the systems where they were present.
-

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Low-voltage fuses –
Part 4: Supplementary requirements for fuse-links for the protection of
semiconductor devices**

**Fusibles basse tension –
Partie 4: Exigences supplémentaires concernant les éléments de remplacement
utilisés pour la protection des dispositifs à semiconducteurs**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

LOW-VOLTAGE FUSES –

**Part 4: Supplementary requirements for fuse-links
for the protection of semiconductor devices**

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IEC 60269-4 has been prepared by subcommittee 32B: Low-voltage fuses, of IEC technical committee 32: Fuses. It is an International Standard.

This sixth edition cancels and replaces the fifth edition published in 2009, Amendment 1:2012 and Amendment 2:2016. This edition constitutes a technical revision.

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

- a) the introduction of voltage source inverter fuse-links, including test requirements.
- b) coverage of the tests on operating characteristics for AC. by the breaking capacity tests.
- c) the updating of examples of standardised fuse-links for the protection of semiconductor devices.

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

Draft	Report on voting
32B/746/FDIS	32B/753/RVD

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

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

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

This part is to be used in conjunction with IEC 60269-1:2024, *Low-voltage fuses – Part 1: General requirements*.

This Part 4 supplements or modifies the corresponding clauses or subclauses of Part 1.

Where no change is necessary, this Part 4 indicates that the relevant clause or subclause applies.

Tables and figures which are additional to those in Part 1 are numbered starting from 101.

Additional annexes are lettered AA, BB, etc.

A list of all parts of the IEC 60269 series, under the general title: *Low-voltage fuses*, can be found on the IEC website.

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

- reconfirmed,
- withdrawn, or
- revised.

LOW-VOLTAGE FUSES –

Part 4: Supplementary requirements for fuse-links for the protection of semiconductor devices

1 Scope

IEC 60269-1 applies with the following supplementary requirements.

Fuse-links for the protection of semiconductor devices shall comply with all requirements of IEC 60269-1, if not otherwise indicated hereinafter, and shall also comply with the supplementary requirements laid down below.

These supplementary requirements apply to fuse-links for application in equipment containing semiconductor devices for circuits of nominal voltages up to 1 000 V AC or 1 500 V DC. For some fuse-links higher rated voltages can be used.

NOTE Such fuse-links are commonly referred to as "semiconductor fuse-links".

The object of these supplementary requirements is to establish the characteristics of semiconductor fuse-links in such a way that they can be replaced by other fuse-links having the same characteristics, provided that their dimensions are identical. For this purpose, this standard refers in particular to

- a) the following characteristics of fuses:
 - 1) their rated values
 - 2) their temperature rises in normal service
 - 3) their power dissipation
 - 4) their time-current characteristics
 - 5) their breaking capacity
 - 6) their cut-off current characteristics and their I^2t characteristics
 - 7) their arc voltage characteristics
- b) type tests for verification of the characteristics of fuses
- c) the markings on fuses
- d) availability and presentation of technical data (see Annex BB).

2 Normative references

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

IEC 60269-1:2024, *Low-voltage fuses – Part 1: General requirements*

IEC 60269-2:2013, *Low-voltage fuses – Part 2: Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application) – Examples of standardized systems of fuses A to K*

IEC 60269-2:2013/AMD1:2016

IEC 60269-2:2013/AMD2:2024

IEC TR 60269-5:2014, *Low-voltage fuses – Part 5: Guidance for the application of low-voltage fuses*

IEC TR 60269-5:2014/AMD1:2020

IEC 60417, *Graphical symbols for use on equipment*

ISO 3, *Preferred numbers – Series of preferred numbers*

3 Terms and definitions

IEC 60269-1 applies with the following supplementary definitions.

3.2 General terms

3.2.101

semiconductor device

device whose essential characteristics are due to the flow of charge carriers within a semiconductor.

[SOURCE: IEC 60050-521:2002, 521-04-01]

3.2.102

semiconductor fuse-link

current-limiting fuse-link capable of breaking, under specific conditions, any current value within the breaking range (see 8.4)

3.2.103

signalling device

device forming part of the fuse and signalling the fuse operation to a remote place

Note 1 to entry: A signalling device consists of a striker and an auxiliary switch. Electronic devices may also be used.

3.2.104

voltage source inverter

VSI

a voltage stiff inverter

Note 1 to entry: Also referred to as a voltage stiff inverter i.e. an inverter that supplies current without any practical change in its output voltage.

[SOURCE: IEC 60050-551:1998, 551-12-11]

3.2.105

voltage source inverter fuse-link

VSI fuse-link

current-limiting fuse-link capable of breaking, under specified conditions, the short circuit current supplied by the discharge of a DC-link capacitor in a voltage source inverter

Note 1 to entry: The abbreviation "VSI fuse-link" is used in this document.

Note 2 to entry: A VSI fuse-link usually operates under a short circuit current supplied by the discharge of a DC-link capacitor through a very low inductance, in order to allow high frequency in normal operation. This short circuit condition leads to a very high rate of rise of current equivalent to a very low value of time constant, typically 3 ms or less. The supply voltage is DC, even though the applied voltage decreases as the current increases during the short circuit.

Note 3 to entry: In some multiple AC drive applications, individual output inverters may be remote from the main input rectifier. In these cases, the associated fault circuit impedances may influence the operation of the fuse-links. – the associated time constant and the size of the capacitors need to be considered when choosing the appropriate short circuit protection.

4 Conditions for operation in service

IEC 60269-1 applies with the following supplementary requirements.

Fuses must be only used according to their rated values.

4.5 Voltage

4.5.1 Rated voltage

For AC, the rated voltage of a fuse-link is related to the applied voltage; it is based on the RMS value of a sinusoidal AC voltage. It is further assumed that the applied voltage retains the same value throughout the operation of the fuse-link. All tests to verify the ratings are based on this assumption.

For DC and VSI fuse-links, the rated voltage of a fuse-link is related to the applied voltage. It is based on the mean value. When DC is obtained by rectifying AC, the ripple is assumed not to cause a variation of more than 5 % above or 9 % below the mean value.

4.5.2 Applied voltage in service

Under service conditions, the applied voltage is that voltage which, in the fault circuit, causes the current to increase to such proportions that the fuse-link will operate.

For AC, consequently, the value of the applied voltage in a single-phase AC circuit is usually identical to the power-frequency recovery voltage. For all cases other than the sinusoidal AC voltage, it is necessary to know the applied voltage as a function of time.

For a unidirectional voltage and for VSI fuse-links, the important values are:

- the average value over the entire period of the operation of the fuse-link;
- the instantaneous value near the end of the arcing period.

4.6 Current

The rated current of a semiconductor fuse-link is based on the RMS value of a sinusoidal AC current at rated frequency.

For DC, the RMS value of current is assumed not to exceed the RMS value based on a sinusoidal AC current at rated frequency.

NOTE The thermal response time of the fuse-element may be so short that it cannot be assumed that operation under conditions which deviate much from sinusoidal current can be estimated on the basis of the RMS current alone. This is so, in particular at lower frequency values and when the current presents salient peaks separated by appreciable intervals of insignificant current; for example, in the case of frequency converters and traction applications.

4.7 Frequency, power factor and time constant

4.7.1 Frequency

The rated frequency refers to the frequency of the sinusoidal current and voltage that form the basis of the type tests.

4.7.3 Time constant (τ)

For DC, the time constants expected in practice are considered to correspond to those in Table 105.

For VSI fuse-links, equivalent time constants expected in practice are considered to correspond to those in Table 106.

NOTE 2 The high rate of rise of short circuit current is due to the low inductance, which is considered to be equivalent to a low time constant.

NOTE 3 Instead of time constant di/dt can be used in case of short circuit condition.

$di/dt = E/L$.

E = voltage value of the DC power source,

L = total inductance of the capacitor discharge circuit.

5 Classification

IEC 60269-1 applies.

6 Characteristics of fuses

IEC 60269-1 applies with the following supplementary requirements.

6.1 Summary of characteristics

6.1.3 Fuse-links

- a) Rated voltage (see 6.2)
- b) Rated current (see 6.3 of IEC 60269-1:2024)
- c) Kind of current and frequency (see 6.4 of IEC 60269-1:2024)
- d) Rated power dissipation (see 6.5 of IEC 60269-1:2024)
- e) Time-current characteristics (see 6.6)
- f) Breaking range (see 6.7.1 of IEC 60269-1:2024)
- g) Rated breaking capacity (see 6.7.2 of IEC 60269-1:2024)
- h) Cut-off current characteristics (see 6.8.2)
- i) I^2t characteristics (see 6.8.3)
- j) Dimensions or size (if applicable)
- k) Arc voltage characteristics (see 6.9)
- l) Fuse-links may only be used with the fuse-base and/or fuse-holder assigned by the manufacturer and defined in the manufacturer's instructions

6.2 Rated voltage

For rated AC voltages up to 690 V and DC voltages up to 750 V, IEC 60269-1 applies; for higher voltages, the values shall be selected from the R 5 series or, where not possible, from the R 10 series of ISO 3.

A fuse-link shall have an AC voltage rating or a DC voltage rating or a VSI voltage rating. It may have one or more of these voltage ratings.

6.4 Rated frequency

The rated frequency is that frequency to which the performance data are related.

6.5 Rated power dissipation of the fuse-link and rated acceptable power dissipation of a fuse-holder

In addition to the requirements of IEC 60269-1, the manufacturer shall indicate the power dissipation as a function of current for the range 50 % to 100 % of the rated current.

In cases where the resistance of the fuse-link is of interest, this resistance should be determined from the functional relation between the power dissipation and the associated value of current.

6.6 Limits of time-current characteristics

6.6.2 Time-current characteristics, time-current zones

6.6.2.1 General requirements

The time-current characteristics depend on the design of the fuse-link, and, for a given fuse-link, on the ambient air temperature and the cooling conditions.

The manufacturer shall provide time-current characteristics based on an ambient temperature of 20 °C to 25 °C in accordance with the conditions specified in 9.3. The time-current characteristics of interest are the pre-arcing characteristic and operating characteristics.

For AC, the time-current characteristics are stated at rated frequency and for pre-arcing or operating times longer than 0,1 s.

For DC, they are stated for time constants according to Table 105 and for pre-arcing or operating times longer than 15τ .

For the higher values of prospective current (shorter times), the same information shall be presented in the form of I^2t characteristics (see 6.8.2).

6.6.2.2 Pre-arcing time-current characteristics

For AC, the pre-arcing time-current characteristic shall be based on a symmetrical AC current of a stated value of frequency (rated frequency).

For DC, the pre-arcing time-current characteristic is of particular significance for times exceeding 15τ for the relevant circuit, and is identical to the AC pre-arcing time-current characteristic in this zone.

NOTE 1 Because of the wide range of circuit time constants likely to be experienced in service, the information for times shorter than 15τ is conveniently expressed as a pre-arcing I^2t characteristic.

NOTE 2 The value of 15τ has been chosen to avoid the effects which different rates of rise of current have on the pre-arcing time-current characteristic at shorter times.

6.6.2.3 Operating time-current characteristics

For AC with times longer than 0,1 s and for DC with times longer than 15τ , the arcing period is negligible compared to the pre-arcing time. The operating time is then equivalent to the pre-arcing time.

6.6.3 Conventional times and currents

6.6.3.1 Conventional times and currents for "aR" fuse-links

See 8.4. and Table 101

6.6.3.2 Conventional times and currents for "gR" and "gS" fuse-links

The conventional times and currents are given in Table 101.

Table 101 – Conventional time and current for "gR" and "gS" fuse-links

Rated current A	Conventional time h	Conventional current			
		Type "gR"		Type "gS"	
		I_{nf}	I_f	I_{nf}	I_f
$I_n \leq 4$	1	$1,1 I_n$	$2,1 I_n$	$1,5 I_n$	$2,1 I_n$
$4 < I_n < 16$	1	$1,1 I_n$	$1,9 I_n$	$1,5 I_n$	$1,9 I_n$
$16 \leq I_n \leq 63$	1	$1,1 I_n$	$1,6 I_n$	$1,25 I_n$	$1,6 I_n$
$63 < I_n \leq 160$	2				
$160 < I_n \leq 400$	3				
$400 < I_n$	4				

NOTE The conventional times also apply for "aR" – fuses

6.6.4 Gates

Not applicable.

6.7 Breaking range and breaking capacity

6.7.1 Breaking range and utilization class

The first letter shall indicate the breaking range:

- "a" fuse-links (partial-range breaking capacity, see 8.4);
- "g" fuse-links (full-range breaking capacity).

The second letter "R" and "S" shall indicate the utilization class for fuse-links complying with this standard for the protection of semiconductor devices.

The type "R" is typically faster acting than type "S" and gives lower I^2t values.

The type "S" generally has lower power dissipation and gives enhanced utilization of cables compared to type "R".

For example:

- aR indicates fuse-links with partial range breaking capacity for the protection of semiconductor devices;
- gR indicates fuse-links with full-range breaking capacity for general application and semiconductor protection, optimised to low I^2t values;
- gS indicates fuse-links with full range breaking capacity for general application and semiconductor protection, optimised to low power dissipation.

Some aR fuse-links are used to protect voltage source inverters. Even though they are common aR fuses on AC, they must be tested differently under VSI DC short-circuit conditions. For these reasons, their designation is still "aR" but their DC characteristics must be clearly stated "for VSI protection" in the manufacturer's data sheets.

6.7.2 Rated breaking capacity

A breaking capacity of at least 50 kA for AC and 20 kA for DC is required.

For AC, the rated breaking capacity is based on type tests performed in a circuit containing only linear impedance and with a constant sinusoidal applied voltage of rated frequency.

For DC, the rated breaking capacity is based on type tests performed in a circuit containing only linear inductance and resistance with mean applied voltage.

For VSI, the rated breaking capacity is based on type tests performed in a circuit with low time constant. The time constant for tests is defined in Table 106. The required rated maximum breaking capacity of VSI fuses is at least 20 kA.

NOTE The addition in practical applications of non-linear impedances and unidirectional voltage components may significantly influence the breaking severity either in a favourable or unfavourable direction.

6.8 Cut-off current and I^2t characteristics

6.8.2 Cut-off current characteristics

The manufacturer shall provide the cut-off current characteristics which shall be given, according to the example shown in Figure 4 of IEC 60269-1:2024, in a double logarithmic presentation with the prospective current as abscissa and, if necessary, with applied voltage and/or frequency as a parameter.

For AC, the cut-off current characteristics shall represent the highest values of current likely to be experienced in service. They shall refer to the conditions corresponding to the test conditions of this standard, for example, given voltage, frequency and power-factor values. The cut-off current characteristics may be defined by the tests specified in 9.6.

