

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Low-voltage fuses –
Part 1: General requirements**

**Fusibles basse tension –
Partie 1: Exigences générales**



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2024 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Secretariat
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, ...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch

Discover our powerful search engine and read freely all the publications previews, graphical symbols and the glossary. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org

The world's leading online dictionary on electrotechnology, containing more than 22 500 terminological entries in English and French, with equivalent terms in 25 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC

Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Recherche de publications IEC -

webstore.iec.ch/advsearchform

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études, ...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch

Découvrez notre puissant moteur de recherche et consultez gratuitement tous les aperçus des publications, symboles graphiques et le glossaire. Avec un abonnement, vous aurez toujours accès à un contenu à jour adapté à vos besoins.

Electropedia - www.electropedia.org

Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 500 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 25 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Low-voltage fuses –
Part 1: General requirements**

**Fusibles basse tension –
Partie 1: Exigences générales**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 29.120.50

ISBN 978-2-8322-9108-5

**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	7
1 Scope	9
2 Normative references	9
3 Terms and definitions	10
3.1 Fuses and their component parts	10
3.2 General terms	12
3.3 Characteristic quantities	14
4 Conditions for operation in service	17
4.1 General	17
4.2 Ambient air temperature (T_a)	18
4.3 Altitude	18
4.4 Atmospheric conditions	18
4.5 Voltage	18
4.6 Current	18
4.7 Frequency, power factor and time constant	18
4.7.1 Frequency	18
4.7.2 Power factor	19
4.7.3 Time constant (τ)	19
4.8 Conditions of installation	19
4.9 Utilization class	19
4.10 Selectivity of fuse-links	19
5 Classification	19
6 Characteristics of fuses	19
6.1 Summary of characteristics	19
6.1.1 General	19
6.1.2 Fuse-holders	19
6.1.3 Fuse-links	20
6.1.4 Complete fuses	20
6.2 Rated voltage	20
6.3 Rated current	21
6.3.1 Rated current of the fuse-link	21
6.3.2 Rated current of the fuse-holder	21
6.4 Rated frequency (see 7.1 and 7.2)	21
6.5 Rated power dissipation of a fuse-link and rated acceptable power dissipation of a fuse-holder.	21
6.6 Limits of time-current characteristics	21
6.6.1 General	21
6.6.2 Time-current characteristics, time-current zones	21
6.6.3 Conventional times and currents	22
6.6.4 Gates	22
6.7 Breaking range and breaking capacity	23
6.7.1 Breaking range and utilization category	23
6.7.2 Rated breaking capacity	24
6.8 Cut-off current and I^2t characteristics	24
6.8.1 General	24
6.8.2 Cut-off current characteristics	24

6.8.3	I^2t characteristics	24
7	Markings.....	24
7.1	General.....	24
7.2	Markings of fuse-holders.....	25
7.3	Markings of fuse-links	25
8	Standard conditions for construction	25
8.1	Mechanical design	25
8.1.1	Replacement of fuse-links.....	25
8.1.2	Connections, including terminals	25
8.1.3	Fuse-contacts	26
8.1.4	Construction of a gauge-piece	26
8.1.5	Mechanical strength of the fuse-link.....	26
8.2	Insulating properties and suitability for isolation	26
8.3	Temperature rise, power dissipation of the fuse-link and acceptable power dissipation of a fuse-holder	27
8.4	Operation.....	27
8.5	Breaking capacity	28
8.6	Cut-off current characteristic.....	28
8.7	I^2t characteristics	29
8.8	Overcurrent selectivity of fuse-links	29
8.9	Protection against electric shock.....	30
8.9.1	General	30
8.9.2	Clearances and creepage distances	30
8.9.3	Leakage currents of fuses suitable for isolation	31
8.9.4	Additional constructional requirements for fuse holders for linked fuse- carriers, suitable for isolation.....	31
8.10	Resistance to heat	32
8.11	Mechanical strength.....	32
8.12	Resistance to corrosion	32
8.12.1	General	32
8.12.2	Resistance to rusting	32
8.12.3	Resistance to season cracking	32
8.13	Resistance to abnormal heat and fire	32
8.14	Electromagnetic compatibility.....	32
9	Tests	32
9.1	Overview.....	32
9.1.1	General	32
9.1.2	Kind of tests	33
9.1.3	Ambient air temperature (T_a)	33
9.1.4	Condition of the fuse.....	33
9.1.5	Arrangement of the fuse and dimensions	33
9.1.6	Testing of fuse-links	33
9.1.7	Testing of fuse-holders	37
9.2	Verification of the insulating properties and of the suitability for isolation	38
9.2.1	Arrangement of the fuse-holder	38
9.2.2	Verification of the insulating properties	38
9.2.3	Verification of the suitability for isolation.....	39
9.2.4	Acceptability of test results	40

9.3	Verification of temperature rise and power dissipation	40
9.3.1	Arrangement of the fuse	40
9.3.2	Measurement of the temperature rise	41
9.3.3	Measurement of the power dissipation of the fuse-link	41
9.3.4	Test method	41
9.3.5	Acceptability of test results	43
9.4	Verification of operation	43
9.4.1	Arrangement of the fuse	43
9.4.2	Ambient air temperature	43
9.4.3	Test method and acceptability of test results	43
9.5	Verification of the breaking capacity.....	47
9.5.1	Arrangement of the fuse	47
9.5.2	Characteristics of the test circuit.....	47
9.5.3	Measuring instruments.....	48
9.5.4	Calibration of test circuit	48
9.5.5	Test method	50
9.5.6	Ambient air temperature	52
9.5.7	Interpretation of oscillograms.....	52
9.5.8	Acceptability of test results	52
9.6	Verification of the cut-off current characteristics.....	53
9.6.1	Test method	53
9.6.2	Acceptability of test results	53
9.7	Verification of I^2t characteristics and overcurrent selectivity	53
9.7.1	Test method	53
9.7.2	Acceptability of test results	53
9.7.3	Verification of compliance for fuse-links at 0,01 s	53
9.7.4	Verification of overcurrent selectivity	54
9.8	Verification of the degree of protection of enclosures	54
9.9	Verification of resistance to heat.....	54
9.10	Verification of non-deterioration of contacts	54
9.10.1	General	54
9.10.2	Arrangement of the fuse	54
9.10.3	Test method	54
9.10.4	Acceptability of test results	54
9.11	Mechanical and miscellaneous tests	55
9.11.1	Mechanical strength.....	55
9.11.2	Miscellaneous tests	55
9.12	Test of durability of markings	58
Annex A (informative)	Measurement of short-circuit power factor	68
Annex B (informative)	Calculation of pre-arcing I^2t values for "gG", "gM" and "gU" fuse-links and calculation of operating I^2t values at reduced voltage	71
B.1	Evaluation of the pre-arcing I^2t value at 0,01 s	71
B.2	Calculation of the value of pre-arcing I^2t under the conditions of test no. 2.....	71
B.3	Calculation of the value of operating I^2t at reduced voltage	71
Annex C (informative)	Calculation of cut-off current-time characteristic.....	72
C.1	Overview.....	72
C.2	Preliminary note.....	72
C.3	Definition	72

C.4	Characteristic.....	72
C.5	Test condition	73
C.6	Calculation from the measured values	73
Annex D (informative) Effect of change of ambient temperature and surroundings on the performance of fuse-links.....		76
D.1	Effect of increase of ambient temperature	76
D.1.1	On current rating	76
D.1.2	On temperature rise.....	76
D.1.3	On conventional fusing and non-fusing current (I_f and I_{nf}).....	76
D.1.4	For motor starting conditions	76
D.2	Effect of decrease of ambient air temperature	76
D.3	Effect of installation conditions.....	76
Annex E (normative) Particular requirements for fuse-bases with screwless-type terminals for external copper conductors.....		77
E.1	General.....	77
E.3	Terms and definitions.....	77
E.7	Marking.....	78
E.8	Standard conditions for construction	78
E.8.1	Fixed connections including terminals.....	78
E.8.2	Dimensions of connectable conductors	78
E.8.3	Connectable cross-sectional areas	79
E.8.4	Insertion and disconnecting of conductors	79
E.8.5	Design and construction of terminals	79
E.8.6	Resistance to ageing	80
E.9	Tests	80
E.9.1	Test of reliability of terminals	80
E.9.2	Tests of reliability of terminals for external conductors: mechanical strength	80
E.9.3	Cycling test.....	81
Bibliography.....		84
Figure 1 – Diagram illustrating the means of verification of the time-current characteristic, using the results of the tests at the "gate" currents (example)		59
Figure 2 – Overload curve and time-current characteristic for "a" fuse-links		60
Figure 3 – Time-current zone for aM fuses.....		61
Figure 4 – General presentation of the cut-off characteristics for a series of AC fuse-links		62
Figure 5 – Typical diagram of the circuit used for breaking capacity test (see 9.5)		63
Figure 6 – Interpretation of oscillograms taken during the AC breaking-capacity tests (see 9.5.7)		64
Figure 7 – Interpretation of oscillograms taken during the DC breaking-capacity tests (see 9.5.7)		65
Figure 8 – Glow-wire and position of the thermocouple		66
Figure 9 – Test apparatus (example)		67
Figure A.1 – Determination of circuit-impedance for calculation of power factor in accordance with method I		70
Figure C.1 – Cut-off current characteristic as a function of actual pre-arcing time		75
Figure E.1 – Connecting samples		82

