
Nizkonapetostne varovalke - 5. del: Navodila za uporabo nizkonapetostnih varovalk

Low-voltage fuses - Part 5: Guidance for the application of low-voltage fuses

iTeh STANDARD

Fusibles basse tension - Partie 5: Lignes directrices pour l'application des fusibles basse tension

(standards.iteh.ai)

Ta slovenski standard je istoveten z: IEC TR 60269-5:2014

SIST-TP IEC TR 60269-5:2022

<https://standards.iteh.ai/catalog/standards/sist/828cc776-9d8b-434c-a160-1378b969fe2a/sist-tp-iec-tr-60269-5-2022>

ICS:

29.120.50

Varovalke in druga
nadtokovna zaščita

Fuses and other overcurrent
protection devices

SIST-TP IEC TR 60269-5:2022

en,fr,de

**iTeh STANDARD
PREVIEW
(standards.iteh.ai)**

SIST-TP IEC TR 60269-5:2022

<https://standards.iteh.ai/catalog/standards/sist/828ce776-9d8b-434c-a160-1378b969fe2a/sist-tp-iec-tr-60269-5-2022>



TECHNICAL REPORT

RAPPORT TECHNIQUE



iTeh STANDARD

Low-voltage fuses –

Part 5: Guidance for the application of low-voltage fuses

(standards.iteh.ai)

Fusibles basse tension –

Partie 5: Lignes directrices pour l'application des fusibles basse tension

[SIST-TP IEC TR 60269-5:2022](https://standards.iteh.ai/catalog/standards/sist/828ce776-9d8b-434c-a160-1378b969fe2a/sist-tp-iec-tr-60269-5-2022)

<https://standards.iteh.ai/catalog/standards/sist/828ce776-9d8b-434c-a160-1378b969fe2a/sist-tp-iec-tr-60269-5-2022>

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX

XA

ICS 29.120.50

ISBN 978-2-8322-1448-0

Warning! Make sure that you obtained this publication from an authorized distributor.

Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.

CONTENTS

FOREWORD.....	6
INTRODUCTION.....	8
1 Scope.....	9
2 Normative references	9
3 Terms and definitions	10
4 Fuse benefits.....	12
5 Fuse construction and operation.....	13
5.1 Components	13
5.2 Fuse-construction	13
5.2.1 Fuse link.....	13
5.2.2 Fuse-link contacts	14
5.2.3 Indicating device and striker	14
5.2.4 Fuse-base	14
5.2.5 Replacement handles and fuse-holders	14
5.3 Fuse operation.....	15
5.3.1 General	15
5.3.2 Fuse operation in case of short-circuit.....	15
5.3.3 Fuse operation in case of overload.....	15
5.3.4 Fuse link pre-arcing time current characteristic.....	16
5.3.5 Fuse operation in altitudes exceeding 2 000 m	17
6 Fuse-combination units.....	18
7 Fuse selection and markings	19
8 Conductor protection	21
8.1 General.....	21
8.2 Utilization category gG.....	22
8.3 Utilization category gN and gD.....	23
8.4 Utilization category gR and gS.....	23
8.5 Utilization category gU.....	24
8.6 Utilization category gK.....	24
8.7 Utilization category gPV.....	24
8.8 Protection against short-circuit current only	24
9 Selectivity of protective devices.....	24
9.1 General.....	24
9.2 Selectivity between fuses.....	25
9.2.1 General	25
9.2.2 Verification of selectivity for operating time $\geq 0,1$ s	25
9.2.3 Verification of selectivity for operating time $< 0,1$ s	26
9.2.4 Verification of total selectivity	26
9.3 Selectivity of circuit-breakers upstream of fuses	26
9.3.1 General	26
9.3.2 Verification of selectivity for operating time $\geq 0,1$ s	27
9.3.3 Verification of selectivity for operating time $< 0,1$ s	27
9.3.4 Verification of total selectivity	27
9.4 Selectivity of fuses upstream of circuit-breakers	28
9.4.1 General	28
9.4.2 Verification of selectivity for operating time $\geq 0,1$ s	28