For DC, the cut-off current characteristics shall represent the highest values of current likely to be experienced in service in circuits having a time constant specified in Table 105 for aR, gS and gR fuse-links, or in Table 106 for aR fuse-links in VSI applications. For aR, gS and gR fuse-links, these values will be exceeded in circuits of smaller time constants than those of Table 105. The manufacturer shall provide the relevant information to enable the determination of these higher cut-off current characteristics.

NOTE The cut-off current characteristic varies with the circuit time constant. The manufacturer should provide the relevant information to enable these variations to be determined at least for time constants of 5 ms and 10 ms.

6.8.3 I^2t characteristics

6.8.3.1 Pre-arcing I^2t characteristic

For AC, the manufacturer shall provide the pre-arcing I^2t characteristic based on a symmetrical AC current at a stated frequency value (rated frequency).

For DC, the manufacturer shall provide the pre-arcing I^2t characteristic based on RMS DC current at a time constant specified in Table 105 for aR, gS and gR fuse-links or in Table 106 for aR fuse-links in VSI applications.

For DC, the pre-arcing I^2t value represents the lowest value likely to be experienced in service. It shall be based on RMS DC current as defined in the test requirements of test No.1 of the breaking capacity.

6.8.3.2 Operating I^2t characteristics

For AC, the manufacturer shall provide the operating I^2t characteristics given with applied voltage as a parameter and for a stated power-factor value. In principle, they shall be based on the moment of current initiation that leads to the highest operating I^2t value (see 9.7). The voltage parameters shall include at least 100 %, and 50 % of rated voltage.

For DC, the manufacturer shall provide the operating I^2t characteristics given with the applied voltage as a parameter and for a time constant specified in the Table 105 for aR, gS and gR fuse-links, or Table 106 for aR fuse-links in VSI applications. The voltage parameters shall include at least 100 % and 50 % of rated voltage. It is permitted to determine the operating I^2t characteristics at lower voltages from tests in accordance with Table 105 or Table 106 according to their DC application or VSI application.

The I^2t at reduced voltages may be calculated using the method described in IEC 60269-1:2024, Clause B.3.

6.9 Arc voltage characteristics

Arc voltage characteristics provided by the manufacturer shall give the highest (peak) value of arc voltage as a function of the applied voltage of the circuit in which the fuse-link is inserted and, in the case of AC, for power factors as stated in Table 104 and, in the case of DC at time constants specified in Table 105 or in Table 106 according to their DC application or VSI application.

7 Markings

IEC 60269-1 applies with the following supplementary requirements.

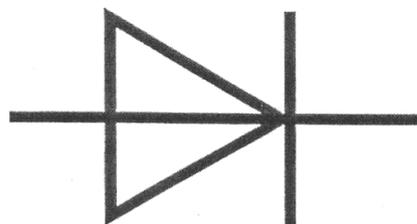
7.3 Marking of fuse-link

Subclause 7.3 of IEC 60269-1:2024 applies with the following addition:

- manufacturer's identification reference and/or symbols enabling all the characteristics listed in 6.1.3 of IEC 60269-1:2024 to be found;
- utilization class, "aR" or "gR" or "gS";
- a combination of symbols of IEC 60417 of a fuse (5016) and a rectifier (5186) as shown below:



Symbol IEC 60417-5016 (2002-10)



Symbol IEC 60417-5186 (2002-10)

For VSI rated fuse-links an additional mark, e.g. "1 200V DC VSI" with the voltage rating value must be stated on the product.

8 Standard conditions for construction

IEC 60269-1 applies with the following supplementary requirements.

8.3 Temperature rise and power dissipation of the fuse-link and acceptable power dissipation of a fuse-holder

Fuse-links shall be so designed and proportioned as to carry, when tested in accordance with 9.3, the rated current without exceeding,

- the temperature rise limit of the hottest upper metal part of the fuse-link indicated by the manufacturer instructions (see Figure 101 and Figure 102).
- the power dissipation at the rated current indicated by the manufacturer instructions.

8.4 Operation

The fuse-link shall be so designed and proportioned as to carry continuously any value of current up to its rated current.

"aR" fuse-links shall operate and break the circuit for any current value not exceeding the rated breaking capacity and not less than the current I_{2a} (see Table 104 and Table 105).

For "gR" and "gS" fuse-links within the conventional time and at currents defined in Table 101:

- it shall not operate, when it carries any current not exceeding the conventional non-fusing current (I_{nf});
- it shall operate when it carries any current equal to, or exceeding, the conventional fusing current (I_f) and equal to or lower than the rated breaking capacity.

8.5 Breaking capacity

A fuse-link shall be capable of breaking, at a voltage not exceeding its rated voltage, any circuit having a prospective current between a current according to 8.4 and the rated breaking capacity:

- for AC, test parameters are given in Table 104;
- for DC, test parameters are given in Table 105;
- for VSI applications, test parameters are given in Table 106.

8.7 I^2t characteristics

The values of operating I^2t determined as described in 9.7 shall not exceed those stated by the manufacturer. The values of pre-arcing I^2t determined as described in 9.7 shall be not less than the values stated (see 6.8.2.1 and 6.8.2.2).

8.15 Arc voltage characteristics

The arc voltage values measured as described in 9.7.5 shall not exceed those stated by the manufacturer (see 6.9).

9 Tests

IEC 60269-1 applies with the following supplementary requirements.

9.1.5 Arrangement of the fuse and dimensions

The fuse-link shall be mounted open in free air in draught-free surroundings free from draughts and, unless otherwise specified, in a vertical position (see 9.3.1). Examples of test arrangements are given in Figure 101 and Figure 102. Test arrangements for other kinds of fuse-links are given in IEC 60269-2 and IEC 60269-3.

9.1.6 Testing of fuse-links

9.1.6.2 Complete tests

The complete tests on fuse-links are listed in Table 102. The internal resistance of all fuse-links shall be determined and recorded in the test report(s).

A fuse-link shall have an AC breaking capacity or a DC breaking capacity or a VSI breaking capacity. It may have one or more of these breaking capacities.

Table 102 – List of complete tests

Test according to subclause		Number of fuse-links to be tested
9.3	Temperature rise and power dissipation	1
9.4.3.1 a)	Conventional non-fusing current	1
9.4.3.1 b)	Conventional fusing current	1
9.4.3.2	Verification of rated current	1
9.4.3.5	Conventional cable overload test (for "gR" and "gS" fuse-links only)	1
9.5	For AC:	
	No 5 "gR" and "gS" breaking capacity and operating characteristics	1
	No. 2a "aR" breaking capacity and operating characteristics	1
	No. 2 Breaking capacity and operating characteristics ^a	3
9.5	For DC:	
	No. 13 "gR" and "gS" breaking capacity and operating characteristics	1
	No.12a "aR" breaking capacity and operating characteristics	1
	No.12 Breaking capacity and operating characteristics	3
	No.11 Breaking capacity and operating characteristics	3
9.5	For VSI fuse-links:	
	No. 21 Breaking capacity and operating characteristics	3
^a Valid for pre-arcing I^2t characteristics, if ambient air temperature is between 10 °C and 30 °C.		

9.1.6.3 Testing of fuse-links of a homogeneous series

Fuse-links having intermediate values of rated current of a homogeneous series are exempted from type tests if the fuse-link of the largest rated current has been tested to the requirements of 9.1.6.2 and if the fuse-link of the smallest rated current has been submitted to the tests indicated in Table 103.

Table 103 – Survey of tests on fuse-links of the smallest rated current of a homogeneous series

Test according to subclause	Number of fuse-links to be tested
8.3 Temperature rise and power dissipation	1

9.3 Verification of temperature rise limits and power dissipation

9.3.1 Arrangement of the fuse

Only one fuse-link shall be used for the test. The fuse-link shall be mounted vertically in the conventional test arrangement. Examples are given in Figure 101 and Figure 102.

The current density of the copper conductors forming part of the conventional test arrangement shall be not less than 1 A/mm² and not more than 1,6 A/mm², these values being based on the rated current of the fuse-link. The ratio of width to thickness of these conductors shall not exceed

- 10 for current ratings less than 200 A;
- 5 for current ratings 200 A and above.

The ambient air temperature during this test shall be between 10 °C and 30 °C.

When conducting the temperature-rise tests, the cross-sectional areas of the conductors connecting the conventional test arrangement to the supply are important. The cross-sectional area shall be selected in accordance with Table 18 of IEC 60269-1:2024, excluding the note, and the conductors on either side of the fuse-link shall be at least 1 m long.

For fuse-links intended to be used in separate fuse-bases, the test may be performed in these fuse-bases with conductors according to Table 18 of IEC 60269-1:2024; in other cases, the test shall be performed in the manner described in these requirements.

For special fuse-links or special applications that cannot be accommodated in the conventional test arrangement, or for which this test arrangement is not applicable, special tests shall be performed according to the manufacturer's instructions and all pertinent data shall be recorded in the test report.

9.3.3 Measurement of power dissipation of the fuse-link

In addition to 9.3.3 of IEC 60269-1:2024, the following applies: the power dissipation test shall be made successively at least at 50 % and at 100 % of rated current. This test may be performed with either AC or DC.

9.3.4 Test method

The cross-sectional area of copper conductors for high current ratings tests corresponding to Subclauses 9.3 and 9.4 is defined in Table 107.

Table 107 – Cross-sectional area of copper conductors for high current ratings tests

Rated current (I_N)	Cross-sectional area
A	(mm × mm)
1 600	2 × 100 × 5
2 000	3 × 100 × 5
2 500	4 × 100 × 5
3 150	3 × 100 × 10
≥ 4 000	$I_N \times \text{mm}^2 / \text{A}^a$
^a For currents ≥ 4 000 A the cross-sectional area is defined with a current density = 1 A/mm ² .	

9.3.5 Acceptability of test results

The temperature rise and the power dissipation of the fuse-link shall be given in the manufacturer's documentation.

9.4 Verification of operation

9.4.1 Arrangement of the fuse

The arrangement of the fuse-link for the verification of operation shall be as described in 9.1.5 and 9.3.1.

9.4.3 Test method and acceptability of test results

The following tests may be performed by AC or DC source.

9.4.3.1 Verification of conventional non-fusing and fusing current

"aR" fuse-links:

Not applicable.

"gR" and "gS" fuse-links:

The following test must be made but can be performed with reduced voltage.

- the fuse-link is subjected to its conventional non-fusing current (I_{nf}) for a time equal to the conventional time specified in Table 101. It shall not operate during this time;
- the fuse-link, after having cooled down to ambient temperature, is subjected to the conventional fusing current (I_f). It shall operate within the conventional time as specified in Table 101. The fuse-link shall operate without external effects or damage.

9.4.3.2 Verification of rated current

The fuse-link is tested under the same test conditions as indicated in 9.3.1.

It is subjected to 100 test cycles, each consisting of an "on" period of 0,1 times the conventional time as specified in Table 101 at rated current and an "off" period of the same duration. After test, the fuse-link must not have changed its resistance by more than 10 %.

NOTE Conventional time for "gR" in Table 101 also applies for "aR".

9.4.3.3.1 Time-current characteristics

The time-current characteristics may be verified on the basis of the results obtained from the oscillographic records taken during the performance of the tests according to 9.5.

The pre-arcing period is determined from the instant of closing the circuit until the instant when the voltage measurement shows the beginning of the arc.

The value of pre-arcing time so determined, referred to the abscissa corresponding to the value of the prospective current, shall be within the time-current zone indicated by the manufacturer.

For AC prospective currents heading to actual pre-arcing time values of less than 10 cycles of rated frequency and up to current values where the melting is adiabatic, the currents shall be initiated in such a manner that the prospective current will be symmetrical.

For DC, the time-current characteristics determined for AC are applicable for times longer than 15τ for the relevant circuit.

When, for the fuse-links of a homogeneous series (see 9.1.6.3), the complete test according to 9.5 is made only on the fuse-link having the largest rated current, it shall be sufficient to verify only the pre-arcing time for the fuse-link having the smallest rated current.

Pre-arcing time-current characteristics can be determined at any convenient voltage value and on any linear circuit. Tests to determine operating time-current characteristics require the proper voltage values and circuit characteristics.

9.4.3.5 Conventional cable overload protection test (for "gR" and "gS" fuse-links only)

"gR" and "gS" fuse-links: IEC 60269-1 applies.

9.4.3.6 Operation of indicating devices and striker, if any

The correct operation of indicating devices is verified in combination with the verification of breaking capacity (see 9.5.5).

For verifying the operation of strikers, if any, an additional test sample shall be tested:

- at a current of I_{2a} (see Table 104 and Table 105);
- at a recovery voltage of 20 V.

The value of the recovery voltage may be exceeded by 10 %.

The striker shall operate during all tests.

However, if, during one of these tests, the indicating device or striker fails, the test shall not be considered negative on this account, if the manufacturer can furnish evidence that such failure is not typical of the fuse type but is due to a fault on the individual tested sample. If such a failure occurs, then twice the number of samples shall be tested for the particular test duty, without further failure.

The characteristics and the verification of the characteristics of indicating devices or strikers are subject to an agreement between the manufacturer and user.

9.5 Verification of the breaking capacity

9.5.1 Arrangement of the fuse

In addition to the conditions of 9.1.4 and 9.3.1, the following applies.

For breaking-capacity tests, the fuse-link shall be mounted in a manner resembling its practical use, in particular with respect to the location of the conductors. In cases where the fuse-link can be used rigidly supported at one end only, it shall be so mounted for the test. Fuse-links intended to be always rigidly supported at both ends shall be so tested.

9.5.5 Test method

9.5.5.1 In order to verify that the fuse-link satisfies the conditions of 8.5 for AC, test Nos. 1 to 2a for "aR" fuse-links and tests numbers 1, 2 and 5 for "gR" and "gS" fuse-links, as described below, shall be made, with the values stated in Table 104 (see 9.5.5.2) for each of these tests. For DC tests, numbers 11 to 12a for "aR" fuse-links and numbers 11, 12 and 13 for "gR" and "gS" fuse-links shall be made, unless otherwise specified, with the values stated in Table 105. For VSI fuse-links, test no 21 shall be made with the values stated in Table 106. Test voltages are given in Tables 104, 105 and 106.

Test Nos. 1 and 2 for AC; or 11 and 12 for DC or 21 for VSI fuse-links: for each of these tests, three fuse-links shall be tested in succession. If, during test No. 1, the requirements of test No. 2 are met on one or more tests, then these tests need not be repeated as part of test No. 2. The same applies for tests numbers 11 and 12 for DC.