Figure E.2 – Examples of terminals.....	83
Table 1 – Standard values of AC rated voltages for fuses	20
Table 2 – Preferred values of DC rated voltages for fuses	20
Table 3 – Conventional time and current for "gG", and "gM" fuse-links.....	22
Table 4 – Gates for specified pre-arcing times of "gG" and "gM" fuse-links ^a	23
Table 5 – Gates for "aM" fuse-links (all rated currents).....	23
Table 6 – Temperature rise limits $\Delta T = (T - T_a)$ for terminals	27
Table 7 – Maximum arc voltage	28
Table 8 – Pre-arcing I^2t values at 0,01 s for "gG" and "gM" fuse-links	29
Table 9 – Rated impulse withstand voltage	30
Table 10 – Minimum clearances in air	30
Table 11 – Minimum creepage distances	31
Table 12 – Survey of complete tests on fuse-links and number of fuse-links to be tested	35
Table 13 – Survey of tests on fuse-links of smallest rated current of homogeneous series and number of fuse-links to be tested	36
Table 14 – Survey of tests on fuse-links of rated currents between the largest and the smallest rated current of a homogeneous series and number of fuse-links to be tested.....	37
Table 15 – Survey of complete tests on fuse-holders and number of fuse-holders to be tested	37
Table 16 – Test voltage	39
Table 17 – Test voltage across the poles for the verification of the suitability for isolation.....	40
Table 18 – Cross-sectional area of copper conductors for tests corresponding to Subclauses 9.3 and 9.4.....	42
Table 19 – Cross-section areas of the copper conductors for the test of "aM" fuses	45
Table 20 – Table for test in Subclause 9.4.3.5	46
Table 21 – Values for breaking-capacity tests on AC fuses	49
Table 22 – Values for breaking-capacity tests on DC fuses	50
Table E.1 – Connectable conductors.....	79
Table E.2 – Cross-sections of copper conductors connectable to terminals.....	79
Table E.3 – Pull forces.....	81

INTERNATIONAL ELECTROTECHNICAL COMMISSION

LOW-VOLTAGE FUSES –

Part 1: General requirements

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) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at <https://patents.iec.ch>. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 60269-1 has been prepared by subcommittee 32B: Low-voltage fuses, of IEC technical committee 32: Fuses. It is an International Standard.

This fifth edition cancels and replaces the fourth edition published in 2006, Amendment 1:2009 and Amendment 2:2014. This edition constitutes a technical revision.

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

- a) New numbering, editorial corrections and normative references updated;
- b) Term "discrimination" replaced by "selectivity" and "utilization category" by "utilization class";
- c) Term "fuses for authorized and unskilled persons" updated;
- d) Replacement of fuse-link added;

- e) Standard values for AC and DC voltages updated;
- f) Rated currents 425A, 355A, and 1 600A added;
- g) Marking: requirements and tests separated to the relevant subclauses;
- h) Requirements for temperature rise limited to terminal temperature rise only;
- i) Graphic symbol for fuse-base updated,

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

Draft	Report on voting
32B/748/FDIS	32B/756/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.

IEC 60269 consists of the following parts, under the general title *Low-voltage fuses*:

- Part 1: General requirements
- Part 2: Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application) – Examples of standardized systems of fuses A to I
- Part 3: Supplementary requirements for fuses for use by unskilled persons (fuses mainly for household or similar application) – Examples of standardized systems of fuses A to F
- Part 4: Supplementary requirements for fuse-links for the protection of semiconductor devices
- Part 5: Guidance for the application of low-voltage fuses
- Part 6: Supplementary requirements for fuse-links for the protection of solar photovoltaic energy systems
- Part 7: Battery Fuses

For reasons of convenience, when a part of this publication has come from other publications, a remark to this effect has been inserted in the text.

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 1: General requirements

1 Scope

This part of IEC 60269 is applicable to fuses incorporating enclosed current-limiting fuse-links with rated breaking capacities of not less than 6 kA, intended for protecting power-frequency AC circuits of nominal voltages not exceeding 1 000 V or DC circuits of nominal voltages not exceeding 1 500 V.

Subsequent parts of this standard, referred to herein, cover supplementary requirements for such fuses intended for specific conditions of use or applications.

Fuse-links intended to be included in fuse-switch combinations according to IEC 60947-3 should also comply with the following requirements.

As far as not stated in subsequent parts for fuse-links, details of performance (see 3.2.4) on DC circuits should be stated in the manufacturer's literature.

NOTE 1 Modifications of, and supplements to, this document required for certain types of fuses for particular applications – for example, certain fuses for rolling stock, or fuses for high-frequency circuits – will be covered, if necessary, by separate standards.

NOTE 2 This document does not apply to miniature fuses, these being covered by IEC 60127.

The object of this standard series is to establish the characteristics of fuses or parts of fuses (fuse-base, fuse-carrier, fuse-link) in such a way that they can be replaced by other fuses or parts of fuses having the same characteristics provided that they are interchangeable as far as their dimensions are concerned. For this purpose, this standard series refers in particular to

- the following characteristics of fuses:
 - rated values;
 - insulation;
 - temperature rise in normal service;
 - power dissipation and acceptable power dissipation;
 - time/current characteristics;
 - breaking capacity;
 - cut-off current characteristics and their I^2t characteristics.
- type test for verification of the characteristics of fuses;
- the marking of fuses.

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 60269-2, *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 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60584-1:2013, *Thermocouples – Part 1: EMF specifications and tolerances*

IEC 60617, *Graphical symbols for diagrams*

IEC 60664-1:2002, *Insulation coordination for equipment within low-voltage supply systems – Part 1: Principles, requirements and tests*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

NOTE For general definitions concerning fuses, see also IEC 60050-441.

3.1 Fuses and their component parts

3.1.1

fuse

device that by the fusing of one or more of its specially designed and proportioned components opens the circuit in which it is inserted by breaking the current when this exceeds a given value for a sufficient time. The fuse comprises all the parts that form the complete device

[SOURCE: IEC 60050-441:1984, 441-18-01]

3.1.2

fuse-holder

combination of the fuse-base with its fuse-carrier

Note 1 to entry: Where, in this document, the term "fuse-holder" is used, it covers fuse-bases and/or fuse-carriers, if no clearer distinction is necessary.

[SOURCE: IEC 60050-441:1984, 441-18-14]

3.1.2.1

fuse-base (fuse-mount)

fixed part of a fuse provided with contacts and terminals

Note 1 to entry: Where applicable, covers are considered as part of the fuse-base.

[SOURCE: IEC 60050-441:1984, 441-18-02]

3.1.2.2

fuse-carrier

movable part of a fuse designed to carry a fuse-link

[SOURCE: IEC 60050-441:1984, 441-18-13]

3.1.3**fuse-link**

part of a fuse including the fuse-element(s), intended to be replaced after the fuse has operated

[SOURCE: IEC 60050-441:1984, 441-18-09]

3.1.4**fuse-contact**

two or more conductive parts designed to ensure circuit continuity between a fuse-link and the corresponding fuse-holder

3.1.5**fuse-element**

part of the fuse-link designed to melt under the action of current exceeding some definite value for a definite period of time

Note 1 to entry: The fuse-link may comprise several fuse-elements in parallel.

[SOURCE: IEC 60050-441:1984, 441-18-08]

3.1.6**indicating device (indicator)**

part of a fuse provided to indicate whether the fuse has operated

[SOURCE: IEC 60050-441:1984, 441-18-17]

3.1.7**striker**

mechanical device forming part of a fuse-link which, when the fuse operates, releases the energy required to cause operation of other apparatus or indicators or to provide interlocking

[SOURCE: IEC 60050-441:1984, 441-18-18]

3.1.8**terminal**

conductive part of a fuse provided for electric connection to external circuits

Note 1 to entry: Terminals may be distinguished according to the kind of circuits for which they are intended (for example, main terminal, earth terminal, etc.) and also according to their design (for example, screw terminal, plug terminal, etc.).