9.4.3	Verification of selectivity for operating time < 0,1 s	28
9.4.4	Verification of total selectivity	28
10	Short-circuit damage protection	30
10.1	General.....	30
10.2	Short-circuit current paths.....	30
10.3	Current limitation	31
10.4	Rated conditional short-circuit current, rated breaking capacity.....	31
11	Protection of power factor correction capacitors	31
12	Transformer protection	32
12.1	Distribution transformers with a high-voltage primary	32
12.2	Distribution transformers with a low-voltage primary	33
12.3	Control circuit transformers.....	33
13	Motor circuit protection	33
13.1	General.....	33
13.2	Fuse and motor-starter coordination	34
13.3	Criteria for coordination at the rated conditional short-circuit current I_q	34
13.4	Criteria for coordination at the crossover current I_{CO}	35
13.5	Criteria for coordination at test current “r”	35
14	Circuit-breaker protection in a.c. and d.c. rated voltage circuits	36
15	Protection of semiconductor devices in a.c. and d.c. rated voltage circuits	36
16	Fuses in enclosures.....	38
16.1	General.....	38
16.2	Limiting temperature of utilization category gG fuse-links according to IEC 60269-2 – System A.....	38
16.3	Other fuse-links	38
17	DC applications.....	38
17.1	General.....	38
17.2	Short-circuit protection.....	38
17.3	Overload protection	39
17.4	Time-current characteristics.....	40
18	Automatic disconnection for protection against electric shock for installations in buildings.....	40
18.1	General.....	40
18.2	Principle of the protection	41
18.3	Examples.....	42
19	Photovoltaic (PV) system protection	43
19.1	General.....	43
19.2	Selection of PV fuse-links	44
19.2.1	Fuse utilization category	44
19.2.2	PV string fuses	44
19.2.3	Fuse replacement.....	44
19.2.4	Unearthed or Ungrounded PV Systems.....	44
19.2.5	Functional earthing fuses.....	44
19.2.6	PV array and PV sub-array fuses.....	45
19.2.7	Fuse monitoring.....	45
19.2.8	Breaking capacity	45
19.2.9	Voltage of gPV fuses	45
19.2.10	Rated current of gPV fuses.....	45

20	Protection of wind mills.....	45
Annex A (informative)	Coordination between fuses and contactors/motor-starters.....	47
A.1	General.....	47
A.2	Examples of suitable fuse-links used for motor protection	47
A.3	Values of I^2t and cut-off current observed in successful tests of fuse-link/motor-starter combinations worldwide.....	48
A.4	Criteria for coordination at the rated conditional short-circuit current I_q	51
A.4.1	General	51
A.4.2	Maximum operating I^2t and cut-off current	51
A.4.3	Guidance for choosing the maximum rated current of an alternative fuse type	52
A.4.4	Further guidance	52
A.5	Criteria for coordination at test current "r"	53
A.6	Types of coordination.....	54
Bibliography.....		57
Figure 1	– Typical fuse-link according to IEC 60269-2.....	13
Figure 2	– Typical fuse-link according to IEC 60269-2.....	14
Figure 3	– Current-limiting fuse operation	15
Figure 4	– Fuse operation on overload.....	16
Figure 5	– Time current characteristic for fuse-links.....	17
Figure 6	– Currents for fuse-link selection.....	23
Figure 7	– Selectivity – General network diagram	25
Figure 8	– Verification of selectivity between fuses F_2 and F_4 for operating time $t \geq 0,1$ s	26
Figure 9	– Verification of selectivity between circuit-breaker C_2 and fuses F_5 and F_6	27
Figure 10	– Verification of selectivity between fuse F_2 and circuit-breaker C_3 for operating time $t \geq 0,1$ s	29
Figure 11	– Verification of selectivity between fuse F_2 and circuit-breaker C_3 for operating time $t < 0,1$ s	30
Figure 12	– Fuse and motor-starter coordination.....	35
Figure 13	– DC circuit	39
Figure 14	– DC breaking operation	39
Figure 15	– Fuse operating time at various d.c. circuit time constants.....	40
Figure 16	– Time-current characteristic.....	42
Figure A.1	– Collation of cut-off currents observed in successful coordination at I_q	49
Figure A.2	– Pre-arcing and operating I^2t values of fuses used in successful coordination tests as a function of contactor rated current AC3.....	50
Figure A.3	– Pre-arcing and operating I^2t values of fuses used in successful coordination tests as a function of fuse rated current I_n	51
Figure A.4	– Illustration of the method of selection of the maximum rated current of a fuse for back-up protection of a contactor of rating $I_e = X$ amperes.....	54
Figure A.5	– Withstand capabilities of a range of contactors and associated overload relays at test current "r"	55
Figure A.6	– Illustration of a method of deriving curves of maximum peak current at test current "r" as a function of fuse rated current	56