Test Nos. 2a and 5 for AC and 12a and 13 for DC: for AC, the values of test current are specified in Table 104. For DC, the values of test current are specified in Table 105. For AC tests, the closing of the circuit in relation to the passage of the applied voltage through zero may be effected at any instant. If the testing arrangement does not permit the current to be maintained at the full voltage during all of the time required, the fuse may be pre-heated at reduced voltage by applying a current approximately equal to the value of the test current. In this case, switching over to the test circuit according to 9.5.2 shall take place before the arc is initiated, and the switching time T_1 (interval without current) shall not exceed 0,2 s. The time interval between re-application of the current and beginning of arcing shall be not less than three times T_1 .

The following text replaces the text of 9.5.5.2 of IEC 60269-1:2024 with the exception of the resistance test:

9.5.5.2 For one of the tests of No. 2 and for test No. 2a or 5 for AC, and one of the tests of No. 12 and for tests 12a or 13 for DC, and for one test of 21 for VSI, the recovery voltage shall be maintained at a value of:

- for AC, 105% + 5 %/-0 % of the rated voltage
- for DC, 105% + 10 %/-0 % of the rated voltage
- for VSI, 105% + 10 %/-0 % of the rated voltage

The tolerance +xx %/-xx % is to be used by testing bodies as tolerance in testing. The practical use of the fuse should be only to 100 % of the rated voltage, unless the manufacturer gives his consent to a higher value.

For at least:

- 30 s after operation of fuse-links not containing organic materials in their body or filler;
- 5 min after operation of the fuse-links in all other cases, switching over to another source of supply being permitted after 15 s if the switching time (interval without voltage) does not exceed 0,1 s.

For all other tests, the recovery voltage shall be maintained at the same value for 15 s after operation of the fuse.

In a lapse of time of at least 6 min and maximum 10 min after the operation, the resistance between the contacts of the fuse-link shall be measured (see 9.5.8) and noted. With the manufacturer's consent, shorter times are possible if the fuse-link does not contain organic materials in its body or filler.

Table 104 – Values for breaking-capacity tests on AC fuses

	Tests according to 9.5.5.1			
	No. 1	No. 2	No. 2a	No. 5
Power-frequency recovery voltage ^c	105+5%/-0% of the rated voltage ^a			
Prospective test current	I_1	I_2	I_{2a} "aR"	$I_5 = 1,25 I_f$ "gR" and "gS"
Tolerance on current	+10 % 0 % ^a	Not applicable		+20 % 0 %
Power factor	0,2 to 0,3 for prospective current up to and including 20 kA 0,1 to 0,2 for prospective current above 20 kA		0,3 to 0,5 ^b	
Making angle after voltage zero	Not applicable	0 +20 -0	Not specified	
Initiation of arcing after voltage zero	65° to 90°	Not applicable		
<p>I_1 is the current which is used in the designation of the rated breaking capacity (see 6.7.2).</p> <p>I_2 is the current which shall be chosen in such a manner that the test is made under conditions which approximate those giving maximum arc energy.</p> <p>NOTE This condition may be deemed to be satisfied if the current at the beginning of arcing (instantaneous value) has reached a value between $0,6\sqrt{2}$ (=0,85) and $0,75\sqrt{2}$ (=1,06) times the prospective current (for AC, the RMS value of the AC component).</p> <p>Informative: The value of current I_2 may be found between three and four times the current which corresponds to a pre-arcing time of one half-cycle of rated frequency on the time-current characteristic.</p> <p>I_{2a} is the minimum value of the breaking capacity of the fuse-link in the overcurrent range specified by the manufacturer (see 8.4).</p> <p>I_5 is the test current deemed to verify that the fuse is able to operate satisfactorily in the range of small overcurrents.</p>				
<p>^a The positive tolerance may be exceeded with the manufacturer's consent.</p> <p>^b Power factors lower than 0,3 may be permitted with the manufacturer's consent.</p> <p>^c For single-phase circuits, the RMS value of the applied voltage is for all practical purposes equal to the RMS value of the power-frequency recovery voltage.</p>				

Table 105 – Values for breaking-capacity tests on DC fuses

	Tests according to 9.5.5.1			
	No. 11	No. 12	No. 12a	No. 13
Mean value of recovery voltage ^a	105 % +10 % -0 % of the rated voltage ^b			
Prospective test current	I_1	I_2	I_{2a} "aR"	$I_5 = 1,25 I_f$ "gR" and "gS"
Tolerance on current	$+10\%$ 0%	Not applicable		$+20\%$ 0%
Time constant ^c	Where prospective test current is greater than 20 kA: 10 ms to 15 ms Where prospective test current I is equal to, or less than, 20 kA: $0,5 (I)^{0,3}$ ms with a tolerance of $+20\%$ ^b (value of I in A)			
<p>I_1 is the current which is used in the designation of the rated breaking capacity (see 6.7.2).</p> <p>I_2 is the current which shall be chosen in such a manner that the test is made under conditions which approximate those giving maximum arc energy.</p> <p>NOTE This condition may be deemed to be satisfied if the current, at the beginning of arcing, has reached a value between 0,5 and 0,8 times the prospective current.</p> <p>I_{2a} is the minimum value of the breaking capacity of the fuse-link in the overcurrent range specified by the manufacturer (see 8.4).</p> <p>I_5 is the test current deemed to verify that the fuse is able to operate satisfactorily in the range of small overcurrents.</p>				
<p>^a This tolerance includes ripple.</p> <p>^b The upper limit may be exceeded with the manufacturer's consent.</p> <p>^c In some practical applications, time-constant values may be found which are shorter than those indicated in the tests and which may result in a more favourable fuse performance. Time constants which are considerably longer than those indicated will in most cases significantly affect the performance, in particular with respect to the rated voltage. For such applications, further information may be available from the manufacturer.</p>				

Table 106 – Values for breaking-capacity tests on VSI fuse-links

	Tests according to 9.5.5.1
	No. 21
Mean value of recovery voltage ^a	105 +10%/-0% of the rated voltage ^b
Prospective test current	I_1
Tolerance on current	$+10\%$ -0%
Time constant	Less than 3 ms ^c
<p>I_1 is the current which is used in the designation of the rated breaking capacity (see 6.7.2).</p>	
<p>^a This tolerance includes ripple.</p> <p>^b The upper limit may be exceeded with the manufacturer's consent.</p> <p>^c The time constant can be higher with the manufacturers' consent.</p>	

9.5.8 Acceptability of test results

Part 1 of IEC 60269 applies.

9.6 Verification of the cut-off current characteristics

9.6.1 Test method

For AC, tests shall be made as specified in Table 104.

For DC, tests shall be made as specified in Table 105.

For VSI fuse-links, tests shall be made as specified in Table 106.

Tests conducted in accordance with 9.5 shall be used for evaluation according to 9.6.2. The tests may be used to prove the characteristics of all fuse-links of a homogeneous series.

9.6.2 Acceptability of test results

For AC, cut-off characteristics shall be verified from tests Nos. 1 and 2 in Table 104.

For DC, cut-off current characteristics shall be verified from tests Nos. 11 and 12 in Table 105.

For VSI fuse-links, cut-off characteristics shall be verified from test No. 21 in Table 106.

9.7 Verification of the I^2t characteristics and overcurrent selectivity

9.7.1 Test method

The test method is that specified in 9.6.1.

9.7.2 Acceptability of test results

For AC, the I^2t characteristics shall be verified from tests Nos. 1 and 2 according to Table 104.

For DC, the I^2t characteristics shall be verified from tests Nos. 11 and 12 according to Table 105.

For VSI fuse-links, the I^2t characteristics shall be verified from tests No. 21 according to Table 106.

The values of the pre-arcing I^2t at each prospective current shall be not less than the values stated by the manufacturer.

The values of operating I^2t at each prospective current shall not exceed the values indicated by the manufacturer for the stated applied voltage.

9.7.3 Verification of compliance for fuse-links at 0,01 s

Not applicable.

9.7.4 Verification of overcurrent selectivity

Not applicable.

9.7.5 Verification of arc voltage characteristics and acceptability of test results

The highest values of arc voltage derived from each of the following tests shall not exceed those indicated by the manufacturer.

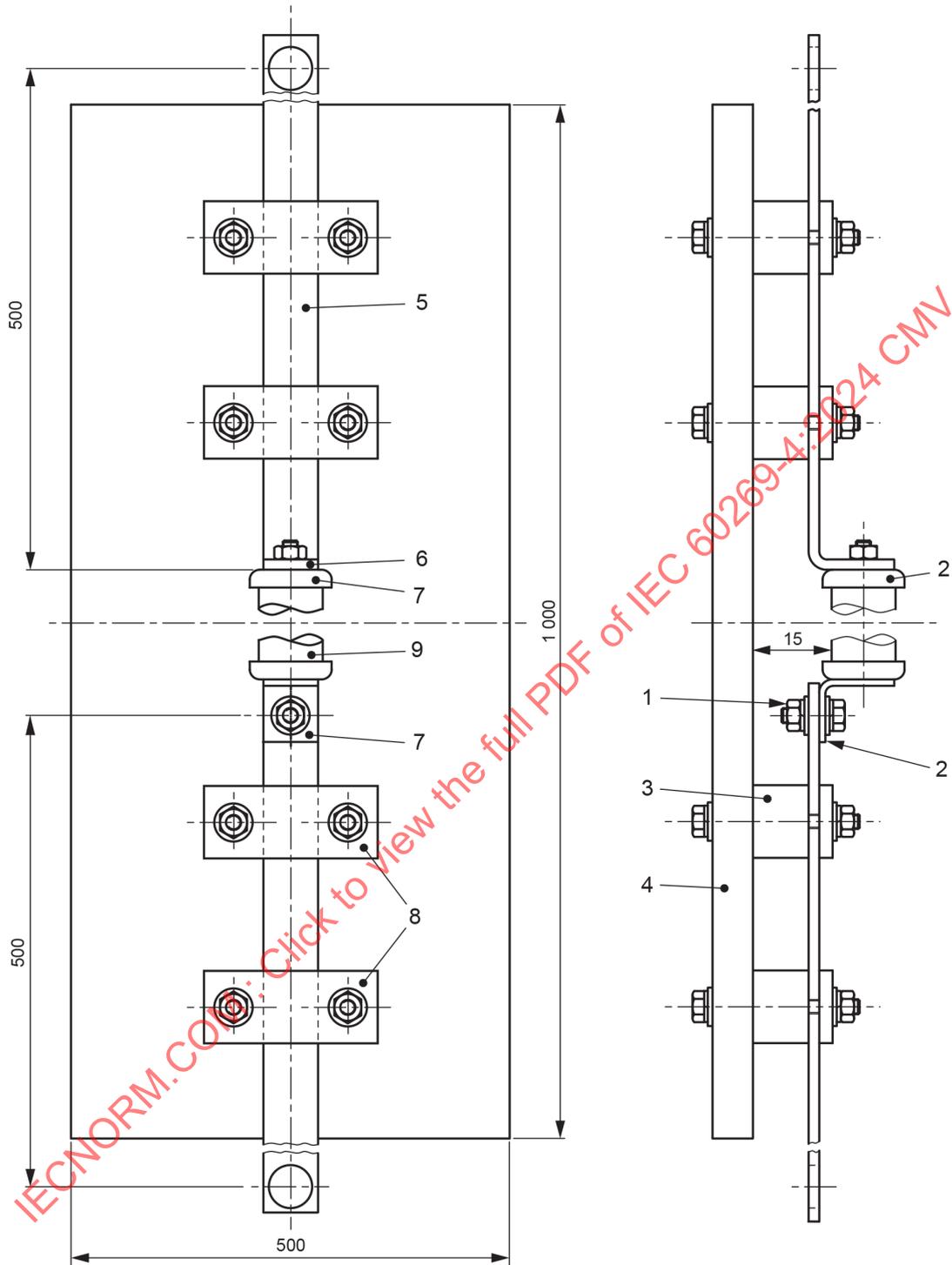
For AC, the arc voltage characteristics shall be verified from tests Nos. 1 and 2 in Table 104.

For DC, the arc voltage characteristics shall be verified from tests Nos. 11 and 12 in Table 105.

For VSI fuse-links, the arc voltage characteristics shall be verified from tests No. 21 in Table 106.

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Dimensions in millimetres

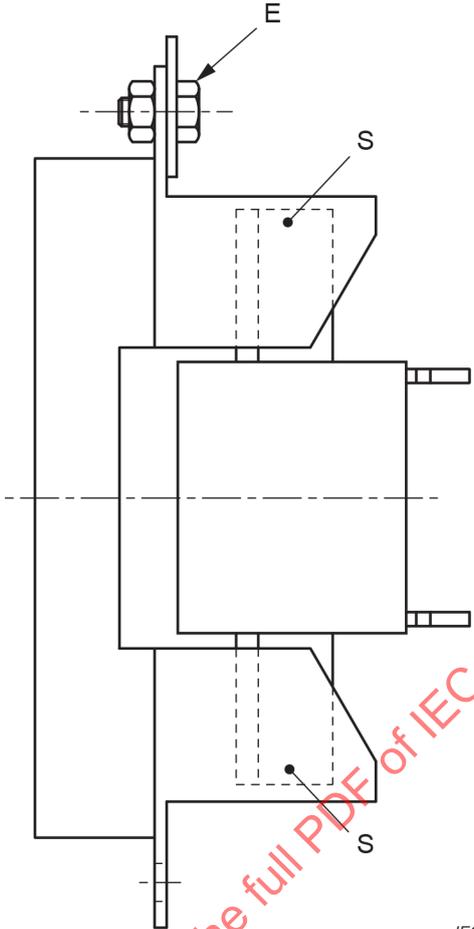


Key

- 1 fixing bolts
- 2 alternative points of measurement of voltage for determination of power dissipation
- 3 insulating blocks (for example, wood)
- 4 insulated base panel (for example, 16 mm plywood)
- 5 matt black finish
- 6 position of thermocouple fixed to hottest upper metal part of the fuse-link, indicated by the manufacturer or otherwise specified
- 7 contact surface to be tin-plated
- 8 insulated clamps. Where necessary, the two upper clamps may be left loose.
- 9 the body of the fuse-link can be round or rectangular

Figure 101 – Example of a conventional test arrangement for bolted fuse-links

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Key

Points of measurement:

E temperature rise

S power dissipation

Figure 102 – Example of a conventional test arrangement for blade contact fuse-links

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Annex AA
(informative)

**Guidance for the coordination of fuse-links
with semiconductor devices**

NOTE The full content of this annex can be read in the user guide IEC TR 60269-5:2014+AMD1:2020 and therefore is not copied here.

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Annex BB (normative)

Survey on information to be supplied by the manufacturer in his literature (catalogue) or on request for a fuse designed for the protection of semiconductor devices

The following information should be given separately for AC and, where applicable, for DC.