3.1.9**dummy fuse-link**

test fuse-link with defined power dissipation and dimensions

3.1.10**test rig**

defined test fuse-base

3.1.11**gauge-piece**

additional part of a fuse-base intended to achieve a degree of non-interchangeability

3.1.12**linked fuse-carrier**

fuse-carrier which is mechanically linked to the fuse-base and gives a defined insertion and withdrawal movement to the fuse-link

3.2 General terms

3.2.1

enclosed fuse-link

fuse-link in which the fuse-element(s) is (are) totally enclosed, so that during operation within its rating it cannot produce any harmful external effects, for example, due to development of an arc, the release of gas or the ejection of flame or metallic particles

[SOURCE: IEC 60050-441:1984, 441-18-12]

3.2.2

current-limiting fuse-link

fuse-link that during and by its operation in a specified current range, limits the current to a substantially lower value than the peak value of the prospective current

[SOURCE: IEC 60050-441:1984, 441-18-10]

3.2.3

"g" fuse-link

<full-range breaking-capacity fuse-link, formerly general purpose fuse-link>

current-limiting fuse-link capable of breaking under specified conditions all currents, which cause melting of the fuse-element up to its rated breaking capacity

3.2.4

"a" fuse-link

<partial-range breaking-capacity fuse-link, formerly back-up fuse-link>

current-limiting fuse-link capable of breaking under specified conditions all currents between the lowest current indicated on its operating time-current characteristic ($k_2 I_n$ in Figure 2) and its rated breaking capacity

Note 1 to entry: "a" fuse-links are generally used to provide short-circuit protection. Where protection is required against over-currents less than $k_2 I_n$ in Figure 2, they are used in conjunction with another suitable switching device designed to interrupt such small overcurrents.

3.2.5

temperatures

3.2.5.1

ambient air temperature

T_a

temperature of the air surrounding the fuse (at a distance of about 1 m from the fuse or its enclosure, if any)

3.2.5.2

fuse-component temperature

T

<fuse-component (contact, terminal, etc.)>

temperature of the relevant part

3.2.6

overcurrent selectivity

coordination of the relevant characteristics of two or more overcurrent protective devices such that, on the occurrence of overcurrents within stated limits, the device intended to operate within these limits does so, while the other(s) do(es) not

[SOURCE: IEC 60050-441:1984, 441-17-15, modified – "discrimination" replaced by "selectivity" in term, "operating" replaced by "relevant" and "incidence" replaced by "occurrence" in definition]

3.2.7**fuse system**

family of fuses following the same physical design principles with respect to the shape of the fuse-links, type of contact, etc.

3.2.8**size**

specified set of dimensions of fuses within a fuse system

Note 1 to entry: Each individual size covers a given range of rated currents for which the specified dimensions of the fuses remain unchanged.

3.2.9**homogeneous series of fuse-links**

series of fuse-links, within a given size, deviating from each other only in such characteristics that for a given test, the testing of one or a reduced number of particular fuse-links of that series may be taken as representative for all the fuse-links of the homogeneous series

Note 1 to entry: The characteristics by which the fuse-links of a homogeneous series may deviate and details on which of the fuse-links shall be tested are specified in association with the tests concerned (see Table 12 and Table 13).

[SOURCE: IEC 60050-441:1984, 441-18-34, modified – Note 1 to entry replaced]

3.2.10**utilization class** (of a fuse-link)

combination of specified requirements related to the conditions in which the fuse-link fulfils its purpose, selected to represent a characteristic group of practical applications (see 6.7.1)

3.2.11**fuses for use by authorized and unskilled persons**

fuse systems divided into systems for use by authorized persons and for use by unskilled persons

Note 1 to entry: For safe replacement of fuses-links of systems used by authorized persons special skills are necessary.

Authorized person is understood to have the meaning defined for categories BA 4 "instructed" (IEC 60050-826:2022, 826-18-02) and BA 5 "skilled" (IEC 60050-826:2022, 826-18-01).

National regulations might supersede these definitions.

Instructed persons are persons adequately advised or supervised by skilled persons to enable them to avoid dangers which electricity may create (operating and maintenance staff).

Skilled persons have technical knowledge or sufficient experience to enable them to avoid dangers which electricity may create (engineers and technicians). For example, dangers for persons may come from touching live parts during operation and from replacing fuse-links under load.

Unskilled persons do not have technical knowledge or sufficient experience. To avoid dangers, which electricity may create, the relevant part of the fuse standard shall provide requirements for maximum safety in service. IEC 60269-3 provides four systems for use by unskilled persons.

3.2.12**replacement of a fuse link**

exchange of a fuse-link

3.2.13**non-interchangeability**

limitations on shape and/on dimensions with the object of avoiding in a specific fuse-base the inadvertent use of fuse-links having electrical properties other than those ensuring the desired degree of protection

[SOURCE: IEC 60050-441:1984, 441-18-33]

3.3 Characteristic quantities

3.3.1

rating

general term employed to designate the characteristic values that together define the working conditions upon which the tests are based and for which the equipment is designed

[SOURCE: IEC 60050-441:1984, 441-18-36]

Note 1 to entry: Rated values usually stated for low-voltage fuses are: voltage, current, breaking capacity, power dissipation and acceptable power dissipation, and frequency, where applicable. In the case of AC, rated voltage and rated current are stated as r.m.s. symmetrical values; in the case of DC, when ripple is present, the rated voltage is stated as a mean value, the rated current as an RMS value. The above applies to any value of voltage and current, if not indicated otherwise.

3.3.2

prospective current (of a circuit and with respect to a fuse)

current that would flow in the circuit if the fuse-link(s) is(are) replaced by a conductor of negligible impedance

Note 1 to entry: For AC, the prospective current is expressed by the RMS value of the AC component.

Note 2 to entry: The prospective current is the quantity to which the breaking capacity and characteristics of the fuse are normally referred, e.g. I^2t and cut-off current characteristics (see 9.5.7).

[SOURCE: IEC 60050-441:1984, 441-17-01, modified – "each pole of the switching device were" replaced by "the fuse-link(s) is", Note to entry replaced]

3.3.3

gates

limiting values within which the characteristics, for example time-current characteristics, are obtained.

3.3.4

breaking capacity of a fuse

value of prospective current that a fuse is capable of breaking at a stated voltage under prescribed conditions of use and behaviour

[SOURCE: IEC 60050-441:1984, 441-17-08, modified – "switching device" removed from term and definition, Note to entry removed]

3.3.5

breaking range

range of prospective currents within which the breaking capacity of a fuse-link is assured

3.3.6

cut-off current

maximum instantaneous value reached by the current during the breaking operation of a fuse-link when it operates in such a manner as to prevent the current from reaching the otherwise attainable maximum

3.3.7

cut-off current characteristic; let-through current characteristic

curve giving the cut-off current as a function of the prospective current under stated conditions of operation

Note 1 to entry: In the case of AC, the values of the cut-off currents are the maximum values which can be reached whatever the degree of asymmetry. In the case of DC, the values of the cut-off currents are the maximum values reached related to the time constants as specified.

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

3.3.8**peak withstand current** (of a fuse-holder)

value of cut-off current that the fuse-holder can withstand

Note 1 to entry: The peak withstand current is not less than the highest cut-off current of any fuse-link with which the fuseholder is intended to be associated.

3.3.9**pre-arcing time; melting time**

interval of time between the beginning of a current large enough to cause a break in the fuse-element(s) and the instant when an arc is initiated

[SOURCE: IEC 60050-441:1984, 441-18-21]

3.3.10**arcing time of a fuse-link**

interval of time between the instant of the initiation of the arc in a fuse and the instant of final arc extinction in the same fuse-link

[SOURCE: IEC 60050-441:1984, 441-17-37 modified – "pole" removed from term and definition]

3.3.11**operating time; total clearing time**

sum of the pre-arcing time and the arcing time

[SOURCE: IEC 60050-441:1984, 441-18-22]

3.3.12 **I^2t ; Joule integral**

integral of the square of the current over a given time interval:

$$I^2t = \int_{t_0}^{t_1} i^2 dt$$

Note 1 to entry: The pre-arcing I^2t is the I^2t integral extended over the pre-arcing time of the fuse.

