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

Niederspannungssicherungen - Teil 4: Zusätzliche Anforderungen an Sicherungseinsätze zum Schutz von Halbleiter-Bauelementen

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

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Amendment 3 - Low-voltage fuses - Part 4: Supplementary requirements for fuse-links for the protection of semiconductor devices

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NOTE FROM TC/SC OFFICERS:

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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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This Consolidated version of IEC 60269-4 bears the edition number 5.2. It consists of the fifth edition (2009-05) [documents 32B/535/FDIS and 32B/541/RVD], its amendment 1 (2012-05) [documents 32B/579/CDV and 32B/586A/RVC] and its amendment 2 (2016-08) [documents 32B/651/FDIS and 32B/663/RVD]. The technical content is identical to the base edition and its amendments.

This Final version does not show where the technical content is modified by amendments 1 and 2. A separate Redline version with all changes highlighted is available in this publication.

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

This fifth edition constitutes a technical revision. The significant technical changes to the fourth edition are:

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

This part is to be used in conjunction with IEC 60269-1:2006, *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.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

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 the base publication and its amendments will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

LOW-VOLTAGE FUSES –

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

1 General

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.

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 greatvariety 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 complimentary equipment has evolved to the standardized voltages and tolerances of IEC 60038.

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).

1.2 Normative references

The following referenced documents are indispensable for the application 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, *Low-voltage fuses – Part 1: General requirements*

IEC 60269-2, *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 60269-3, *Low-voltage fuses – 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, *Low-voltage fuses – Part 5: Guidance for the application of low-voltage fuses*~~

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

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

2 Terms and definitions

IEC 60269-1 applies with the following supplementary definitions.

2.2 General terms

2.2.101
semiconductor device
device whose essential characteristics are due to the flow of charge carriers within a semiconductor

[IEV 521-04-01]

2.2.102
semiconductor fuse-link
current-limiting fuse-link capable of breaking, under specific conditions, any current value within the breaking range (see 7.4)

2.2.103
signalling device
device forming part of the fuse and signalling the fuse operation to a remote place

NOTE A signalling device consists of a striker and an auxiliary switch. Electronic devices may also be used.

2.2.104
voltage source inverter
VSI
a voltage stiff inverter

[IEV 551-12-11]

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

2.2.105
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 The abbreviation “VSI fuse-link” is used in this document.

NOTE 2 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 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.

3 Conditions for operation in service

IEC 60269-1 applies with the following supplementary requirements.

3.4 Voltage

3.4.1 Rated voltage

For AC., the rated voltage of a fuse-link is related to the applied voltage; it is based on the r.m.s. 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.~~

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.

3.4.2 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.

3.5 Current

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

For DC., the r.m.s. value of current is assumed not to exceed the r.m.s. 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 r.m.s. 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.

3.6 Frequency, power factor and time constant

3.6.1 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.

3.6.3 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. The manufacturer should be consulted for validation.

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

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 allowable current-carrying capacity under specific conditions.

4 Classification

IEC 60269-1 applies.

5 Characteristics of fuses

IEC 60269-1 applies with the following supplementary requirements.

5.1 Summary of characteristics

5.1.2 Fuse-links

a) Rated voltage (see 5.2)
b) Rated current (see 5.3 of IEC 60269-1)
c) Kind of current and frequency (see 5.4 of IEC 60269-1)
d) Rated power dissipation (see 5.5 of IEC 60269-1)
e) Time-current characteristics (see 5.6)
f) Breaking range (see 5.7.1 of IEC 60269-1)
g) Rated breaking capacity (see 5.7.2 of IEC 60269-1)
h) Cut-off current characteristics (see 5.8.1)
i) I^2t characteristics (see 5.8.2)
j) Dimensions or size (if applicable)
k) Arc voltage characteristics (see 5.9)

5.2 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.

5.4 Rated frequency

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

5.5 Rated power dissipation of the fuse-link

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.

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.

5.6 Limits of time-current characteristics

5.6.1 Time-current characteristics, time-current zones

5.6.1.1 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 8.3. 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 15*τ*.

For the higher values of prospective current (shorter times), the same information shall be presented in the form of I^2t characteristics (see 5.8.2).

5.6.1.2 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 15*τ* 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 15*τ* is conveniently expressed as a pre-arcing I^2t characteristic.

NOTE 2 The value of 15*τ* 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.

5.6.1.3 Operating time-current characteristics

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

5.6.2 Conventional times and currents

5.6.2.1 Conventional times and currents for “aR” fuse-links

See 7.4. and Table 101

5.6.2.2 Conventional times and currents for “gR” and “gS” fuse-links

The conventional times and currents are given in Table 101.

~~Table 101 – Conventional times and currents 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~~
~~$I_n \leq 63$ [a]~~	~~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~~				

~~[a] In Annex CC, some examples specify the requirements for $I_n \leq 16$.~~

~~NOTE For explanation of gR and gS see 5.7.1.~~

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 ≤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 ≤ I_n ≤63	1	1,1 I_n	1,6 I_n	1,25 I_n	1,6 I_n
63 < I_n ≤160	2				
160 < I_n ≤400	3				
400 < I_n	4				
Note: The conventional times also apply for "aR" - fuses					

5.6.3 Gates

Not applicable.

5.6.4 Overload curves

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 co-ordinate 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.