- a) Name of the manufacturer (trade mark)
- b) Type or list reference of the manufacturer
- c) Rated voltage (see 4.4.1)
- d) Rated current (see 4.5)
- e) Rated frequency or frequencies (see 6.4)
- f) Rated breaking capacity (at rated voltage and at different applied voltages) (see 6.7.2 and 9.5)
- g) Pre-arcing and operating time-current characteristics (diagrams) and application class (symbol), where applicable (see 6.6.1 and 9.4.3.3.1)
- h) Pre-arcing I^2t characteristic (see 6.8.2.1 and 9.7.2)
- i) Operating I^2t characteristic in relation to the voltage with indication of the power factor or time constant (see 6.8.2.2 and 9.7.2)
- j) Arc voltage characteristic (see 6.9 and 9.7.5)
- k) Cut-off current characteristic (see 6.8.1 and 9.6)
- l) Temperature rise at rated current under conventional test conditions and indication of a defined measuring point (see 7.3 and 9.3.5)
- m) Power dissipation for at least 50 % and 100 % of the rated current, at fixed points or in the form of a diagram for that range (additional parameters may be 63 % and 80 %) (see 8.3 and 9.3.3)
- n) Required minimum operating voltage of the indicator (see 9.4.3.6)
- o) Permissible current as a function of the ambient temperature (diagram) (see 9.4.3.2)
- p) Instructions for mounting, where necessary, with respect to the dimensions (sketch)
- q) Current carrying ability under special conditions of mounting (for example, cross-sectional area of connected conductors, inadequate cooling, additional heat sources, etc.)

Annex CC (normative)

Examples of standardized fuse-links for the protection of semiconductor devices

CC.1 General

This annex is divided into seven specific examples of standardised dimensions:

- system of fuse-links with bolted connections, type A – British
- system of fuse-links with bolted connections, type B – DIN
- system of fuse-links with bolted connections, type C – North American
- system of fuse-links with flush end connections, type A
- system of fuse-links with flush end connections, type B – North American
- system of fuse-links with cylindrical contact caps, type A – North American
- system of fuse-links with cylindrical contact caps, type B – French

Fuse-links for the protection of semiconductor devices may also have the same dimensions as fuse-links according to:

- IEC 60269-2: system of fuses A, B, F and H;
- IEC 60269-3: system of fuses A.

In addition to meeting the requirements of this standard, the power dissipation of the fuse-link shall not exceed the acceptable power dissipation of the associated fuse bases or fuse-holders. Where the power dissipation of the fuse-link exceeds the acceptable power dissipation of the standardised fuse base or fuse-holder, de-rating values shall be given by the manufacturer.

CC.2 System of fuse-links with bolted connections, type A – British

CC.2.1 Scope

The following supplementary requirements apply to fuse-links having bolted connections, whose dimensions comply with the requirements given in Figure CC.1 to Figure CC.3. Their rated voltages and currents are as follows:

- 230 V AC up to 900 A;
- 690 V AC up to 710 A.

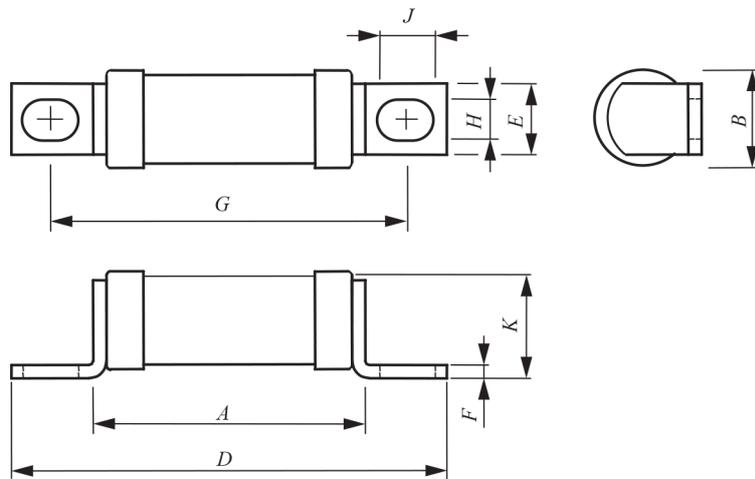
CC.2.2 Mechanical design (see 8.1 of IEC 60269-1:2024)

The standardized dimensions of the fuse-links are given in Figure CC.1 to Figure CC.3.

CC.2.3 Construction of a fuse-link

For indication of operation, a striker fuse-link may be used. The standardised dimensions of the striker fuse-links are given in Figure CC.4.

Dimensions in millimetres

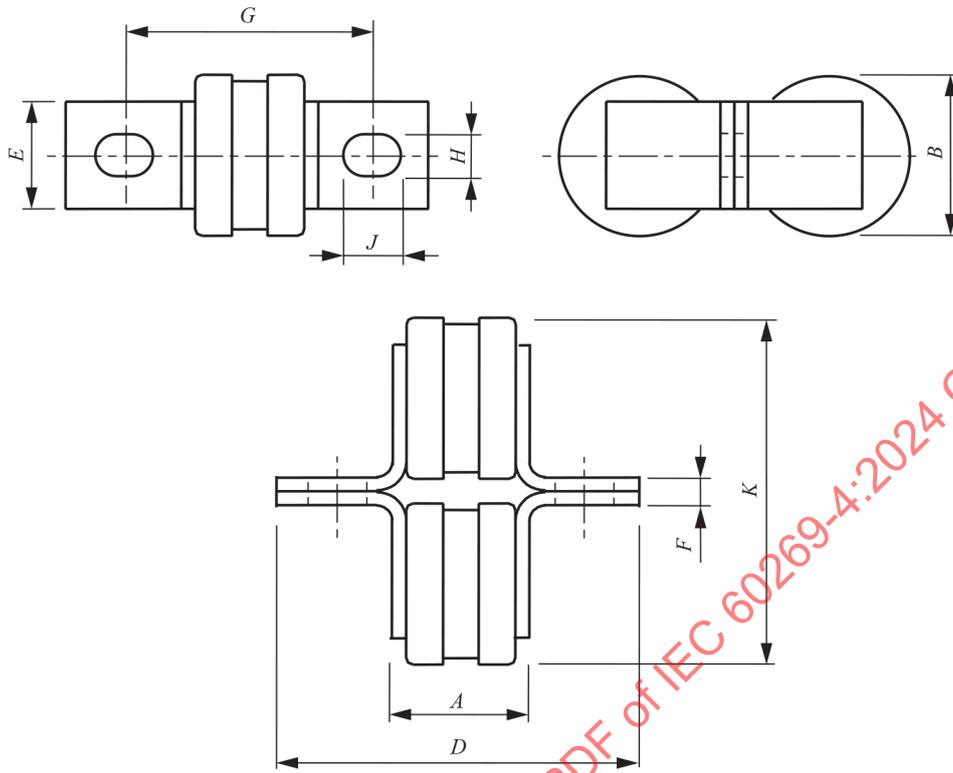
**Key**

Typical voltage rating V AC	Preferred maximum current rating A	<i>A</i> max.	<i>B</i> max.	<i>D</i> max.	<i>E</i> nom.	<i>F</i> max.	<i>G</i> nom.	<i>H</i> nom.	<i>J</i> min.	<i>K</i> max.
230	20	29	8,7	47,6	6,4	0,9	38	4	4,8	8,8
690	20	55	8,7	75	6,4	0,9	64,5	4	4,8	8,8
230	180	29,2	17,7	58,4	12,7	2,5	42	6,4	7,9	19,3
690	100	50,6	17,7	79,8	12,7	2,5	63,5	6,4	7,9	19,3
230	450	32,6	38,2	85	25,4	3,3	59	10,3	13	41,5
690	355	60	38,2	114	25,4	3,3	85	10,3	13	41,5

NOTE For DC and VSI voltage ratings consult the manufacturer.

Figure CC.1 – Single body fuse-links

Dimensions in millimetres



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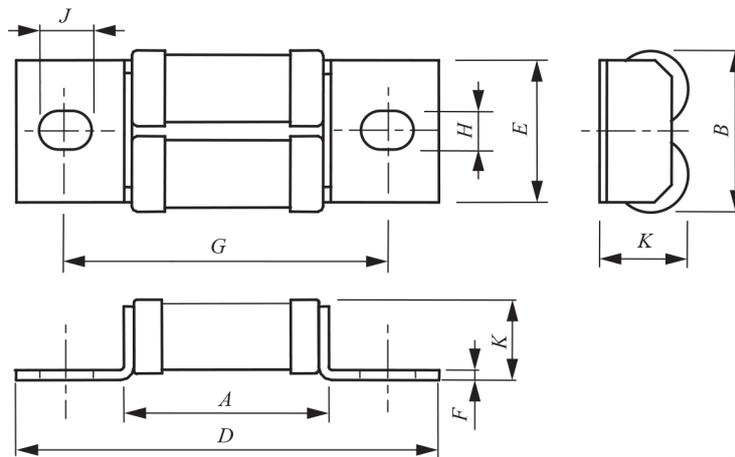
Key

Typical voltage rating V AC	Preferred maximum current rating A	A max.	B max.	D max.	E nom.	F nom.	G nom.	H nom.	J min.	K max.
230	900	32,6	38,2	85	25,4	6,4	59	10,3	13	83
690	710	60	38,2	114	25,4	6,4	85	10,3	13	83

NOTE For DC and VSI voltage ratings consult the manufacturer.

Figure CC.2 – Double body fuse-links

Dimensions in millimetres



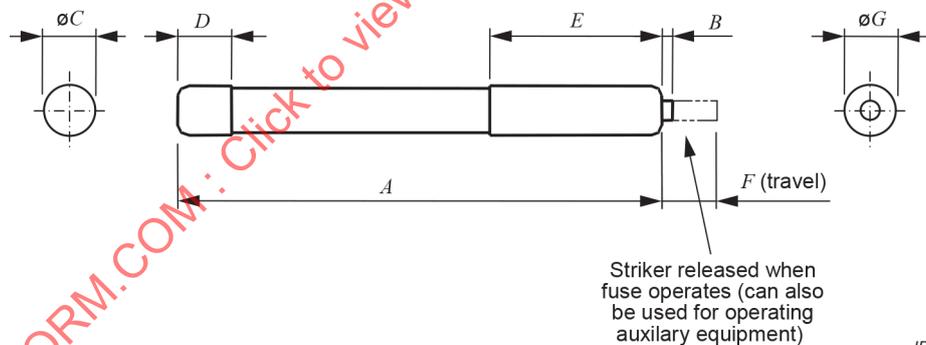
Key

Typical voltage rating V AC	Preferred maximum current rating A	A	B	D	E	F	G	H	J	K
690	200	max.	max.	max.	nom.	max.	nom.	nom.	min.	max.
		50,6	37	95	32	1,6	70	8,7	10,3	19,9

NOTE For DC and VSI voltage ratings consult the manufacturer.

Figure CC.3 – Twin body fuse-links

Dimensions in millimetres



Key

Typical voltage rating V AC	A	B	ØC	D	E	F	ØG
230	max.	nom.	nom.	max.	nom.	nom.	max.
690	48	0,8	6,4	5,6	19	5,6	7,9
	62	0,8	6,4	5,6	19	5,6	7,9

NOTE For DC and VSI voltage ratings consult the manufacturer.

Figure CC.4 – Striker fuse-links

CC.3 System of fuse-links with bolted connections, type B – DIN

CC.3.1 Scope

The following supplementary requirements apply to fuse-links having bolted connections, whose dimensions comply with the requirements given in Figure CC.5 and Figure CC.6. They have rated currents up to 1 250 A and rated voltages up to 1 250 V AC.

CC.3.2 Mechanical design (see 8.1 of IEC 60269-1:2024)

The standardized dimensions of the fuse-links are given in Figure CC.5 and Figure CC.6.

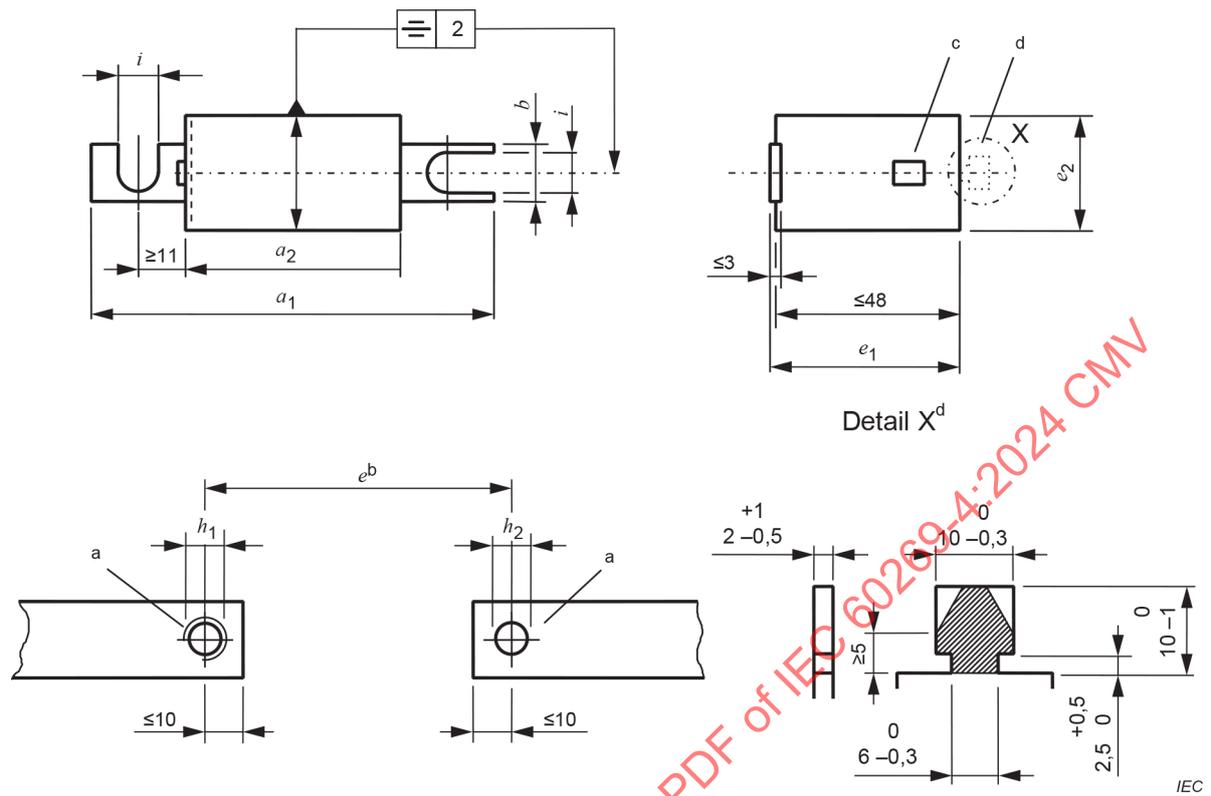
Fuse-links with other fixing dimensions, for example elongated holes, longitudinal or cross-slots, shall be agreed between manufacturer and user.