Table 1 – Derating factors for different altitudes	18
Table 2 – Definitions and symbols of switches and fuse-combination units	19
Table 3 – Fuse application	20
Table 4 – Maximum operational voltage of a.c. fuse-links	21
Table 5 – Typical operational voltage ratings of d.c. fuse-links	21
Table 6 – Fuse selection for power factor correction capacitors (fuses according to IEC 60269-2, system A)	32
Table 7 – Conventional non fusing current	37
Table 8 – Time constants of typical d.c. circuits	40
Table A.1 – Examples of typical fuse-link ratings used for motor-starter protection illustrating how the category of fuse-link can influence the optimum current rating	48
Table A.2 (Table 12 of IEC 60947-4-1:2009) – Value of the prospective test current according to the rated operational current	53
Table A.3 – Types of coordination	54

iTeh STANDARD PREVIEW (standards.iteh.ai)

SIST-TP IEC TR 60269-5:2022

<https://standards.iteh.ai/catalog/standards/sist/828ce776-9d8b-434c-a160-1378b969fe2a/sist-tp-iec-tr-60269-5-2022>

INTERNATIONAL ELECTROTECHNICAL COMMISSION

LOW-VOLTAGE FUSES –

Part 5: Guidance for the application of low-voltage fuses

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC 60269-5, which is a technical report, has been prepared by subcommittee 32B: Low-voltage fuses, of IEC technical committee 32: Fuses.

This second edition cancels and replaces the first edition published in 2010. This edition constitutes a technical revision.

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

- a) recommendations for fuse operations in high altitudes added
- b) more details for operational voltages added
- c) recommendations for photovoltaic system protection added
- d) numerous details improved

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
32B/621A/DTR	32B/624/RVC

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

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 this publication 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.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

Fuses protect many types of equipment and switchgear against the effects of over-current which can be dramatic:

- thermal damage of conductors or bus-bars;
- vaporisation of metal;
- ionisation of gases;
- arcing, fire, explosion,
- insulation damage.

Apart from being hazardous to personnel, significant economic losses can result from downtime and the repairs required to restore damaged equipment.

Modern fuses are common overcurrent protective devices in use today, and as such provide an excellent cost effective solution to eliminate or minimize the effects of overcurrent.

**iTeh STANDARD
PREVIEW
(standards.iteh.ai)**

SIST-TP IEC TR 60269-5:2022

<https://standards.iteh.ai/catalog/standards/sist/828ce776-9d8b-434c-a160-1378b969fe2a/sist-tp-iec-tr-60269-5-2022>

LOW-VOLTAGE FUSES –

Part 5: Guidance for the application of low-voltage fuses

1 Scope

This technical report, which serves as an application guide for low-voltage fuses, shows how current-limiting fuses are easy to apply to protect today's complex and sensitive electrical and electronic equipment. This guidance specifically covers low-voltage fuses up to 1 000 V a.c. and 1 500 V d.c. designed and manufactured in accordance with IEC 60269 series. This guidance provides important facts about as well as information on the application of fuses.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050 (all parts), *International Electrotechnical Vocabulary*. Available from <http://www.electropedia.org/>

IEC/TR 60146-6, *Semiconductor convertors – Part 6: Application guide for the protection of semiconductor convertors against overcurrent by fuses*

IEC 60269 (all parts), *Low-voltage fuses*
<https://standards.iteh.ai/catalog/standards/sist/828ce776-918b-424c-a160-1378b969f2a/sist-tr-iec-tr-60269-5-2022>

IEC 60269-1:2006, *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 – Part 3: Supplementary requirements for fuses for use by unskilled persons (fuses mainly for household or similar applications) – Examples of standardized systems of fuses A to F*

IEC 60269-4:2009, *Low-voltage fuses – Part 4: Supplementary requirements for fuse-links for the protection of semiconductor devices*