Note 2 to entry: The operating I^2t is the I^2t integral extended over the operating time of the fuse.

Note 3 to entry: The energy, in joules, released in 1 Ω of resistance in a circuit protected by a fuse is equal to the value of the operating I^2t expressed in A²s.

[SOURCE: IEC 60050-441:1984, 441-18-23]

3.3.13 **I^2t characteristic**

curve giving I^2t values (pre-arcing I^2t and/or operating I^2t) as a function of prospective current under stated conditions of operation

3.3.14 **I^2t zone**

range contained by the minimum pre-arcing I^2t characteristic and the maximum operating I^2t characteristic, under specified conditions.

3.3.15**rated current of a fuse-link**

I_n

value of current that the fuse-link can carry continuously without deterioration under specified conditions

3.3.16**time-current characteristic**

curve giving the time, e.g. pre-arcing time or operating time as a function of the prospective current under stated conditions of operation

Note 1 to entry: For times longer than 0,1 s, for practical purposes the difference between pre-arcing and operating time is negligible.

[SOURCE: IEC 60050-441:1984, 441-17-13]

3.3.17**time-current zone**

range contained by the minimum pre-arcing time-current characteristics and the maximum operating time-current characteristic, under specified conditions

3.3.18**conventional non-fusing current**

I_{nf}

value of current specified as that which the fuse-link is capable of carrying for a specified time (conventional time) without melting

[SOURCE: IEC 60050-441:1984, 441-18-27]

3.3.19**conventional fusing current**

I_f

value of current specified as that which causes operation of the fuse-link within a specified time (conventional time)

[SOURCE: IEC 60050-441:1984, 441-18-28]

3.3.20**overload curve of an "a" fuse-link**

curve showing the time for which an "a" fuse-link is able to carry the current without deterioration

SEE: 9.4.3.4 and Figure 2

3.3.21**power dissipation (of a fuse-link)**

power released in a fuse-link carrying a stated value of electric current under prescribed conditions of use and behaviour

Note 1 to entry: The prescribed conditions of use and behaviour generally include a constant RMS value of the electric current after steady-state temperature conditions are reached.

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-38]

3.3.22**acceptable power acceptance (of a fuse-base or a fuse-holder)**

stated value of power dissipation of a fuse-link which a fuse-base or a fuse-holder can accept under prescribed conditions of use and behavior

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-39]

3.3.23**recovery voltage**

voltage which appears across the terminals of a pole of a fuse after the breaking of the current

Note 1 to entry: This voltage may be considered in two successive intervals of time, one during which a transient voltage exists (see 2.3.23.1) followed by a second one during which only the power frequency or DC recovery voltage (see 2.3.23.2) exists.

[SOURCE: IEC 60050-441:1984, 441-17-25, modified – "switching device" removed from definition, Note 1 to entry modified]

3.3.23.1**transient recovery voltage****abbreviation TRV**

recovery voltage during the time in which it has a significant transient character

Note 1 to entry: The transient recovery voltage may be oscillatory or non-oscillatory or a combination of these, depending on the characteristics of the circuit and the fuse. It includes the voltage shift of the neutral of a polyphase circuit.

Note 2 to entry: The transient recovery voltage in three-phase circuits is, unless otherwise stated, that which appears across the first pole to clear, because this voltage is generally higher than that which appears across each of the other two poles.

[SOURCE: IEC 60050-441:1984, 441-17-26]

3.3.23.2**power-frequency or DC recovery voltage**

recovery voltage after the transient voltage phenomena have subsided

Note 1 to entry: The power frequency or DC recovery voltage may be referred to as a percentage of the rated voltage.

[SOURCE: IEC 60050-441:1984, 441-17-27, modified – "or DC" added to term, Note 1 to entry added)]

3.3.24**arc voltage of a fuse**

instantaneous value of the voltage which appears across the terminals of a fuse during the arcing time

[SOURCE: IEC 60050-441:1984, 441-18-30]

3.3.25**isolating distance (for a fuse)**

shortest distance between the fuse-base contacts or any conductive parts connected thereto measured on a fuse with the fuse-link or the fuse-carrier removed

[SOURCE: IEC 60050-441:1984, 441-18-06]

4 Conditions for operation in service**4.1 General**

Where the following conditions apply, fuses complying with this document are deemed capable of operating satisfactorily without further qualification. These conditions also apply for tests except those otherwise specified in Clause 9.

4.2 Ambient air temperature (T_a)

The ambient air temperature T_a (see 3.2.5.1) does not exceed 40 °C, its mean value measured over a period of 24 h does not exceed 35 °C, and its mean value measured over a period of one year is lower.

The minimum value of the ambient air temperature is –5 °C.

In cases where the temperature conditions vary significantly from these values, this should be taken into consideration from the points of view of operation, temperature rise, etc. See Annex D.

NOTE The time-current characteristics given are related to a reference ambient air temperature of 20 °C. These time-current characteristics also approximately apply to a temperature of 30 °C.

4.3 Altitude

The altitude of the site of installation of the fuses does not exceed 2 000 m above sea-level.

4.4 Atmospheric conditions

The air is clean and its relative humidity does not exceed 50 % at the maximum temperature of 40 °C.

Higher relative humidity is permitted at lower temperatures, for example, 90 % at 20 °C.

Under these conditions, moderate condensation may occasionally occur due to variation in temperature.

Where fuses are to be used under conditions different from those mentioned in 4.1, 4.2 and 4.3, in particular outdoors without protection, the information shall be given in the manufacturer's literature. This applies also in cases where deposits of sea salt or abnormal deposits of industrial origin may occur.

4.5 Voltage

The system voltage has a maximum value not exceeding 110 % of the rated voltage of the fuse. For DC when obtained by rectifying AC, the ripple shall not cause a variation of more than 5 % above or 9 % below the mean value of 110 % of the rated voltage.

For fuses rated 690 V the maximum system voltage shall not exceed 105 % of the rated voltage of the fuse.

NOTE Attention is drawn to the fact that the indicating device or striker of a fuse may not operate if the fuse-link operates at a voltage, which is considerably lower than its rated voltage (see 9.4.3.6).

4.6 Current

The currents to be carried and to be broken are within the range specified in 8.4 and 8.5.

4.7 Frequency, power factor and time constant

4.7.1 Frequency

For AC the frequency is the rated frequency of the fuse-link.

4.7.2 Power factor

For AC the power factor is not lower than that shown in Table 20, appropriate to the value of prospective current.

4.7.3 Time constant (τ)

For DC the time constant corresponds to that shown in Table 21.

Some service duties may be found which exceed the limits shown in Table 21 as regards time constant. For such an application, a fuse-link which has been tested to verify that it meets the required time constant and is marked accordingly shall be used.

4.8 Conditions of installation

The fuse is installed in accordance with the manufacturer's instructions.

If the fuse is likely to be exposed in service to abnormal vibrations or shocks, the manufacturer should be consulted.

4.9 Utilization class

Utilization classes (for example, "gG") are specified according to 6.7.1.

4.10 Selectivity of fuse-links

Limits of selectivity for times greater than 0,1 s are given in Table 2 and Table 3.

For "gG" and "gM" fuse-links pre-arcing I^2t values are given in Table 7 and operating I^2t values are given in subsequent parts. Values for other breaking ranges and utilization categories are shown in subsequent parts.

5 Classification

Fuses are classified according to Clause 6 and the subsequent parts.

6 Characteristics of fuses

6.1 Summary of characteristics

6.1.1 General

The characteristics of a fuse shall be stated in the following terms, where such terms are applicable.

6.1.2 Fuse-holders

- a) Rated voltage (see 6.2)
- b) Rated current (see 6.3.2)
- c) Kind of current and rated frequency if applicable (see 6.4)
- d) Rated acceptable power dissipation (see 6.5)
- e) Dimensions or size
- f) Number of poles, if more than one
- g) Peak withstand current

6.1.3 Fuse-links

- a) Rated voltage (see 6.2)
- b) Rated current (see 6.3.1)
- c) Kind of current and rated frequency, if applicable (see 6.4)
- d) Rated power dissipation (see 6.5)
- e) Time-current characteristics (see 6.6)
- f) Breaking range (see 6.7.1)
- g) Rated breaking capacity (see 6.7.2)
- h) Cut-off current characteristics (see 6.8.1)
- i) I^2t characteristics (see 6.8.2)
- k) Dimensions or size

6.1.4 Complete fuses

Degree of protection according to IEC 60529.

6.2 Rated voltage

For AC the standard values of rated voltages are given in Table 1.