CC.3.3 Construction of a fuse-link

If the fuse-link is provided with an indicator or striker, then its position has to be agreed between the manufacturer and user.

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Dimensions in millimetres

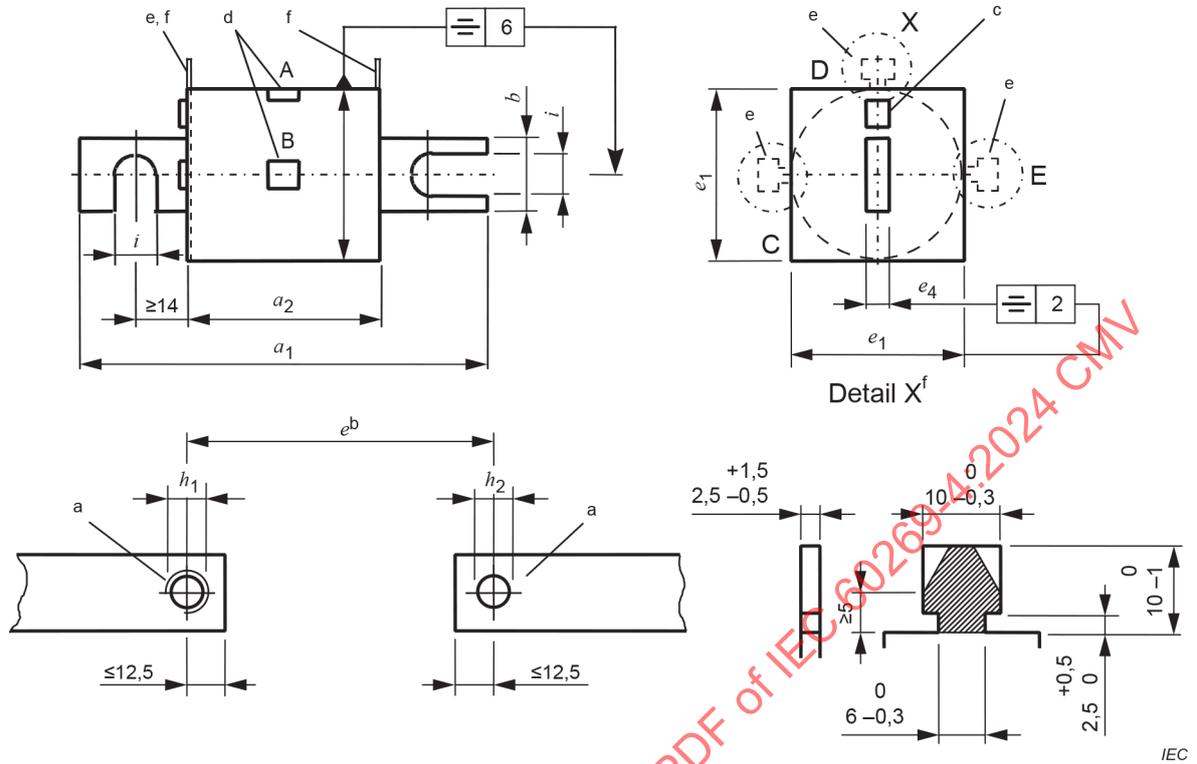


Key

Body size	e ± 2	$a1$ max.	$a2$ max.	b min.	$e1$ max.	$e2$ max.	$h1$	$h2$ $+0,3$ 0	i 0 $-0,5$
000	80	105	56	20	51	21	M8	9	9
00	80	105	56	20	51	30	M10	11	11
	110	140	86						

Figure CC.5 – Fuse-links with bolted connections, type B, body sizes 000 and 00

Dimensions in millimetres



Key

Body size	e ± 2	a_1 max.	a_2 max.	b min.	e_1 max.	e_4 max.	h_1	h_2 $+0,3$ 0	i 0 $-0,5$
0	80 110	110 150	50 80	19	45	6,5	M10	11	11
1	80 110	110 150	50 80	24	53	6,5	M10	11	11
2	80 110	110 150	50 80	24	61	6,5	M10	11	11
3	80 110 170 210	110 150 210 250	50 80 140 180	29	76	6,5	M12 7)	13	13 8)

- 1) Thread or corresponding through-hole for flat terminations
- 2) Distance of terminals
- 3) Indicator or striker (if required)
- 4) Indicator or striker, position A or B (if required)
- 5) Alternative positions C, D and E for lug for signalling device (if required)
- 6) Gripping lugs, dimensions according to Figure 101 of IEC 60269-2:2013/AMD2:2024 (if required)
- 7) M10 also possible
- 8) 11 also possible for M10

Figure CC.6 – Fuse-links with bolted connections, type B, body sizes 0, 1, 2 and 3

CC.4 System of fuse-links with bolted connections, type C – North American

CC.4.1 Scope

The following supplementary requirements apply to fuse-links having bolted connections, whose dimensions comply with the requirements given in Figure CC.7. Their AC rated voltages (see CC.4.3) and currents are as follows:

- 130/150 V AC up to 1 000 A;
- 250/300 V AC up to 800 A;
- 500 V AC up to 1 200 A;
- 700 V AC up to 600 A;
- 1 000 V AC up to 800 A.

For DC voltage ratings, see CC.4.4.

CC.4.2 Mechanical design (see 8.1 of IEC 60269-1:2024)

The standardized dimensions of the fuse-links are given in Figure CC.7.

CC.4.3 Table 104

The power-frequency recovery voltage shall be:

$$U_{\text{Test}} = 100 \begin{matrix} +5 \\ -0 \end{matrix} \% \text{ of the rated voltage.}$$

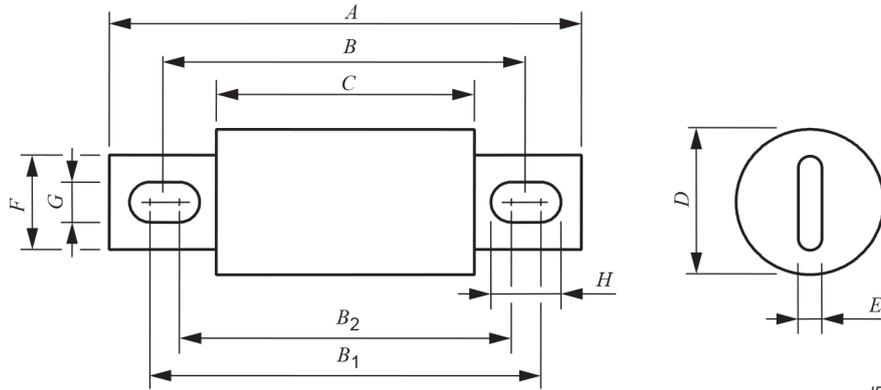
CC.4.4 Table 105

The mean value of the recovery voltage shall be:

$$100 \begin{matrix} +5 \\ -9 \end{matrix} \% \text{ of the rated voltage.}$$

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Dimensions in millimetres



Key

Typical voltage rating V AC.	Preferred current rating A	<i>A</i>	<i>B</i>	<i>B</i> ₁	<i>B</i> ₂	<i>C</i>	<i>D</i>	<i>E</i>	<i>F</i>	<i>G</i>	<i>H</i>
		max.	nom.	max.	min.	max.	max.	max.	min.	max.	max.
150	50 to 450	69,1	52,4	57,5	45	31	29,1	5,2	22,6	8,3	20,9
	500 to 1 000	90,6	62,0	67	47,5	33,4	40,9	6,8	25,8	10,7	30,2
250/300	35 to 60	82,6	61,9	67,5	55,5	42,9	21	3,6	19,5	9,1	21,1
	65 to 200	81,1	60,3	64	54	42,9	31,8	5,2	25,8	9,1	19,1
	225 to 800	99,2	70,6	79	55,5	42,1	51,2	6,8	25,4	12,3	25,6
500	35 to 60	92,6	62,7	75	54	54,1	25,4	3,6	19,5	9,1	30,1
	65 to 100	93,5	73,0	79	66,5	55,6	25,8	3,7	19,5	9,3	21,8
	110 to 200	93,8	73,0	76,5	66,5	55,7	31,4	5,2	25,8	9,1	19,1
	225 to 400	111,9	83,3	89	68	54,8	38,5	6,8	25,8	11,4	32,4
	450 to 600	115,6	86,5	91,5	69	58	51,2	6,8	38,5	12,3	33,8
	700 to 800	166	110,0	128	85,5	58	63,9	10,1	51,2	15,9	58,4
	900 to 1 200	178,6	127,0	140	110	84,2	77,4	11,5	60,7	17,9	47,9
700	35 to 60	112,6	92,1	100	72	74,6	25,8	5,2	19	10,7	38,7
	65 to 100	113,6	92,1	95,5	72	74,6	31,4	5,2	19	10,7	34,2
	110 to 200	131	102,4	108	72	73,8	38,5	6,8	25,8	12,3	48,3
	225 to 400	131	102,4	111	73	73,8	51,2	6,8	38,5	14,7	52,7
	450 to 600	181,6	129,4	147	81	73,9	63,9	10,1	38,5	16,3	82,3
1 000	35 to 60	128,6	108,0	111	98	90,5	25,8	5,2	19,5	8,3	21,3
	65 to 100	128,6	108,0	111	104	90,5	31,4	5,2	25,8	9,3	16,3
	110 to 200	146,9	118,4	123	104	89,7	39,3	6,8	25,8	11,7	29,7
	225 to 400	148,1	118,4	124	104	90,5	51,2	6,8	38,5	11,4	31,4
	450 to 800	197,7	150,8	154	117	101,6	89,8	10,1	51,2	16,3	53,3

NOTE For DC and VSI voltage ratings consult the manufacturer.

Figure CC.7 – Bolted fuse-links, type C

CC.5 System of fuse-links with flush end connections type A

CC.5.1 Scope

The following supplementary requirements apply to fuse-links having flush end connections whose dimensions comply with the requirements given in Figure CC.8. They have rated currents up to 5 000 A and rated voltages up to 1 250 V AC.

CC.5.2 Mechanical design (see 8.1 of IEC 60269-1:2024)

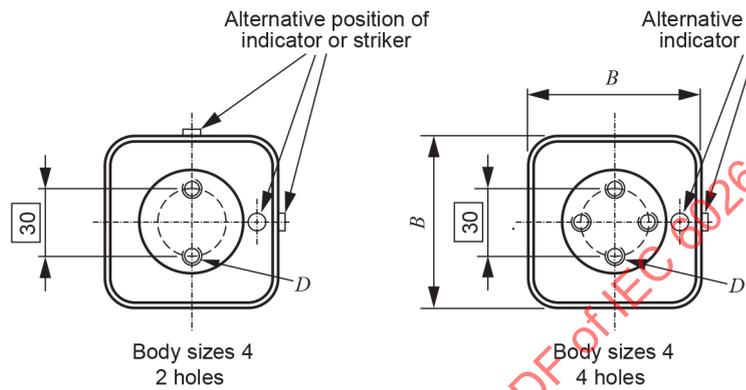
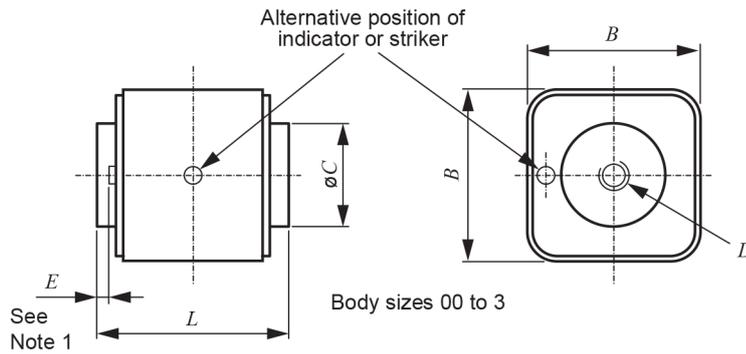
The standardized dimensions of the fuse-links are given in Figure CC.8.

CC.5.3 Construction of a fuse-link

The fuse-links may have indicators or strikers, and if they are fitted, the standardised positions are shown in Figure CC.8.

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Dimensions in millimetres



IEC

Key

Body size	Typical voltage rating V AC	Preferred maximum current rating A	L max.	B max.	C min.	D		E
						Thread	Minimum depth	
00	690	400	65	30×48	15	M8	5	0,2
01	690	630	53	45	17	M8	5	0,2
01	1 000	500	77	45	17	M8	5	0,2
01	1 250	400	82	45	17	M8	5	0,2
1	690	1 000	53	53	19	M8	8	0,3
1	1 000	800	77	53	19	M8	8	0,3
1	1 250	630	82	53	19	M8	8	0,3
2	690	1 600	53	61	23	M10	9	0,4
2	1 000	1 250	77	61	23	M10	9	0,4
2	1 250	1000	82	61	23	M10	9	0,4
3	690	2 500	53	76	28	M12	9	0,5
3	1 000	2 000	93	76	28	M12	9	0,5
3	1 250	1 600	99	76	28	M12	9	0,5
4 hole								
4	690	5 000	67	120	50	M10	9	2,0
4	1 000	4 000	89	120	50	M10	9	2,0
4	1 250	3 150	110	120	50	M10	9	2,0
2 hole								
4	690	5 000	94	120	50	M12	10	2,0
4	1 000	4 000	100	120	50	M12	10	2,0
4	1 250	3 150	120	120	50	M12	10	2,0

NOTE 1 Minimum distance between mounting face and other fuse features.

NOTE 2 Alternative shapes of the end contact are permitted provided the surface area is not less than those shown.

NOTE 3 For DC and VSI voltage ratings consult the manufacturer.

Figure CC.8 – Flush end fuse-links, type A

CC.6 System of fuse-links with flush end connections, type B – North American

CC.6.1 Scope

The following supplementary requirements apply to fuse-links having flush end connections, whose dimensions comply with the requirements given in Figure CC.9. Their AC rated voltages (see CC.6.3) and currents are as follows:

- 130/150 V or 150 V AC up to 6 000 A;
- 250/300 V AC up to 4 500 A;
- 600 V AC up to 2 000 A.

For DC voltage ratings see CC.6.4.

CC.6.2 Mechanical design (see 8.1 of IEC 60269-1:2024)

The standardized dimensions of the fuse-links are given in Figure CC.9.