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

IEC 60364-4-41:2005, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*

IEC 60364-4-43:2008, *Low-voltage electrical installations – Part 4-43: Protection for safety – Protection against overcurrent*

IEC 60364-5-52, *Low-voltage electrical installations – Part 5-52: Selection and erection of electrical equipment – Wiring systems*

IEC 60947 (all parts), *Low-voltage switchgear and controlgear*

IEC 60947-3:2008, *Low-voltage switchgear and controlgear – Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units*

IEC 60947-4-1:2009, *Low-voltage switchgear and controlgear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters*

IEC/TR 61912-1:2007, *Low-voltage switchgear and controlgear – Overcurrent protective devices – Part 1: Application of short-circuit ratings*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1

switch (mechanical)

mechanical switching device capable of making, carrying and breaking currents under normal circuit conditions, which may include specified operating overload conditions and also carrying, for a specified time, currents under specified abnormal conditions such as those of short-circuits

Note 1 to entry: A switch may be capable of making but not breaking, short-circuit currents.

[SOURCE: IEC 60050-441:1984, 441-14-10]

3.2

disconnector

mechanical switching device that, in the open position, complies with the requirements specified for isolating function

Note 1 to entry: Some disconnectors may not be capable of switching load.

[SOURCE: IEC 60050-441:1984, 441-14-05, modified (modified definition and Note 1 to entry added)]

3.3

fuse-combination unit

combination of a mechanical switching device and one or more fuses in a composite unit, assembled by the manufacturer or in accordance with his instructions

[SOURCE: IEC 60050-441:1984, 441-14-04, modified (Note removed)]

3.4

switch-fuse

switch in which one or more poles have a fuse in series in a composite unit

[SOURCE: IEC 60050-441:1984, 441-14-14]

3.4.1

single-break and double-break

switch-fuse must be single break (it opens the circuit on one side of the fuse link) or double break (it opens the circuit on both sides of the fuse link)

3.5

fuse-switch

switch in which a fuse-link or a fuse-carrier with fuse-link forms the moving contact

[SOURCE: IEC 60050-441:1984, 441-14-17]

3.5.1

single-break and double-break

fuse-switch must be single break (it opens the circuit on one side of the fuse link) or double break (it opens the circuit on both sides of the fuse link)

3.6

Switching device SD

device designed to make or break the current in one or more electric circuits

Note 1 to entry: A switching device may perform one or both of these operations.

[SOURCE: IEC 60050-441:1984, 441-14-01, modified (Note 1 to entry added)]

3.7

short-circuit protective device SCPD

device intended to protect a circuit or parts of a circuit against short-circuits by interrupting them

3.8

overload protection

protection intended to operate in the event of overload on the protected section

[SOURCE: IEC 60050-448:1995, 448-14-31]

3.9

overload

operating conditions in an electrically undamaged circuit, which cause an over-current

[SOURCE: IEC 60050-441:1984, 441-11-08]

3.10

overcurrent

current exceeding the rated current

[SOURCE: IEC 60050-442:1998, 442-01-20]

3.11

rated conditional short-circuit current (of a switching device)

I_q
prospective current that a switching device, protected by a short-circuit protective device, can satisfactorily withstand for the operating time of that device under test conditions specified in the relevant product standard

3.12

selectivity of protection

ability of a protection to identify the faulty sections and/or phase(s) of a power system

Note 1 to entry: Whereas the terms “selectivity” and “discrimination” have a similar meaning according to the IEC definitions, this report prefers and uses the term “selectivity” to express the ability of one over-current device to operate in preference to another over-current device in series, over a given range of over-current. The effect of standing load current on selectivity in the overload zone is also considered.

[SOURCE: IEC 60050-448:1995, 448-11-06, modified (Note 1 to entry added)]

4 Fuse benefits

The current-limiting fuse provides complete protection against the effects of overcurrents by protecting both, electric circuits and their components. Fuses offer a combination of advantageous features, for example:

- a) High breaking capacity (high current interrupting rating).
- b) No need for complex short-circuit calculations.
- c) Easy and inexpensive system expansion in case of increased fault currents.
- d) High current limitation (low I^2t values).
- e) Mandatory fault elimination before reenergizing.
Fuses cannot be reset, thus forcing the user to identify and correct the fault condition before re-energizing the circuit.
- f) Reliability.
No moving parts to wear out or become contaminated by dust, oil or corrosion. Fuse replacement ensures protection is restored to its original level when the fuse is replaced.
- g) Cost effective protection.
Compact size offers low cost overcurrent protection at high short-circuit levels.
- h) No damage for starters and contactors (type 2 protection according to IEC 60947-4-1).
By limiting short-circuit energy and peak currents to extremely low levels, fuses are particularly suitable for type 2 protection without damage to components in motor circuits.
- i) Safe, silent operation.
No emission of gas, flames, arcs or other materials when clearing the highest levels of short-circuit currents. In addition, the speed of operation at high short-circuit currents significantly limits the arc flash hazard at the fault location.
- j) Easy coordination.
Standardized fuse characteristics and a high degree of current limitation ensure effective coordination between fuses and other devices.
- k) Standardized performance.
Fuse-links designed and manufactured in accordance with IEC 60269 series ensure availability of replacements with standardized characteristics throughout the world.
- l) Improved power quality.
Current-limiting fuses interrupt high fault currents in a few milliseconds, minimizing dips or sags in system supply voltage.
- m) Tamperproof.
Once installed, fuses cannot be modified or adjusted thus preserving their level of performance and avoiding malfunction.
- n) No maintenance.
Properly sized fuses require no maintenance, adjustments or recalibrations. They can remain in service providing originally designed overcurrent protection levels for many decades.
- o) High level of energy efficiency.
The resistance and therefore the power dissipation of the fuse is very low compared with other protection devices. The magnitude of power loss compared to the power transmitted by rated current is much less than 0,1%.
- p) Excellent personnel and equipment protection in case of arc flash.
Properly sized current limiting fuses operating in their current limiting range interrupt currents due to arcing fault in a few milliseconds, keeping arc energy well below hazardous and damaging levels.

5 Fuse construction and operation

5.1 Components

A fuse is a protective device comprising

- the fuse-link,
- the fuse-base,
- the fuse-carrier or replacement handle.

These components may be integrated in a fuse combination unit.

5.2 Fuse-construction

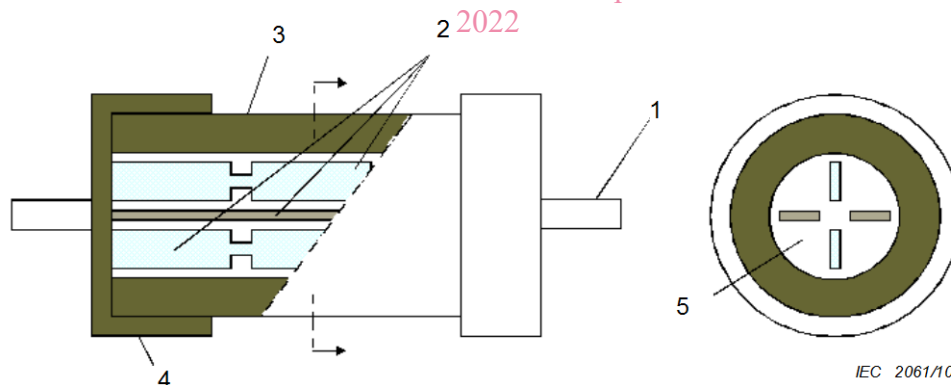
5.2.1 Fuse link

Figures 1 and 2 show the design of typical low-voltage fuse-links for industrial application. Such fuse-links are commonly called current-limiting or high breaking capacity fuse-links. Fuse-links according to IEC 60269-2 (fuses for industrial application) are available in current ratings up to 6 000 A.

Fuse-links according to IEC 60269-3 (fuses for household application) are available in current ratings up to 100 A.

The fuse-element is usually made of flat silver or copper with multiple restrictions in the cross-section, called notches. This restriction (or notch) pattern is an important feature of fuse design, normally achieved by precision stamping.

M-effect (see 5.3.3) material is added to the fuse-element to achieve controlled fuse operation in the overload range. The purity of the fuse-element materials and their precise physical dimensions are of vital importance for reliable fuse operation.



Key

- 1 Blade contact
- 2 Fuse-elements
- 3 Fuse body
- 4 End cap
- 5 Filler

Figure 1 – Typical fuse-link according to IEC 60269-2