Table 1 – Standard values of AC rated voltages for fuses

Series I V	Series II V
230	120
	208
	240
	277
400	415
500	480
690	600
1 000	347

For DC the standard values of rated voltages are given in Table 2.

Table 2 – Preferred values of DC rated voltages for fuses

Series I V	Series II V
	110
220	
	250
400	
440	460
500	
	600
750	
1 000	
	1 200
1 500	

For specific applications, rated voltage of different values to Table 1 and Table 2 shall be given in the manufacturer's instructions.

NOTE The rated voltage of the fuse is the lowest value of the rated voltages of its parts (fuse-holder, fuse-link).

6.3 Rated current

6.3.1 Rated current of the fuse-link

The preferred rated currents for the fuse-links are the following values expressed in A:

2 – 4 – 6 – 8 – 10 – 12 – 13 – 16 – 20 – 25 – 32 – 35 – 40 – 50 – 63 – 80 – 100 – 125 – 160 – 200 – 224 – 250 – 315 – 355 – 400 – 425 – 500 – 630 – 800 – 1 000 – 1 250 – 1 600

If it is necessary to choose lower values or intermediate values or higher values, these values should be selected from the series R10 of ISO 3, and in exceptional cases, from R20 or R40 of ISO 3.

6.3.2 Rated current of the fuse-holder

The rated current of the fuse-holder, expressed in amperes, should be selected from the series of rated currents of fuse-links if not otherwise specified in subsequent parts. For "gG" and "aM" fuses, the rated current of the fuse-holder represents the highest rated current of the fuse-link with which it is intended to be used.

6.4 Rated frequency (see 7.1 and 7.2)

The absence of any marking regarding rated frequency shall imply that the fuse meets the conditions laid down in this document for frequencies between 45 Hz and 62 Hz only.

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

The rated power dissipation of a fuse-link is stated by the manufacturer if not otherwise specified in subsequent parts. That value shall not be exceeded under specified test conditions.

The rated acceptable power dissipation of a fuse-holder is stated by the manufacturer if not otherwise specified in the subsequent parts. It is intended to be the maximum power dissipation the fuse-holder can tolerate under specified test conditions without exceeding the specified temperature rise.

6.6 Limits of time-current characteristics

6.6.1 General

The limits are based on a reference ambient air temperature T_a of +20 °C.

6.6.2 Time-current characteristics, time-current zones

They depend on the design of the fuse-link, and, for a given fuse-link, on the ambient air temperature and the cooling conditions.

NOTE For ambient air temperatures deviating from the temperature range according to 4.1, consultation with the manufacturer is necessary.

For fuse-links not complying with the standardized time-current zones as specified in the subsequent parts, the manufacturer should keep available (with their tolerances):

- the pre-arcing and operating time-current characteristics;

or

– the time-current zone.

NOTE For pre-arcing times smaller than 0,1 s, the manufacturer should keep available I^2t characteristics with their tolerances (see 6.8.3).

When the time-current characteristics are presented for pre-arcing times exceeding 0,1 s, they should be given with current as abscissa and time as ordinate. Logarithmic scales shall be used on both coordinate axes.

The basis of the logarithmic scales (the dimensions of one decade) shall be in the ratio 2/1 with the longer dimensions on the abscissa. However, because of long-established practice in other countries (for example UL fuse systems), a ratio of 1/1 is recognized as an alternative presentation.

6.6.3 Conventional times and currents

The conventional times and currents for "gG" and "gM" fuse-links are given in Table 3.

Table 3 – Conventional time and current for "gG", and "gM" fuse-links

Rated current I_n for "gG"	Conventional time	Conventional current	
Characteristic current I_{ch} for "gM" ^b A	h	I_{nf}	I_f
$I_n < 16$	1	a	a
$16 \leq I_n \leq 63$	1		
$63 < I_n \leq 160$	2	$1,25 I_n$	$1,6 I_n$
$160 < I_n \leq 400$	3		
$400 < I_n$	4		
^a Values for fuse-links with rated current less than 16 A are given in subsequent parts.			
^b For "gM" fuse-links, see 6.7.1.			

6.6.4 Gates

For "gG" and "gM" fuse-links, the gates given in Table 4 apply.

Table 4 – Gates for specified pre-arcing times of "gG" and "gM" fuse-links^a

1 I_n for "gG" I_{ch} for "gM" ^b A	2 I_{min} (10 s) ^c A	3 I_{max} (5 s) A	4 I_{min} (0,1 s) A	5 I_{max} (0,1 s) A
13	24	65	65	130
16	33	65	85	150
20	42	85	110	200
25	52	110	150	260
32	75	150	200	350
35	83	175	225	445
40	95	190	260	450
50	125	250	350	610
63	160	320	450	820
80	215	425	610	1 100
100	290	580	820	1 450
125	355	715	1 100	1 910
160	460	950	1 450	2 590
200	610	1 250	1 910	3 420
224	600	1 600	2 000	4 300
250	750	1 650	2 590	4 500
315	1 050	2 200	3 420	6 000
355	1 100	2 750	3 500	7 700
400	1 420	2 840	4 500	8 060
425	1 350	3 300	4 500	9 500
450	1 600	3 300	5 250	9 300
500	1 780	3 800	6 000	10 600
630	2 200	5 100	8 060	14 140
800	3 060	7 000	10 600	19 000
1 000	4 000	9 500	14 140	24 000
1 250	5 000	13 000	19 000	35 000
1 600	7 500	16 000	24 000	43 000

^a Values for fuses with rated current less than 13A are given in subsequent parts.

^b For "gM" fuse-links, see 6.7.1.

^c I_{min} (10 s) is the minimum value of current for which the pre-arcing time is not less than 10 s.

For "aM" fuses the standard gates for time- current characteristics based on reference ambient air temperature of 20 °C are given in Table 5 and Figure 3. The standardized k-factors are $k_0 = 1,5$; $k_1 = 4$ and $k_2 = 6,3$.

Table 5 – Gates for "aM" fuse-links (all rated currents)

	$4 I_n$	$6,3 I_n$	$8 I_n$	$10 I_n$	$12,5 I_n$	$19 I_n$
$t_{operating}$	-	60 s	-	-	0,5 s	0,10 s
$t_{pre-arcing}$	60 s	-	0,5 s	0,2 s	-	-

6.7 Breaking range and breaking capacity

6.7.1 Breaking range and utilization category

The first letter shall indicate the breaking range:

- "g" fuse-links (full-range breaking-capacity fuse-link);
- "a" fuse-links (partial-range breaking-capacity fuse-link).

The second letter shall indicate the utilization category; this letter defines with accuracy the time-current characteristics, conventional times and currents, gates.

6.7.2 Rated breaking capacity

The rated breaking capacity of a fuse-link is given by the manufacturer corresponding to the rated voltage. Values of minimum rated breaking capacity are given in subsequent parts.

6.8 Cut-off current and I^2t characteristics

6.8.1 General

The value for cut-off and I^2t characteristics shall take into account manufacturing tolerances and shall refer to the service conditions as specified in subsequent parts, for example, the values of voltage, frequency and power factor.

6.8.2 Cut-off current characteristics

The cut-off current characteristics shall represent the maximum instantaneous values of current likely to be experienced in service (see 9.6.1 and Annex C).

Where the cut-off current characteristics are required, and unless specified in subsequent parts, they should be given by the manufacturer according to the example shown in Figure 4, in a double logarithmic presentation with the prospective current as abscissa.

6.8.3 I^2t characteristics

The pre-arcing I^2t characteristics for pre-arcing times of less than 0,1 s down to a time corresponding to the rated breaking capacity shall be given by the manufacturer. They shall represent the lowest values likely to be experienced in service as a function of the prospective current.

The operating I^2t characteristics with specified voltages as parameters shall be given by the manufacturer for pre-arcing times less than 0,1 s. They shall represent the highest values likely to be experienced in service as a function of the prospective current.

When presented graphically, the I^2t characteristics shall be given with prospective current as abscissa and I^2t values as ordinate. Logarithmic scales shall be used on both coordinate axes. (For the use of the logarithmic scales, see 6.6.2.)

7 Markings

7.1 General

The marking shall be durable and easily legible. Compliance is checked by test 9.12.

NOTE 1 The marking for rated current and rated voltage may, for instance, be as follows:

$$10 \text{ A} \quad 500 \text{ V} \quad \text{or} \quad 10/500 \quad \text{or} \quad \frac{10}{500}$$

NOTE 2 For all parts of fuses relevant symbols from IEC 60417 can be used.