CC.6.3 Table 104

The power-frequency recovery voltage shall be:

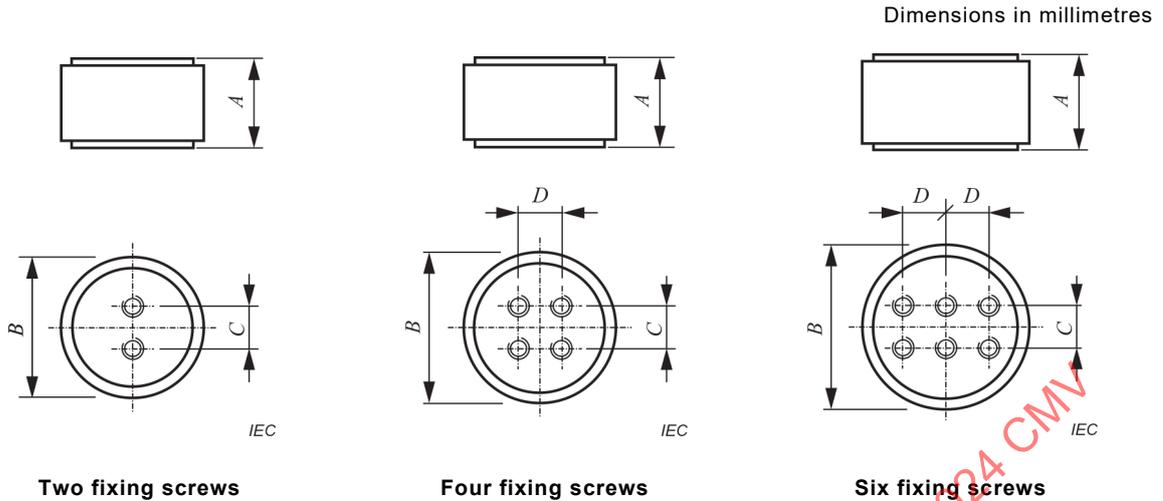
$$U_{\text{Test}} = 100 \begin{matrix} +5 \\ -0 \end{matrix} \% \text{ of the rated voltage.}$$

CC.6.4 Table 105

The mean value of the recovery voltage shall be:

$$100 \begin{matrix} +5 \\ -9 \end{matrix} \% \text{ of the rated voltage.}$$

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Key

Typical voltage rating V AC	Preferred current rating A	A max.	B max.	C max.	D max.	Thread inches ^a	Fixing screws
130/150	1 000 to 2 000	49,2	51,2	25,8		3/8"-24 × 1/2"	2
	2 500 to 3 000	49,2	76,6	38,5		1/2"-20 × 1/2"	2
	3 500 to 4 000	49,2	89,5	38,5	38,5	1/2"-20 × 1/2"	4
	5 000 to 6 000	61,9	146,5	38,5	38,5	1/2"-20 × 1/2"	6
250/300	800 to 1 200	67,4	76,6	38,5		3/8"-24 × 1/2"	2
	1 500 to 2 500	67,4	89,5	38,5	38,5	3/8"-24 × 1/2"	4
	3 000 to 4 500	67,4	114,7	38,5	38,5	1/2"-20 × 1/2"	4
600	700 to 800	103,2	76,6	38,5		3/8"-24 × 1/2"	2
	1 000 to 1 200	103,2	89,5	38,5	38,5	3/8"-24 × 1/2"	4
	1 500 to 2 000	103,2	114,7	38,5	38,5	1/2"-20 × 1/2"	4

^a Diameter – threads per inch × depth.

NOTE For DC. and VSI voltage ratings consult the manufacturer.

Figure CC.9 – Flush end fuse-links, type B

CC.7 System of fuse-links having cylindrical contact caps, type A – North American

CC.7.1 Scope

The following supplementary requirements apply to fuse-links having cylindrical contact caps whose dimensions comply with the requirements given in Figure CC.10. Their AC. rated voltages (see CC.7.3) and currents are as follows:

- 150 V AC 35A to 60A;
- 600 V AC 1 to 30 A;
- 1 000 V AC 1 to 30 A.

For DC voltage ratings see CC.7.4.

CC.7.2 Mechanical design (see 8.1 of IEC 60269-1:2024)

The standardized dimensions of the fuse-links are given in Figure CC.10.

CC.7.3 Table 104

The power-frequency recovery voltage shall be:

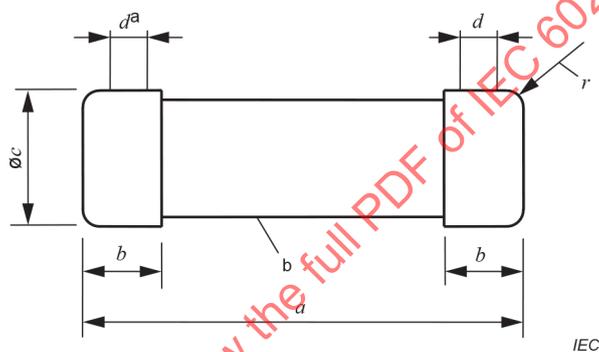
$$U_{\text{Test}} = 100 \begin{matrix} +5 \\ -0 \end{matrix} \% \text{ of the rated voltage.}$$

CC.7.4 Table 105

The mean value of the recovery voltage shall be:

$$U_{\text{Test}} = 100 \begin{matrix} +5 \\ -0 \end{matrix} \% \text{ of the rated voltage.}$$

Dimensions in millimetres

**Key**

Typical voltage rating	Preferred maximum current rating	<i>a</i>	<i>b</i>	<i>c</i>	<i>d</i>	<i>r</i>
V AC	A		max.		min.	
150	35-60	$51 \begin{matrix} +0,6 \\ -1 \end{matrix}$	15,9	$20,6 \pm 0,2$	6	2 ± 1
600	1-30	$127 \begin{matrix} +0,6 \\ -3 \end{matrix} \pm 2$	16,2	$20,6 \pm 0,2$	11	2 ± 1
1 000	1-30	$66,7 \begin{matrix} +0,6 \\ -2 \end{matrix}$	16,2	$14,5 \pm 0,2$	11	2 ± 1

NOTE For DC. and VSI voltage ratings consult the manufacturer.

^a Cylindrical part within which the specified tolerances shall not be exceeded.

^b The diameter of the cartridge between the end caps shall not exceed diameter *c*.

Figure CC.10 – Fuse-links with cylindrical contact caps, type A

CC.8 System of fuse-links having cylindrical contact caps, type B – French

CC.8.1 Scope

The supplementary requirements apply to fuse-links having cylindrical contact caps whose dimensions comply with the requirements given in Figure CC.11 and Figure CC.12. The preferred rated voltages and corresponding rated currents are as follows (see Table CC.1):

Table CC.1 – Typical rated voltages and preferred maximum rated currents

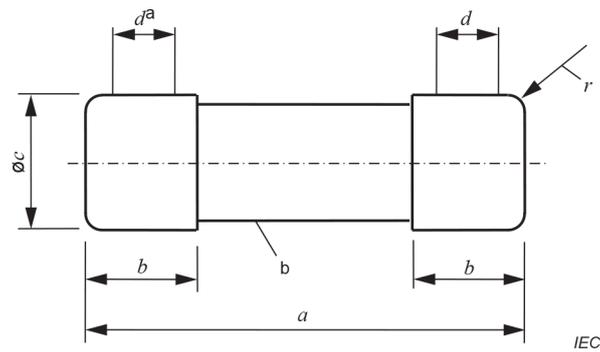
Typical voltage rating	Preferred maximum current rating	Size
V AC.	A	
600	63	14 × 51
600	125	22 × 58
690	32	10 × 38
690	50	14 × 51
690	100	22 × 58
690	250	27 × 60
800	100	27 × 60
1 500	63	20 × 127
1 500	63	22 × 127
1 500	100	36 × 127
2 500	25	20 × 127
3 000	63	20 × 190
3 000	100	36 × 190

NOTE For DC and VSI voltage ratings consult the manufacturer.

CC.8.2 Mechanical design (see 8.1 of IEC 60269-1:2024)

The standardized dimensions of the fuse-links are given in Figure CC.11 and Figure CC.12.

Dimensions in millimetres



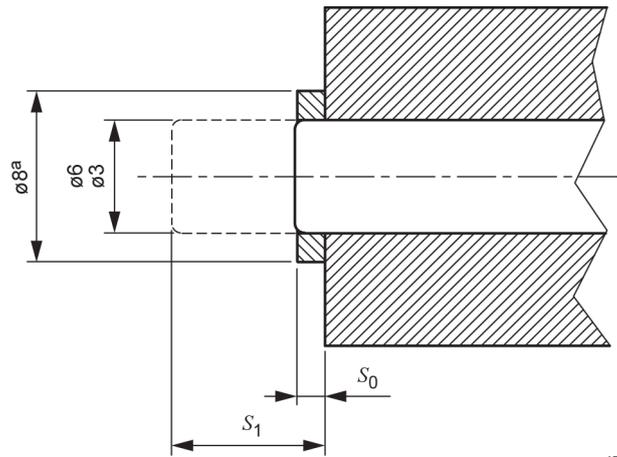
The drawings are not intended to govern the design of fuse-links except as regards the notes and dimensions shown.

Size	a	b max.	c	d min.	r
10 × 38	38 ^{+0,9} _{-0,6}	10,5	10,3 ± 0,1	6	1,5 ± 0,5
14 × 51	51 ^{+0,6} ₋₁	13,8	14,3 ± 0,1	7,5	2 ± 1
22 × 58	58 ^{+0,1} ₋₂	16,2	22,2 ± 0,1	11	2 ± 1
27 × 60	60.3 ± 0.8	16.3	27 ± 0,2	14	1,7 ± 1
20 × 127	127 ± 1	16.2	20,6 ± 0,2	10.8	2 ± 1
20 × 190	188 ± 2 ³⁾	16,2	20,6 ± 0,2	10,8	2 ± 1
22 × 127	127 ± 2 ³⁾	16,2	22,2 ± 0,1	11	2 ± 1
36 × 127	127 ± 1	27	36,3 ± 1	24.7	2 ± 1
36 × 190	188 ± 2 ³⁾	27	36,3 ± 1	24.7	2 ± 1

- a Cylindrical part within which the specified tolerances shall not be exceeded.
 b The diameter of the cartridge between the end caps shall not exceed diameter c .
 c For striker versions, the tolerance is ± 1.

Figure CC.11 – Fuse-links with cylindrical contact caps, type B

Dimensions in millimetres



Key

S_0 1 mm maximum

S_1 7 mm to 10 mm

^a Diameter of cylinder in which the striker must stay

NOTE The overall length a (see Figure CC.11) does not include S_0 .

The drawing is not intended to govern the design of fuse-links except as regards the notes and dimensions shown.

**Figure CC.12 – Fuse-links with cylindrical contact caps with striker, type B
(additional dimensions for all sizes except 10 × 38)**

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IEC 60664-1:2020, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

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COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

FUSIBLES BASSE TENSION –

Partie 4: Exigences supplémentaires concernant les éléments de remplacement utilisés pour la protection des dispositifs à semiconducteurs

AVANT-PROPOS

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Cette sixième édition annule et remplace la cinquième édition parue en 2009, l'Amendement 1:2012 et l'Amendement 2:2016. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

- a) les éléments de remplacement pour onduleur à source de tension ont été ajoutés, y compris les exigences d'essai;
- b) les essais des caractéristiques de fonctionnement en courant alternatif sont couverts par les essais du pouvoir de coupure;
- c) les exemples d'éléments de remplacement normalisés pour la protection des dispositifs à semiconducteurs ont été mis à jour.

Le texte de cette Norme internationale est issu des documents suivants:

Projet	Rapport de vote
32B/746/FDIS	32B/753/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à son approbation.

La langue employée pour l'élaboration de cette Norme internationale est l'anglais.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2, il a été développé selon les Directives ISO/IEC, Partie 1 et les Directives ISO/IEC, Supplément IEC, disponibles sous www.iec.ch/members_experts/refdocs. Les principaux types de documents développés par l'IEC sont décrits plus en détail sous www.iec.ch/standardsdev/publications.

La présente partie doit être utilisée conjointement avec l'IEC 60269-1:2024, *Fusibles basse tension – Partie 1: Exigences générales*.

La présente Partie 4 complète ou modifie les articles ou paragraphes correspondants de la Partie 1.

Lorsqu'aucune modification n'est nécessaire, la Partie 4 indique que l'article ou le paragraphe correspondant s'applique.

Les tableaux et figures qui s'ajoutent à ceux de la Partie 1 sont numérotés à partir de 101.

Les annexes qui sont ajoutées sont désignées AA, BB, etc.

Une liste de toutes les parties de la série IEC 60269, publiées sous le titre général *Fusibles basse tension*, se trouve sur le site web de l'IEC.

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FUSIBLES BASSE TENSION –

Partie 4: Exigences supplémentaires concernant les éléments de remplacement utilisés pour la protection des dispositifs à semiconducteurs

1 Domaine d'application

L'IEC 60269-1 s'applique avec les exigences supplémentaires suivantes.

Sauf indication contraire dans le texte qui suit, les éléments de remplacement utilisés pour la protection des dispositifs à semiconducteurs doivent satisfaire à l'ensemble des exigences de l'IEC 60269-1 ainsi qu'aux exigences supplémentaires ci-après.

Les présentes exigences supplémentaires s'appliquent aux éléments de remplacement destinés à être associés à des matériels comportant des dispositifs à semiconducteurs et utilisés dans des circuits de tensions nominales inférieures ou égales à 1 000 V en courant alternatif ou à 1 500 V en courant continu. Pour certains éléments de remplacement, des tensions assignées supérieures peuvent être utilisées.

NOTE Ces éléments de remplacement sont couramment dénommés "éléments de remplacement pour semiconducteurs".

Les présentes exigences supplémentaires ont pour objet d'établir les caractéristiques des éléments de remplacement pour semiconducteurs de sorte qu'ils puissent être remplacés par d'autres éléments de remplacement de mêmes caractéristiques, sous réserve que leurs dimensions soient identiques. À cette fin, la présente norme traite en particulier:

- a) des caractéristiques suivantes des fusibles:
 - 1) leurs valeurs assignées;
 - 2) leurs échauffements en service normal;
 - 3) leur puissance dissipée;
 - 4) leurs caractéristiques temps-courant;
 - 5) leur pouvoir de coupure;
 - 6) leurs caractéristiques de courant coupé limité et caractéristiques I^2t ;
 - 7) leurs caractéristiques de tension d'arc;
- b) les essais de type destinés à vérifier les caractéristiques des fusibles;
- c) les marquages des fusibles;
- d) la disponibilité et la présentation des données techniques (voir l'Annexe BB).

