



BSI Standards Publication

Low-voltage fuses

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

National foreword

This Published Document is the UK implementation of IEC TR 60269-5:2014+A1:2020. It is dual numbered as PD 88-5:2014+A1:2020 in the UK. It supersedes PD IEC/TR 60269-5:2010 (dual numbered as PD 88-5:2010), which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to IEC text carry the number of the IEC amendment. For example, text altered by IEC amendment 1 is indicated by **A1** **A1**.

The UK participation in its preparation was entrusted to Technical Committee PEL/32, Fuses.

A list of organizations represented on this committee can be obtained on request to its committee manager.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2021
Published by BSI Standards Limited 2021

ISBN 978 0 580 99863 8

ICS 29.120.50

Compliance with a British Standard cannot confer immunity from legal obligations.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 31 January 2021.

Amendments/ corrigenda issued since publication

Date	Text affected
------	---------------



IEC TR 60269-5

Edition 2.0 2014-03

TECHNICAL REPORT

RAPPORT TECHNIQUE



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

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

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE **XA**
CODE PRIX

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	15
5.2.4 Fuse-base	15
5.2.5 Replacement handles and fuse-holders	15
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	16
5.3.4 Fuse link pre-arcing time current characteristics.....	17
5.3.5 Fuse operation in altitudes exceeding 2 000 m	18
6 Fuse-combination units.....	18
7 Fuse selection and markings	20
8 Conductor protection	22
8.1 General.....	22
8.2 Utilization category gC.....	22
8.3 Utilization category gM and gD.....	23
8.4 Utilization category gT and gS.....	24
8.5 Utilization category gU.....	24
8.6 Utilization category gK.....	24
8.7 Utilization category gPV.....	24
8.8 Utilization category gBat.....	24
8.9 Protection against short-circuit current only	24
9 Selectivity of protective devices.....	25
9.1 General.....	25
9.2 Selectivity between fuses.....	26
9.2.1 General	26
9.2.2 Verification of selectivity for operating time $\geq 0,1$ s	26
9.2.3 Verification of selectivity for operating time $< 0,1$ s	26
9.2.4 Verification of total selectivity	27
9.3 Selectivity between circuit-breakers upstream and fuses.....	27
9.3.1 General	27
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	28
9.4 Selectivity between fuses upstream and 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_c	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
15.1	General recommendations	36
15.2	Fuse application with inverters.....	38
15.2.1	Inverters	38
15.2.2	Purpose of the fuse	39
15.2.3	Current carrying capacity	43
15.2.4	Voltage consideration	43
15.2.5	I^2t characteristics	44
15.2.6	Breaking range.....	44
16	Fuses in enclosures	44
16.1	General.....	44
16.2	Limiting temperature of utilization category gG fuse-links according to IEC 60269-5 – System A.....	45
16.3	Other fuse-links	45
17	DC applications	45
17.1	General.....	45
17.2	Short-circuit protection.....	45
17.3	Overload protection	46
17.4	Time-current characteristics.....	47
18	Automatic disconnection for protection against electric shock for installations in buildings.....	48
18.1	General.....	48
18.2	Principle of the protection	48
18.3	Examples.....	49
19	Photovoltaic (PV) system protection	50
19.1	General.....	50
19.2	Selection of PV fuse-links	51

19.2.1	Fuse utilization category	51
19.2.2	PV string fuses	51
19.2.3	Fuse replacement	51
19.2.4	Unearthed or Ungrounded PV Systems	51
19.2.5	Functional earthing fuses	52
19.2.6	PV array and PV sub-array fuses	52
19.2.7	Fuse monitoring	52
19.2.8	Breaking capacity	52
19.2.9	Voltage of gPV fuses	52
19.2.10	Rated current of gPV fuses	52
20	Protection of wind mills	52
21	Guidance for the selection of a fuse for the protection of Battery systems	53
21.1	General	53
21.2	Voltage characteristics	53
21.2.1	Rated voltage	53
21.3	Current carrying capability	53
21.3.1	Rated current	53
21.4	Breaking capacity	53
Annex A (informative)	Coordination between fuses and contactors/motor-starters	54
A.1	General	54
A.2	Examples of suitable fuse-links used for motor protection	54
A.3	Values of I^2t and cut-off current observed in successful tests of fuse-link/motor-starter combinations worldwide	55
A.4	Criteria for coordination at the rated conditional short-circuit current I_q	58
A.4.1	General	58
A.4.2	Maximum operating I^2t and cut-off current	58
A.4.3	Guidance for choosing the maximum rated current of an alternative fuse type	59
A.4.4	Further guidance	59
A.5	Criteria for coordination at test current "r"	60
A.6	Types of coordination	61
Bibliography	64
Figure 1	– Typical fuse-link according to IEC 60269-2	14
Figure 2	– Typical fuse-link according to IEC 60269-2	14
Figure 3	– Current-limiting fuse operation	16
Figure 4	– Fuse operation on overload	17
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	46
Figure 14 – DC breaking operation	47
Figure 15 – Fuse operating time at various d.c. circuit time constants	48
Figure 16 – Time-current characteristic	49
Figure 17 – Inverter double-way connection with arm fuses for regenerative or non-regenerative load	38
Figure 18 – Inverter double-way connection with d.c. loop fuses for regenerative or non-regenerative load	38
Figure 19 – Multi inverters systems double-way connection with d.c. loop fuses for regenerative or non-regenerative load	39
Figure 20 – Capacitor discharge	40
Figure 21 – Voltage across the capacitor	41
Figure 22 – Inductance of the circuit	42
Figure A.1 – Collation of cut-off currents observed in successful coordination at I_q	56
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	57
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	58
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	61
Figure A.5 – Withstand capabilities of a range of contactors and associated overload relays at test current "r"	62
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	63
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 fusing current	37
Table 8 – Time constants of typical d.c. circuits	47
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	55
Table A.2 (Table 12 of IEC 60947-4-1:2009) – Value of the prospective test current according to the rated operational current	60
Table A.3 – Types of coordination	61

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 far 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, accept 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.

IEC TR 60269-5:2014+A1:2020
© IEC 2020

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.

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*

- A1 IEC 60269-1:2006, *Low-voltage fuses - Part 1: General requirements*
 IEC 60269-1:2006/AMD1:2009
 IEC 60269-1:2006/AMD2:2014 A1

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*

- A1 IEC 60269-4, *Low-voltage fuses – Part 4: Supplementary requirements for fuse-links for the protection of semiconductor devices* A1

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*