7.2 Markings of fuse-holders

The following information shall be marked on all fuse-holders:

- name of the manufacturer or a trade mark by which he may be readily identified;
- manufacturer's identification reference enabling all the characteristics listed in 6.1.2 to be found;
- rated voltage;
- rated current;
- kind of current and rated frequency, when applicable.

A fuse-holder marked with AC ratings may also be used for DC if a fuse-holder contains a removable fuse-base and a removable fuse-carrier. Both should be separately marked for the purpose of identification.

7.3 Markings of fuse-links

The following information shall be marked on all fuse-links except small fuse-links where this is impracticable:

- name of the manufacturer or a trade mark by which he may be readily identified;
- manufacturer's identification reference, enabling all the characteristics listed in 6.1.3 to be found;
- rated voltage;
- rated current;
- breaking range and utilization category (letter code), where applicable (see 6.7.1);
- kind of current and, if applicable, rated frequency (see 6.4).

Fuse-links should be marked separately for AC and DC if the fuse-link is provided for AC and DC.

For small fuse-links, where it is impracticable to include all the specified information on the fuse-link, the trade mark, list reference of the manufacturer, rated voltage and the rated current shall be marked.

8 Standard conditions for construction

8.1 Mechanical design

8.1.1 Replacement of fuse-links

A fuse-link shall have adequate mechanical strength and its contacts shall be securely fixed.

8.1.2 Connections, including terminals

The fixed connections shall be such that the necessary contact force is maintained under the conditions of service and operation.

No contact force on connections shall be transmitted through insulating material other than ceramic or other material with characteristics not less suitable, unless there is sufficient resilience in the metallic parts to compensate for any possible shrinkage or other deformation of the insulating material. Tests are specified in subsequent parts, where necessary.

Terminals shall be such that they cannot turn or be displaced when the connecting screws are tightened, and such that the conductors cannot be displaced. The parts gripping the conductors shall be of metal and shall have such a shape that they cannot unduly damage conductors.

Terminals shall be so arranged that they are readily accessible (after removal of covers, if any) under the intended conditions of installation.

NOTE Requirements of screwless-type terminals are given in Annex E.

8.1.3 Fuse-contacts

Fuse-contacts shall be such that the necessary contact force is maintained under the conditions of service and operation, in particular under the conditions corresponding to 8.5.

Contact shall be such that the electromagnetic forces occurring during operation under conditions in accordance with 8.5 shall not impair the electrical connections between

- a) the fuse-base and the fuse-carrier;
- b) the fuse-carrier and the fuse-link;
- c) the fuse-link and the fuse-base, or, if applicable, any other support.

In addition, fuse contacts shall be so constructed and of such material that, when the fuse is properly installed and service conditions are normal, adequate contact is maintained

- a) after repeated engagement and disengagement;
- b) after being left undisturbed in service for a long period (see 9.10).

Fuse-contacts of copper alloy shall be free from season cracking.

These requirements are verified by the tests according to 9.10, 9.11.2.1 and in Clause 8 of subsequent parts of IEC 60269.

8.1.4 Construction of a gauge-piece

A gauge-piece, if any, shall be so designed that it withstands normal stresses occurring during use.

8.1.5 Mechanical strength of the fuse-link

A fuse-link shall have adequate mechanical strength and its contacts shall be securely fixed.

8.2 Insulating properties and suitability for isolation

The fuses shall be such that they do not lose their insulating properties at the voltages to which they are subjected in normal service. The fuse shall be suitable for isolation when it is in its normal open position, the fuse-link remaining inside the fuse-carrier, or when the fuse-link, and, when applicable, the fuse-carrier is removed. The applicable overvoltage category is specified in subsequent parts.

The fuse shall be deemed to satisfy these conditions if it passes the tests for verification of insulating properties and suitability for isolation in accordance with 9.2.

The minimum creepage distances, clearances and distances through insulating material or sealing compound shall comply with the values specified in subsequent parts.

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

The fuse-holder shall be so designed and proportioned as to carry continuously, under standard conditions of service, the rated current of the fuse-link with which it is provided without exceeding

- the temperature-rise limits specified in Table 6 at the rated acceptable power dissipation of the fuse-holder as indicated by the manufacturer or otherwise specified in subsequent parts.

The fuse-link shall be so designed and proportioned as to carry continuously, under standard conditions of service, its rated current without exceeding

- the rated power dissipation of the fuse-link as indicated by the manufacturer or otherwise specified in the subsequent parts.

In particular, the temperature-rise limits specified in Table 6 shall not be exceeded

- when the rated current of the fuse-link is equal to the rated current of the fuse-holder intended to accommodate this fuse-link;
- when the power dissipation of the fuse-link is equal to the rated acceptable power dissipation of the fuse-holder.

These requirements are verified by the tests according to 9.3.

Table 6 – Temperature rise limits $\Delta T = (T - T_a)$ for terminals

	Contacts	Temperature rise ΔT in K
Terminals	Bare Copper	60
	Bare Brass or tin-plated	65
	Silver-plated or nickel-plated	70 ^{a)}
^{a)} The limit of temperature rise is governed by the use of PVC insulated conductors or for other connection methods or conductors the manufacturer has to give maximum values of temperature rise in his documentation and the conductor rating must be observed. Temperature limits of the fuse and the conductor must be aligned.		

8.4 Operation

The fuse-link shall be so designed and proportioned that, when tested in its appropriate test arrangement at rated frequency and an ambient air temperature of $(20 \pm 5) ^\circ\text{C}$,

- it is able to carry continuously any current not exceeding its rated current;
- it is able to withstand overload conditions as they may occur in normal service (see 9.4.3.4).

For a "g" fuse-link within the conventional time,

- the fuse-link does not operate, when it carries any current not exceeding the conventional non-fusing current (I_{nf});
- it operates when it carries any current equal to or exceeding the conventional fusing current (I_f).

NOTE Time-current zones, if any, are to be considered.

For an "a" fuse-link,

- the fuse-link does not operate when it carries a current not exceeding $k_1 I_n$ for the corresponding time indicated in the overload curve (see Figure 2);

- when carrying a current between $k_1 I_n$ and $k_2 I_n$, the fuse-element may melt, provided that the pre-arcing time is greater than the value indicated in the pre-arcing time-current characteristic;
- it operates when it carries a current exceeding $k_2 I_n$ within its time-current zone, including the arcing time.

The time-current values measured in 9.4.3.3 shall fall within the time-current zone provided by the manufacturer.

A fuse-link is deemed to satisfy these conditions if it passes the tests prescribed in 9.4.

8.5 Breaking capacity

The fuse shall be capable of breaking, at rated frequency, and at a voltage not exceeding the recovery voltage specified in 9.5, any circuit having a prospective current between,

- for "g" fuse-links, the current I_f ;
- for "a" fuse-links, the current $k_2 I_n$; and
- in the case of AC, the rated breaking capacity at power factors not lower than those shown in Table 21 appropriate to the value of the prospective current;
- in the case of DC, the rated breaking capacity at time constants not greater than those limits shown in Table 22 appropriate to the value of the prospective current.

During operation of the fuse-link in a test circuit as described in 9.5, the arc voltage shall not exceed the values given in Table 7.

NOTE Where fuse-links are used in circuits with system voltages belonging to a range lower than that corresponding to the rated voltage of the fuse-links, consideration should be given to the arc voltage, which should not exceed the value in Table 7 corresponding to the system voltage.

Table 7 – Maximum arc voltage

Rated voltage U_n of the fuse-link V		Maximum arc voltage, peak value V
AC and DC currents	Up to and including 60	1 000
	61 to 300	2 000
	301 to 690	2 500
	691 to 800	3 000
	801 to 1 000	3 500
DC only	1 001 to 1 200	3 500
	1 201 to 1 500	5 000
NOTE For fuse-links having rated current less than 16 A, the maximum arc voltage is not specified in this document but is under consideration.		

A fuse shall be deemed to satisfy these conditions if it passes the tests prescribed in 9.5.

8.6 Cut-off current characteristic

If not otherwise specified in subsequent parts, the values of cut-off current measured as specified in 9.6 shall be less than, or equal to, the values corresponding to the cut-off current characteristics assigned by the manufacturer (see 6.8.2).

NOTE For the cut-off current characteristics as function of the actual pre-arcing time, see Annex C.

8.7 I^2t characteristics

The pre-arcing I^2t values verified according to 9.7 shall not be less than the characteristics stated by the manufacturer in accordance with 6.8.3, and lie within the limits given in Table 8 for "gG" and "gM" fuse-links. For pre-arcing times smaller than 0,01 s, limits are given in subsequent parts, if required. Values for "gD" and "gN" fuse-links are given in IEC 60269-2, fuse system H.