2 Références normatives

Les documents suivants sont cités dans le texte de sorte qu'ils constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60269-1:2024, *Fusibles basse tension – Partie 1: Exigences générales*

IEC 60269-2:2013, *Fusibles basse tension – Partie 2: Exigences supplémentaires pour les fusibles destinés à être utilisés par des personnes habilitées (fusibles pour usages essentiellement industriels) – Exemples de systèmes de fusibles normalisés A à K*

IEC 60269-2:2013/AMD1:2016

IEC 60269-2:2013/AMD2:2024

IEC TR 60269-5:2014, *Fusibles basse tension – Partie 5: Lignes directrices pour l'application des fusibles basse tension*

IEC TR 60269-5:2014/AMD1:2020

IEC 60417, *Symboles graphiques à utiliser sur les équipements*

ISO 3, *Nombres normaux – Séries de nombres normaux*

3 Termes et définitions

L'IEC 60269-1 s'applique, avec les définitions supplémentaires suivantes

3.2 Termes généraux

3.2.101

dispositif à semiconducteurs

dispositif dont les caractéristiques essentielles sont dues au flux de porteurs de charges à l'intérieur d'un semiconducteur

[SOURCE: IEC 60050-521:2002, 521-04-01]

3.2.102

élément de remplacement pour semiconducteurs

élément de remplacement limiteur de courant capable d'interrompre, dans des conditions spécifiques, tout courant à l'intérieur de la zone de coupure (voir le 7.4)

3.2.103

dispositif de signalisation

dispositif incorporé dans le fusible et signalant le fonctionnement du fusible à distance

Note 1 à l'article: Un dispositif de signalisation consiste en un percuteur et en un interrupteur auxiliaire. Des dispositifs électroniques peuvent également être utilisés.

3.2.104

onduleur à source de tension

VSI

onduleur à source de tension

Note 1 à l'article: L'abréviation "VSI" est dérivée du terme anglais développé correspondant "voltage source inverter".

Note 2 à l'article: Également appelé "onduleur alimenté par une source de tension imposée", autrement dit un onduleur qui fournit un courant sans modifier sa tension de sortie.

[SOURCE: IEC 60050-551:1998, 551-12-11]

3.2.105

élément de remplacement pour onduleur à source de tension élément de remplacement VSI

élément de remplacement limiteur de courant capable d'interrompre, dans les conditions spécifiées, le courant de court-circuit fourni par la décharge d'un condensateur connecté au courant continu, dans un onduleur à source de tension

Note 1 à l'article: L'abréviation "élément de remplacement VSI" est utilisée dans le présent document.

Note 2 à l'article: Un élément de remplacement VSI fonctionne généralement à un courant de court-circuit fourni par la décharge d'un condensateur connecté au courant continu à travers une très faible inductance, dans le but de permettre un fonctionnement normal à hautes fréquences. Cette condition de court-circuit conduit à un taux d'accroissement du courant très élevé équivalent à une très faible valeur de la constante de temps, généralement inférieure ou égale à 3 ms. La tension d'alimentation est un courant continu même si la tension appliquée diminue lorsque le courant augmente durant le court-circuit.

Note 3 à l'article: Dans certaines applications d'entraînements à plusieurs sources en courant alternatif, la sortie des onduleurs peut être éloignée de l'entrée principale du redresseur. Dans ces cas, les impédances liées à un circuit en défaut peuvent influencer le fonctionnement des éléments de remplacement. Il est alors nécessaire de tenir compte de la constante de temps associée et de la taille des condensateurs lors du choix de la protection appropriée contre les courts-circuits.

4 Conditions de fonctionnement en service

L'IEC 60269-1 s'applique avec les exigences supplémentaires suivantes.

Les fusibles doivent être utilisés conformément à leurs valeurs assignées uniquement.

4.5 Tension

4.5.1 Tension assignée

En courant alternatif, la tension assignée d'un élément de remplacement se rapporte à la tension appliquée; elle est fondée sur la valeur efficace d'une tension en courant alternatif sinusoïdale. De plus, il est admis par hypothèse que la tension appliquée se maintient à la même valeur pendant toute la durée de fonctionnement de l'élément de remplacement. Tous les essais de vérification des valeurs assignées reposent sur cette hypothèse.

En courant continu et pour les éléments de remplacement VSI, la tension assignée d'un élément de remplacement se rapporte à la tension appliquée. Elle repose sur la valeur moyenne. Dans le cas d'un courant continu obtenu par redressement du courant alternatif, il est admis par hypothèse que les ondulations ne provoquent pas une variation supérieure à 5 % ou inférieure à 9 % de la valeur moyenne.

4.5.2 Tension appliquée en service

Dans les conditions de service, la tension appliquée est la tension qui, dans le circuit en défaut, provoque une augmentation du courant telle que l'élément de remplacement se déclenche.

En courant alternatif, par conséquent, la valeur de la tension appliquée dans un circuit monophasé à courant alternatif est généralement identique à la tension de rétablissement à fréquence industrielle. Pour les cas autres que celui de la tension en courant alternatif sinusoïdale, il est nécessaire de connaître la tension appliquée en fonction du temps.

Pour une tension unidirectionnelle et pour les éléments de remplacement VSI, les valeurs importantes sont:

- la valeur moyenne sur l'ensemble de la durée de fonctionnement de l'élément de remplacement;
- la valeur instantanée vers la fin de la période d'arc.

4.6 Courant

Le courant assigné d'un élément de remplacement pour semiconducteurs est fondé sur la valeur efficace d'un courant alternatif sinusoïdal à fréquence assignée.

En courant continu, il est admis par hypothèse que la valeur efficace du courant ne dépasse pas la valeur efficace fondée sur un courant alternatif sinusoïdal à fréquence assignée.

NOTE Le temps de réponse thermique de l'élément fusible peut avoir une valeur si faible qu'il ne peut pas être admis par hypothèse qu'un fonctionnement dans des conditions s'écartant sensiblement du courant sinusoïdal peut être estimé en se fondant sur la seule valeur efficace du courant. Cela s'applique en particulier à des fréquences de valeur moins élevée et lorsque le courant présente des pointes importantes alternant avec des intervalles considérables de valeurs de courant insignifiantes, comme c'est le cas dans les convertisseurs de fréquence ou les applications de traction par exemple.

4.7 Fréquence, facteur de puissance et constante de temps

4.7.1 Fréquence

La fréquence assignée se rapporte à la fréquence de la tension et du courant sinusoïdaux qui constituent l'objet des essais de type.

4.7.3 Constante de temps (τ)

En courant continu, les constantes de temps indiquées dans le Tableau 105 correspondent aux constantes de temps susceptibles d'être rencontrées dans la pratique.

Pour les éléments de remplacement VSI, les constantes de temps indiquées dans le Tableau 106 correspondent à des constantes de temps équivalentes susceptibles d'être rencontrées dans la pratique.

NOTE 2 Le taux d'accroissement élevé du courant de court-circuit est dû à la faible inductance, qui est considérée comme équivalente à une faible valeur de la constante de temps.

NOTE 3 Il est possible d'utiliser di/dt en lieu et place de la constante de temps en cas de condition de court-circuit.

$di/dt = E/L$.

E = valeur de la tension de la source de puissance en courant continu;

L = inductance totale du circuit de décharge des condensateurs.

5 Classification

L'IEC 60269-1 s'applique.

6 Caractéristiques des fusibles

L'IEC 60269-1 s'applique avec les exigences supplémentaires suivantes.

6.1 Récapitulatif des caractéristiques

6.1.3 Éléments de remplacement

- a) Tension assignée (voir le 6.2)
- b) Courant assigné (voir le 6.3 de l'IEC 60269-1:2024)
- c) Type du courant et fréquence (voir le 6.4 de l'IEC 60269-1:2024)
- d) Puissance dissipée assignée (voir le 6.5 de l'IEC 60269-1:2024)
- e) Caractéristiques temps-courant (voir le 6.6)
- f) Zone de coupure (voir le 6.7.1 de l'IEC 60269-1:2024)

- g) Pouvoir de coupure assigné (voir le 6.7.2 de l'IEC 60269-1:2024)
- h) Caractéristiques de courant coupé limité (voir le 6.8.2)
- i) Caractéristiques I^2t (voir le 6.8.3)
- j) Dimensions ou taille (s'il y a lieu)
- k) Caractéristiques de tension d'arc (voir le 6.9)
- l) Les éléments de remplacement ne peuvent être utilisés qu'avec le socle et/ou l'ensemble-porteur attribué par le fabricant et défini dans les instructions de ce dernier

6.2 Tension assignée

Pour les tensions assignées inférieures ou égales à 690 V en courant alternatif et à 750 V en courant continu, l'IEC 60269-1 s'applique. Pour les tensions supérieures, les valeurs doivent être choisies dans la série R 5 ou, si cela n'est pas possible, dans la série R 10 de l'ISO 3.

Un élément de remplacement doit avoir une tension assignée en courant alternatif ou en courant continu ou une tension assignée VSI. Il peut avoir une ou plusieurs de ces tensions assignées.

6.4 Fréquence assignée

La fréquence assignée est la fréquence à laquelle se rapportent les caractéristiques de fonctionnement.

6.5 Puissance dissipée assignée de l'élément de remplacement et puissance dissipée acceptable assignée pour un ensemble-porteur

En plus des exigences de l'IEC 60269-1, le fabricant doit indiquer la puissance dissipée en fonction du courant pour la plage comprise entre 50 % et 100 % du courant assigné.

Lorsqu'il est pertinent de connaître la résistance de l'élément de remplacement, il convient de déterminer celle-ci en se fondant sur la relation fonctionnelle entre la puissance dissipée et la valeur de courant correspondante.

6.6 Limites des caractéristiques temps-courant

6.6.2 Caractéristiques temps-courant, zones temps-courant

6.6.2.1 Exigences générales

Les caractéristiques temps-courant dépendent de la conception de l'élément de remplacement ainsi que, pour un élément de remplacement donné, de la température de l'air ambiant et des conditions de refroidissement.

Le fabricant doit fournir des caractéristiques temps-courant pour une température ambiante comprise entre 20 °C et 25 °C conformément aux conditions spécifiées en 9.3. Les caractéristiques temps-courant pertinentes sont les caractéristiques de préarc et de fonctionnement.

En courant alternatif, les caractéristiques temps-courant sont établies à la fréquence assignée et pour des durées de préarc et de fonctionnement supérieures à 0,1 s.

En courant continu, elles sont établies conformément au Tableau 105 et pour des durées de préarc et de fonctionnement supérieures à 15 τ .

Pour les valeurs de courant présumé plus élevées (durées plus courtes), les mêmes données doivent être présentées sous forme de caractéristiques I^2t (voir le 6.8.2).

6.6.2.2 Caractéristiques temps-courant de préarc

En courant alternatif, la caractéristique temps-courant de préarc doit être fondée sur un courant alternatif symétrique d'une fréquence donnée (fréquence assignée).

En courant continu, la caractéristique temps-courant de préarc présente une importance particulière pour des durées supérieures à 15τ pour le circuit considéré. Dans cette zone, elle est identique à la caractéristique temps-courant de préarc en courant alternatif.

NOTE 1 En raison du grand nombre de constantes de temps du circuit susceptibles d'être rencontrées en service, une méthode pratique consiste à exprimer les données relatives à des durées inférieures à 15τ sous forme de caractéristique I^2t de préarc.

NOTE 2 La valeur de 15τ a été choisie pour éviter les effets des différents taux d'accroissement du courant sur la caractéristique temps-courant de préarc à des temps plus courts.

6.6.2.3 Caractéristiques temps-courant de fonctionnement

En courant alternatif avec des durées supérieures à 0,1 s et en courant continu pour des durées supérieures à 15τ , la période d'arc n'est pas significative par rapport à la durée de préarc. La durée de fonctionnement est alors équivalente à la durée de préarc.

6.6.3 Courants et temps conventionnels

6.6.3.1 Courants et temps conventionnels pour les éléments de remplacement "aR"

Voir le 8.4 et le Tableau 101.

6.6.3.2 Courants et temps conventionnels pour les éléments de remplacement "gR" et "gS"

Les courants et temps conventionnels sont indiqués dans le Tableau 101.

Tableau 101 – Courant et temps conventionnels pour les éléments de remplacement "gR" et "gS"

Courant assigné A	Temps conventionnel h	Courant conventionnel			
		Type "gR"		Type "gS"	
		I_{nf}	I_f	I_{nf}	I_f
$I_n \leq 4$	1	$1,1 I_n$	$2,1 I_n$	$1,5 I_n$	$2,1 I_n$
$4 < I_n < 16$	1	$1,1 I_n$	$1,9 I_n$	$1,5 I_n$	$1,9 I_n$
$16 \leq I_n \leq 63$	1				
$63 < I_n \leq 160$	2				
$160 < I_n \leq 400$	3	$1,1 I_n$	$1,6 I_n$	$1,25 I_n$	$1,6 I_n$
$400 < I_n$	4				

NOTE Les temps conventionnels s'appliquent également aux fusibles "aR".

6.6.4 Balises

Ne s'applique pas.

6.7 Zone de coupure et pouvoir de coupure

6.7.1 Zone de coupure et catégorie d'emploi

La première lettre doit indiquer la zone de coupure:

- éléments de remplacement "a" (pouvoir de coupure partiel, voir le 8.4);
- éléments de remplacement "g" (pouvoir de coupure intégral).

La seconde lettre "R" ou "S" doit indiquer la catégorie d'emploi pour les éléments de remplacement conformes à la présente norme pour la protection des dispositifs à semiconducteurs.

Le type "R" est généralement plus rapide que le type "S" et donne des valeurs I^2t inférieures.

Le type "S" a généralement une puissance dissipée inférieure et permet d'améliorer l'utilisation des conducteurs par rapport au type "R".

Par exemple:

- aR désigne les éléments de remplacement à pouvoir de coupure partiel qui sont destinés à la protection des dispositifs à semiconducteurs;
- gR désigne les éléments de remplacement à pouvoir de coupure intégral qui sont destinés à la protection des semiconducteurs et à un usage général, optimisés pour réduire les valeurs I^2t ;
- gS désigne les éléments de remplacement à pouvoir de coupure intégral qui sont destinés à la protection des semiconducteurs et à un usage général, optimisés pour réduire la puissance dissipée.

Certains éléments de remplacement aR sont utilisés pour la protection des onduleurs à source de tension. Même si ce sont des éléments de remplacement aR ordinaires en courant alternatif, ceux-ci doivent être soumis à l'essai différemment dans des conditions de court-circuit VSI en courant continu. C'est pourquoi leur désignation est toujours "aR", mais leurs caractéristiques en courant continu doivent être clairement spécifiées "pour la protection des VSI" dans le catalogue du fabricant.

6.7.2 Pouvoir de coupure assigné

Un pouvoir de coupure supérieur ou égal à 50 kA en courant alternatif et à 20 kA en courant continu est exigé.

