IEC 60269-4

Edition 6.0 2024-08

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

IEC 60269-4:2024-08(en-fr)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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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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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
$16 \leq I_n \leq 63$ $63 < I_n \leq 160$ $160 < I_n \leq 400$ $400 < I_n$	1 2 3 4	1,1 I_n	1,6 I_n	1,25 I_n	1,6 I_n
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 prearcing 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.