The operating I^2t values verified according to 9.7 shall be less than, or equal to, the characteristics stated by the manufacturer in accordance with 6.8.3 or specified in subsequent parts.

Table 8 – Pre-arcing I^2t values at 0,01 s for "gG" and "gM" fuse-links

I_n for "gG" I_{ch} for "gM" A	I^2t_{min} $10^3 \times (A^2s)$	I^2t_{max} $10^3 \times (A^2s)$
16	0,3	1,0
20	0,5	1,8
25	1,0	3,0
32	1,8	5,0
35	2,2	8,0
40	3,0	9,0
50	5,0	16,0
63	9,0	27,0
80	16,0	46,0
100	27,0	86,0
125	46,0	140,0
160	86,0	250,0
200	140,0	400,0
224	200,0	520,0
250	250,0	760,0
315	400,0	1 300,0
400	760,0	2 250,0
500	1 300,0	3 800,0
630	2 250,0	7 500,0
800	3 800,0	13 600,0
1 000	7 840,0	25 000,0
1 250	13 700,0	47 000,0

8.8 Overcurrent selectivity of fuse-links

Requirements concerning overcurrent selectivity are dependant upon the fuse system, the rated voltage and the application of the fuse; relevant requirements may be given in subsequent parts.

8.9 Protection against electric shock

8.9.1 General

For the protection of persons against electric shock, three states of the fuse shall be taken into consideration:

- when the complete fuse is properly mounted, installed and wired with fuse-base, fuse-link and, where applicable, gauge-piece, fuse-carrier and enclosure forming part of the fuse (normal service condition);
- during the replacement of the fuse-link;
- when the fuse-link, and where applicable, the fuse-carrier is removed.

The rated impulse withstand voltage is given in Table 9 appropriate to the rated voltage and the overvoltage category of the fuse, which are specified in subsequent parts.

The requirements are specified in subsequent parts. See also 9.8.

Table 9 – Rated impulse withstand voltage

Rated voltage of the fuse up to and including V	Rated impulse withstand voltage U_{imp} (1,2/50 μs) kV			
	Overvoltage category			
	IV	III	II	I
230	4	2,5	1,5	0,8
400	6	4	2,5	1,5
690	8	6	4	2,5
1 000	12	8	6	4

8.9.2 Clearances and creepage distances

The clearances shall be not less than the values given in Table 10 to reduce the risk of disruptive discharge due to overvoltage.

Table 10 – Minimum clearances in air

Rated impulse withstand voltage U_{imp} kV	Minimum clearances mm
	Inhomogeneous field conditions
0,8	0,8
1,5	0,8
2,5	1,5
4,0	3,0
6,0	5,5
8,0	8,0
12,0	14,0

NOTE The values of minimum clearances in air are based on 1,2/50 μs impulse voltage, for barometric pressure of 80 kPa, equivalent to normal atmospheric pressure at 2 000 m above sea-level.

Creepage distances shall also correspond to the material group, as defined in 2.7.1.3 of IEC 60664-1:2002, corresponding with the rated voltage given in Table 11.

Table 11 – Minimum creepage distances

Rated voltage of the fuse up to and including V	Creepage distances for equipment subject to long-term stress mm		
	Material group I	Material group II	Material group III
230	3,2	3,6	4
400	5	5,6	6,3
690	8	9	10
1 000	12,5	14	16

8.9.3 Leakage currents of fuses suitable for isolation

For fuses suitable for isolation and having a rated voltage greater than 50 V, the leakage current shall be measured through each pole with the contacts in the open position.

The value of the leakage current, with a test voltage equal to 1,1 times the rated voltage, shall not exceed

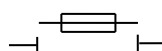
- 0,5 mA per pole for fuses in a new condition;
- 2 mA per pole for fuses having been submitted to tests according to 9.5.

8.9.4 Additional constructional requirements for fuse holders for linked fuse-carriers, suitable for isolation

The fuse-holder shall be marked with the symbol IEC 60617-S00369.

NOTE 1 Symbol IEC 60617. New definition with double opening to be used (2021-04-29).

SC 34B Fuse-disconnector double opening C "Fuse base"



When the fuse is in open position, with the fuse-link remaining inside the fuse-carrier, the isolating distance between the fuse contacts in accordance with the isolating function shall be provided. Indication of this position shall be provided by the position of the fuse-carrier.

This requirement is verified in accordance with 9.2.

When there exists a locking means specified by the manufacturer in order to lock the fuses in the isolated position, locking shall be possible only in this position. Fuses shall be designed so that the fuse-carrier remains attached to the fuse-base giving a correct indication of the open position, and of locking, if any.

NOTE 2 Locking in the close position is permitted for particular applications.

For fuses incorporating electronic circuits connected to the main poles, the disconnection of the electronic circuit(s) is permitted during dielectric tests.

8.10 Resistance to heat

All components shall be sufficiently resistant to heat which may occur in normal use.

If not otherwise specified in subsequent parts, this requirement is considered as being met when satisfactory results are obtained in tests according to 9.9 and 9.10.

8.11 Mechanical strength

All components of the fuse shall be sufficiently resistant to mechanical stresses which may occur in normal use.

If not otherwise specified in the subsequent parts, this requirement is considered as being met when satisfactory results are obtained on tests according to 9.3 to 9.5 and 9.11.1.

8.12 Resistance to corrosion

8.12.1 General

All metallic components of the fuse shall be resistant to corrosive influences which may occur in normal use.

8.12.2 Resistance to rusting

Ferrous components shall be so protected that they meet the relevant tests.

If not otherwise specified in subsequent parts, this requirement is considered as being met when satisfactory results are obtained on tests according to 9.11.2.3 and 9.11.2.3.

8.12.3 Resistance to season cracking

Current-carrying parts shall be sufficiently resistant to season cracking. Relevant tests are specified in 9.11.2.1 and 9.11.2.1.

8.13 Resistance to abnormal heat and fire

All components of the fuse shall be sufficiently resistant to abnormal heat and fire. The test is specified in 9.11.2.2.

8.14 Electromagnetic compatibility

Fuses within the scope of this document are not sensitive to normal electromagnetic disturbances, and therefore no immunity tests are required.

Significant electromagnetic disturbance generated by a fuse is limited to the instant of its operation. Provided that the maximum arc voltages during operation in the type tests comply with the requirements of 8.5, the requirements for electromagnetic compatibility are deemed to be satisfied.

9 Tests

9.1 Overview

9.1.1 General

Tests shall be made according to the IEC rules.

9.1.2 Kind of tests

The tests specified in this clause are type tests and are performed under the responsibility of the manufacturer.

If, during one of these tests, a failure occurs and the manufacturer can furnish evidence that this failure is not typical of the fuse-type but due to an individual fault of the tested sample, the relevant test shall be repeated. This does not apply to the breaking capacity test.

If acceptance tests are agreed upon between user and manufacturer, the test shall be selected from the type tests.

Type tests are performed in order to verify that a particular type of fuse or a range of fuses forming a homogeneous series (see 9.1.6.3) corresponds to the specified characteristics, and operates satisfactorily under normal conditions of service or under particular specified conditions.

Compliance with the type test is deemed to prove that all fuses of identical construction meet the requirements of this document.

If any part of the fuse is modified in a manner liable to adversely affect the result of a type test already performed, that type test shall be repeated.

9.1.3 Ambient air temperature (T_a)

The ambient air temperature shall be measured by measuring devices protected against draughts and heat radiation, placed at the height of the centre of the fuse and at a distance of approximately 1 m. At the beginning of each test, the fuse shall be approximately at the ambient air temperature.

9.1.4 Condition of the fuse

Tests shall be made on fuses in a clean and dry condition.

9.1.5 Arrangement of the fuse and dimensions

Except for the degree of protection test (see 9.8), the fuse shall be mounted in free air in draught-free surroundings in the normal operation position, for example, vertical, and, unless otherwise specified, on insulating material of sufficient rigidity to withstand the forces encountered without applying external load to the fuse under test.

The fuse-link shall be mounted either as in normal use, or in the fuse-holder for which it is intended, or in a test rig in accordance with the indications given in the relevant subclause in a subsequent part.

Before the tests are started, the specified external dimensions shall be measured and the results compared with the dimensions specified in the relevant data sheets of the manufacturer or specified in subsequent parts.

9.1.6 Testing of fuse-links

9.1.6.1 General

Fuse-links shall be tested with the kind(s) of current and, for AC, frequency for which they are rated, unless otherwise specified in subsequent parts.