En courant alternatif, le pouvoir de coupure assigné est fondé sur des essais de type effectués dans un circuit d'impédance exclusivement linéaire, en appliquant une tension sinusoïdale constante de fréquence assignée.

En courant continu, le pouvoir de coupure assigné est fondé sur des essais de type effectués dans un circuit d'inductance et de résistance exclusivement linéaires, en appliquant une tension moyenne.

Pour les VSI, le pouvoir de coupure assigné est fondé sur des essais de type effectués dans un circuit avec une faible constante de temps. La constante de temps pour les essais est définie dans le Tableau 106. Le pouvoir de coupure assigné maximal exigé pour les fusibles VSI est de 20 kA au minimum.

NOTE Dans la pratique, l'adjonction d'impédances non linéaires et de composantes de tension unidirectionnelles peut avoir une incidence favorable ou défavorable significative sur les conditions de coupure.

6.8 Caractéristiques de courant coupé limité et caractéristiques I^2t

6.8.2 Caractéristiques de courant coupé limité

Le fabricant doit fournir les caractéristiques de courant coupé limité qui doivent être représentées, conformément à l'exemple représenté sur la Figure 4 de l'IEC 60269-1:2024, sur un graphique à double échelle logarithmique en portant le courant présumé en abscisse et, si nécessaire, la tension appliquée et/ou la fréquence comme paramètre.

En courant alternatif, les caractéristiques de courant coupé limité doivent représenter les valeurs les plus élevées du courant susceptibles d'être rencontrées en service. Elles doivent se rapporter à des conditions correspondant aux conditions d'essai établies dans la présente norme, par exemple à des valeurs données de la tension, de la fréquence et du facteur de puissance. Les caractéristiques de courant coupé limité peuvent être définies par les essais spécifiés en 9.6.

En courant continu, les caractéristiques de courant coupé limité doivent représenter les valeurs les plus élevées du courant susceptibles d'être rencontrées en service dans des circuits dont la constante de temps est spécifiée dans le Tableau 105 pour les éléments de remplacement aR, gS et gR ou dans le Tableau 106 pour les éléments de remplacement aR dans les applications VSI. Pour les éléments de remplacement aR, gS et gR, ces valeurs sont dépassées dans les circuits dont les constantes de temps sont inférieures aux valeurs indiquées dans le Tableau 105. Le fabricant doit fournir les informations pertinentes pour permettre de déterminer les valeurs les plus élevées des caractéristiques de courant coupé limité.

NOTE La caractéristique de courant coupé limité varie en fonction de la constante de temps du circuit. Il convient que le fabricant fournisse les informations permettant de déterminer ces variations au moins pour les constantes de temps de 5 ms et de 10 ms.

6.8.3 Caractéristiques I^2t

6.8.3.1 Caractéristique I^2t de préarc

En courant alternatif, le fabricant doit fournir la caractéristique I^2t de préarc fondée sur un courant alternatif symétrique d'une fréquence donnée (fréquence assignée).

En courant continu, le fabricant doit fournir la caractéristique I^2t de préarc fondée sur la valeur efficace du courant à une constante de temps spécifiée dans le Tableau 105 pour les éléments de remplacement aR, gS et gR ou dans le Tableau 106 pour les éléments de remplacement aR dans les applications VSI.

En courant continu, la valeur I^2t de préarc représente la valeur la plus faible susceptible d'être rencontrée en service. Elle doit être fondée sur la valeur efficace d'un courant continu, comme cela est défini dans les exigences d'essai de l'essai du pouvoir de coupure n° 1.

6.8.3.2 Caractéristiques I^2t de fonctionnement

En courant alternatif, le fabricant doit fournir les caractéristiques I^2t de fonctionnement indiquées avec la tension appliquée comme paramètre et pour un facteur de puissance donné. En principe, elles doivent être fondées sur l'instant d'établissement du courant qui donne la valeur I^2t de fonctionnement la plus élevée (voir le 9.7). Les paramètres de tension doivent inclure au moins 100 % et 50 % de la tension assignée.

En courant continu, le fabricant doit fournir les caractéristiques I^2t de fonctionnement indiquées avec la tension appliquée comme paramètre et pour une constante de temps spécifiée dans le Tableau 105 pour les éléments de remplacement aR, gS et gR ou dans le Tableau 106 pour les éléments de remplacement aR dans les applications VSI. Les paramètres de tension doivent inclure au moins 100 % et 50 % de la tension assignée. Il est admis de déterminer les caractéristiques I^2t de fonctionnement à des tensions moins élevées par rapport aux essais selon le Tableau 105 ou le Tableau 106 en fonction de leur application en courant continu ou dans une application VSI.

La caractéristique I^2t à des tensions réduites peut être calculée selon la méthode décrite dans la Partie 1, Annexe B3.

6.9 Caractéristiques de la tension d'arc

Les caractéristiques de la tension d'arc fournies par le fabricant doivent indiquer la valeur (de crête) la plus élevée de la tension d'arc en fonction de la tension appliquée du circuit dans lequel est inséré l'élément de remplacement ainsi que, en courant alternatif, pour les valeurs du facteur de puissance spécifiées dans le Tableau 104 et, en courant continu, pour les constantes de temps spécifiées dans le Tableau 105 ou dans le Tableau 106 en fonction de leur application en courant continu ou dans un VSI.

7 Marquages

L'IEC 60269-1 s'applique avec les exigences supplémentaires suivantes.

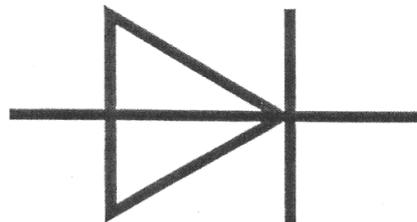
7.2 Marquages des ensembles-porteurs

Le 7.2 de l'IEC 60269-1:2024 s'applique, avec l'ajout suivant:

- référence d'identification du fabricant et/ou symboles permettant de trouver l'ensemble des caractéristiques indiquées en 6.1.3 de l'IEC 60269-1:2024;
- catégorie d'emploi, "aR" ou "gR" ou "gS";
- combinaison des symboles de l'IEC 60417 d'un fusible (5016) et d'un redresseur (5186) comme cela est représenté ci-dessous:



Symbole IEC 60417-5016 (2002-10)



Symbole IEC 60417-5186 (2002-10)

Pour les éléments de remplacement VSI, un marquage supplémentaire indiquant par exemple "VSI de 1 200 V en courant continu" accompagné de la tension assignée doit être apposé sur le produit.

8 Conditions normales d'établissement

L'IEC 60269-1 s'applique avec les exigences supplémentaires suivantes.

8.3 Échauffement, puissance dissipée de l'élément de remplacement et puissance dissipée acceptable pour l'ensemble-porteur

L'élément de remplacement doit être conçu et dimensionné de manière à supporter, lorsqu'il est soumis à l'essai conformément au 9.3, le courant assigné sans dépasser,

- la limite d'échauffement à l'endroit le plus chaud de la partie métallique supérieure de l'élément de remplacement indiqué par le fabricant (voir la Figure 101 et la Figure 102);
- la puissance dissipée au courant assigné indiquée dans les instructions du fabricant.

8.4 Fonctionnement

L'élément de remplacement doit être conçu et dimensionné de manière à supporter d'une façon continue tout courant inférieur ou égal à son courant assigné.

Les éléments de remplacement "aR" doivent fonctionner et provoquer la coupure du circuit pour toute valeur du courant inférieure ou égale au pouvoir de coupure assigné et au moins égale au courant I_{2a} (voir le Tableau 104 et le Tableau 105).

Pour les éléments de remplacement "gR" et "gS", dans le temps conventionnel et aux courants définis dans le Tableau 101:

- l'élément de remplacement ne doit pas fonctionner lorsqu'il est parcouru par un courant inférieur ou égal au courant conventionnel de non-fusion (I_{nf});
- l'élément de remplacement fonctionne lorsqu'il est parcouru par un courant supérieur ou égal au courant conventionnel de fusion (I_f) et égal ou inférieur au pouvoir de coupure assigné.

8.5 Pouvoir de coupure

Un élément de remplacement doit être capable de couper, à une tension inférieure ou égale à sa tension assignée, tout circuit dont le courant présumé est compris entre un courant spécifié en 8.4 et le pouvoir de coupure assigné:

- en courant alternatif, les paramètres d'essai sont donnés dans le Tableau 104;
- en courant continu, les paramètres d'essai sont donnés dans le Tableau 105;
- pour les applications VSI, les paramètres d'essai sont donnés dans le Tableau 106.

8.7 Caractéristiques I^2t

Les valeurs I^2t de fonctionnement déterminées comme cela est décrit en 9.7 ne doivent pas être supérieures aux valeurs indiquées par le fabricant. Les valeurs I^2t de préarc déterminées comme cela est décrit en 9.7 ne doivent pas être inférieures aux valeurs indiquées (voir les 6.8.2.1 et 6.8.2.2).

8.15 Caractéristiques de la tension d'arc

Les valeurs de la tension d'arc mesurées comme cela est décrit en 9.7.5 ne doivent pas être supérieures aux valeurs indiquées par le fabricant (voir le 6.9).

9 Essais

L'IEC 60269-1 s'applique avec les exigences supplémentaires suivantes.

9.1.5 Disposition du fusible et dimensions

L'élément de remplacement doit être disposé à l'air libre et à l'abri des courants d'air et, sauf spécification contraire, en position verticale (voir le 9.3.1). Des exemples de montages d'essai sont représentés sur la Figure 101 et la Figure 102. Des montages d'essai pour d'autres types d'éléments de remplacement sont fournis dans l'IEC 60269-2 et l'IEC 60269-3.

9.1.6 Essais des éléments de remplacement

9.1.6.2 Essais complets

Le Tableau 102 répertorie les essais complets des éléments de remplacement. La résistance interne de tous les éléments de remplacement doit être déterminée et consignée dans le ou les rapports d'essai.

Un élément de remplacement doit avoir un pouvoir de coupure en courant alternatif, un pouvoir de coupure en continu ou un pouvoir de coupure VSI. Il peut avoir un ou plusieurs de ces pouvoirs de coupure.

Tableau 102 – Liste des essais complets

Essai selon le paragraphe		Nombre d'éléments de remplacement à soumettre à l'essai
9.3	Échauffement et puissance dissipée	1
9.4.3.1 a)	Courant conventionnel de non-fusion	1
9.4.3.1 b)	Courant conventionnel de fusion	1
9.4.3.2	Vérification du courant assigné	1
9.4.3.5	Essai de la protection conventionnelle des conducteurs contre les surcharges (pour les éléments de remplacement "gR" et "gS" seulement)	1
En courant alternatif:		
9.5	N° 5 Pouvoir de coupure et caractéristiques de fonctionnement pour "gR" et "gS"	1
	N° 12a Pouvoir de coupure et caractéristiques de fonctionnement pour "aR"	1
	N° 2 Pouvoir de coupure et caractéristiques de fonctionnement ^a	3
	N° 1 Pouvoir de coupure et caractéristiques de fonctionnement ^a	3
En courant continu:		
9.5	N° 13 Pouvoir de coupure et caractéristiques de fonctionnement pour "gR" et "gS"	1
	N° 12a Pouvoir de coupure et caractéristiques de fonctionnement pour "aR"	1
	N° 12 Pouvoir de coupure et caractéristiques de fonctionnement	3
	N° 11 Pouvoir de coupure et caractéristiques de fonctionnement	3
Pour les éléments de remplacement VSI:		
9.5	N° 21 Pouvoir de coupure et caractéristiques de fonctionnement	3
^a Valable pour les caractéristiques I^2t de préarc si la température de l'air ambiant est comprise entre 10 °C et 30 °C.		

9.1.6.3 Essais des éléments de remplacement d'une série homogène

Pour les éléments de remplacement de valeurs de courant assigné intermédiaires dans une série homogène, les éléments de remplacement peuvent être dispensés des essais de type si l'élément de remplacement dont le courant assigné est le plus élevé a été soumis à l'essai selon les exigences du 9.1.6.2 et que l'élément de remplacement dont le courant assigné est le plus faible a été soumis aux essais indiqués dans le Tableau 103.

Tableau 103 – Liste des essais des éléments de remplacement de courant assigné le plus faible dans une série homogène

Essai selon le paragraphe	Nombre d'éléments de remplacement à soumettre à l'essai
8.3 Échauffement et puissance dissipée	1

9.3 Vérification des limites d'échauffement et de la puissance dissipée

9.3.1 Disposition du fusible

L'essai doit être effectué sur un seul élément de remplacement. L'élément de remplacement doit être monté verticalement dans le montage d'essai conventionnel. Des exemples sont représentés sur la Figure 101 et la Figure 102.

La densité de courant des conducteurs en cuivre faisant partie du montage d'essai conventionnel ne doit pas être inférieure à 1 A/mm² ni supérieure à 1,6 A/mm², ces valeurs étant fondées sur le courant assigné de l'élément de remplacement. Le rapport largeur/épaisseur de ces conducteurs ne doit pas dépasser:

- 10 pour les courants assignés inférieurs à 200 A;
- 5 pour les courants assignés supérieurs ou égaux à 200 A.

Pendant ces essais, la température de l'air ambiant doit être comprise entre 10 °C et 30 °C.

Pour les essais d'échauffement, la section des conducteurs utilisés pour raccorder le montage d'essai conventionnel à l'alimentation est importante. La section doit être choisie conformément au Tableau 17 de l'IEC 60269-1:2024, à l'exclusion de la note, et la longueur des conducteurs de part et d'autre de l'élément de remplacement doit être de 1 m au minimum.

Pour les éléments de remplacement destinés à être utilisés dans des socles séparés, l'essai peut être effectué en montant l'élément de remplacement dans ces socles et en reliant les conducteurs conformément au Tableau 17 de l'IEC 60269-1:2024. Dans les autres cas, l'essai doit être effectué de la manière décrite dans les présentes exigences.

Pour des éléments de remplacement spéciaux ou à usage spécial, qui ne peuvent pas être installés dans le montage d'essai conventionnel ou pour lesquels ce montage d'essai ne s'applique pas, des essais particuliers doivent être effectués conformément aux instructions du fabricant et toutes les données pertinentes doivent être consignées dans le rapport d'essai.

9.3.3 Mesurage de la puissance dissipée de l'élément de remplacement

En plus du 9.3.3 de l'IEC 60269-1:2024, la condition suivante s'applique: l'essai de puissance dissipée doit être effectué successivement à au moins 50 % et à 100 % du courant assigné. Cet essai peut être effectué en courant alternatif ou en courant continu.

9.3.4 Méthode d'essai

La section des conducteurs en cuivre destinés aux essais de courants assignés élevés selon les 9.3 et 9.4 est spécifiée dans le Tableau 107.