9.1.6.2 Complete tests

Before the tests are commenced, the internal resistance R of all samples shall be measured at an ambient-air temperature of $(20 \pm 5) ^\circ\text{C}$ with a measuring current of not more than $0,1 I_n$. The value R shall be recorded in the test report.

A survey of the complete tests is given in Table 12.

9.1.6.3 Testing of fuse-links of a homogeneous series

Fuse-links of different rated currents are considered to form a homogeneous series provided

- they have enclosures identical in form and construction, and with the exception of fuse-elements, in dimension. This condition is also met when only the fuse-link contacts differ, in which case tests are performed with the fuse-link having the fuse-link contacts most likely to produce the least favourable test results;
- they have the same arc-extinguishing medium and the same completeness of filling;
- their fuse-elements consist of identical materials. They shall have the same length and form;

NOTE For example, they can be formed with identical tools from material of different thickness.

- their cross-section, which may vary along the length of fuse-elements, as well as the number of fuse-elements, shall not exceed the cross-section and the number of fuse-elements, respectively, of those fuse-links having the highest rated current;
- the minimum distances between adjacent fuse-elements and between the fuse-elements and the inner surface of the cartridge is not less than those in the fuse-link having the highest rated current;
- they are suitable to be used with a given fuse-holder, or are intended to be used without a fuse-holder, but in an arrangement identical for all rated currents of the homogeneous series.
- With respect to the temperature-rise test, the product $RI_n^{3/2}$ does not exceed the corresponding value for the fuse-link which has the largest rated current of the homogeneous series. The resistance R shall be measured with the fuse-link as indicated in 9.1.6.2.
- With respect to the breaking-capacity test, the rated breaking capacity is not greater than that of the fuse-link having the largest current within the homogeneous series. Otherwise, the fuse-link of the largest rated current among those having the greater rated breaking capacity shall be subjected to tests no. 1 and no. 2.

For fuse-links of a homogeneous series,

- the fuse-link having the largest rated current shall be tested completely according to Table 12;
- the fuse-link having the smallest rated current shall be tested only according to Table 13;
- the fuse-links between the largest and the smallest rated current shall be tested according to Table 14.

Table 12 – Survey of complete tests on fuse-links and number of fuse-links to be tested

Test according to subclause	Number of samples																										
	"g" fuse-links													"a" fuse-links													
	1	1	1	1	1	1	3	1	3	1	1	1	1	3	1	1	1	1	3	3	1	4	3	3			
9.1.5 Dimensions	X	X	X												X	X	X										
9.1.6.2 Resistance	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
9.3 Temperature rise, power dissipation	X														X												
9.4.3.1 a) Conventional non-fusing current	X																										
9.4.3.1 b) Conventional fusing current	X																										
9.4.3.2 Rated current		X																									
9.4.3.3 Time-current characteristics, gates																											
Gates, "g" fuse-links a) I_{min} (10 s)											X																
b) I_{max} (5 s)												X															
c) I_{min} (0,1 s)													X														
d) I_{max} (0,1 s)														X													
Gates, "a" fuse-links																						X					
9.4.3.4 Overload									X																	X	
9.4.3.5 Conventional cable overload protection								X																			
9.4.3.6 Indicating device ^{c)}				X	X	X	X	X							X	X	X	X	X								
Striker ^{c)}			X	X	X	X	X	X							X	X	X	X	X	X							
9.5 no. 5 Breaking capacity ^{a)}				X											X												
9.5 no. 4 Breaking capacity ^{a)}					X											X											
9.5 no. 3 Breaking capacity ^{a)}						X											X										
9.5 no. 2 Breaking capacity ^{b)}							X											X									
9.5 no. 1 Breaking capacity ^{b)}								X												X							
9.6 Cut-off current characteristic ^{d)}																											
9.7 I^2t characteristic ^{d)}																											
9.8 Degree of protection ^{d)}																											
9.9 Resistance to heat ^{d)}																											
9.10 Non-deterioration of contacts ^{d)}																											
9.11.1 Mechanical strength ^{d)}																											
9.11.2.1 Freedom from season cracking ^{d) e)}																											
9.11.2.2 Resistance to abnormal heat and fire ^{d)}														X											X		
9.11.2.3 Resistance to rusting ^{d)}																											
9.12 Marking	X														X												

^{a)} Valid also for time-current characteristic, if ambient air temperature is between 15 °C and 25 °C (see 9.4.3.3). For fuse-links tested in test-rigs, tests in accordance with 3a), 4a) and 5a) of 9.4.3.3 may be used.

^{b)} Valid also for cut-off current and I^2t characteristics (see 9.6 and 9.7).

^{c)} For fuse-links with indicating device or striker only.

^{d)} Tests according to 9.6 to 9.11 relating to fuse systems which are mentioned in subsequent parts may be possible. Number of samples to be tested depends on system and material.

^{e)} For fuse-links with current-carrying parts made of rolled copper alloy with less than 83 % copper.

Table 13 – Survey of tests on fuse-links of smallest rated current of homogeneous series and number of fuse-links to be tested

Test according to subclause		Number of samples																			
		"g" fuse-links												"a" fuse-links							
		1	1	1	1	1	3	1	1	3	1	1	1	1	1	1	1	3	1	3	4
9.1.5	Dimensions	X	X	X											X	X	X				
9.1.6.2	Resistance	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
9.4.3.1 a)	Conventional non-fusing current					X															
9.4.3.1 b)	Conventional fusing current					X															
9.4.3.2	Rated current				X																
9.4.3.3	Time-current characteristics																				
	no. 3a ^{d)}	X													X						
	no. 4a ^{d)}		X													X					
	no. 5a ^{d)}			X													X				
9.4.3.3.2	Gates, "g" fuse-links																				
a)	$I_{\min}$ (10 s)										X										
	b) $I_{\max}$ (5 s)											X									
	c) $I_{\min}$ (0,1 s)												X								
	d) $I_{\max}$ (0,1 s)													X							
	Gates, "a" fuse-links																			X	
9.4.3.4	Overload									X									X		
9.4.3.5	Conventional cable overload protection								X												
9.4.3.6	Indicating device ^{c)}					X											X				
	Striker ^{c)}					X	X										X	X			
9.5 no. 1	Breaking capacity ^{a)}					X											X				
9.6	Cut-off current characteristic ^{b)}																				
9.7	I^2t characteristic ^{b)}																				
9.8	Degree of protection ^{b)}																				
9.9	Resistance to heat ^{b)}																				
9.10	Non-deterioration of contacts ^{b)}																				
9.11.1	Mechanical strength ^{b)}																				
9.11.2.2	Resistance to abnormal heat and fire ^{b)}																				
9.11.2.3	Resistance to rusting ^{b)}																				
a) Valid also for cut-off current and I^2t characteristics (see 9.6 and 9.7).																					
b) Tests according to 9.6 and 9.11 relating to fuse systems which are mentioned in subsequent parts may be possible. Number of samples to be tested depends on system and material.																					
c) For fuse-links with indicating device or striker only.																					
d) With the exception of "gD", "gG" and "gM", as adequate tests are carried out in connection with verification of the gates (see 8.4.3.3.2).																					

Table 14 – Survey of tests on fuse-links of rated currents between the largest and the smallest rated current of a homogeneous series and number of fuse-links to be tested

Test according to subclause		Number of samples									
		"g" fuse-links							"a" fuse-links		
		1	1	1	1	1	1	1	1	2	2
9.1.5	Dimensions	X		X					X		X
9.1.6.1	Resistance	X	X	X	X	X	X	X	X	X	X
9.4.3.1 a)	Conventional non-fusing current		X								
9.4.3.2	Rated current	X									
9.4.3.3.1	Time-current characteristics no. 4a ^{a)}			X					X		
9.4.3.3.2	Gates, "g" fuse-links					X					
	a) I_{min} (10 s)										
	b) I_{max} (5 s)						X				
	c) I_{min} (0,1 s)							X			
	d) I_{max} (0,1 s)								X		
	Gates, "a" fuse-links									X	X
9.4.3.5	Conventional cable overload protection test				X						
^{a)} With the exception of "gD" "gG" and "gM", as adequate tests are carried out in connection with verification of the gates (see 9.4.3.3.2).											
The tests according to Table 14 may be performed at reduced voltages.											

9.1.7 Testing of fuse-holders

The fuse-holders shall be subjected to the tests according to Table 15.

Table 15 – Survey of complete tests on fuse-holders and number of fuse-holders to be tested

Test according to subclause		Number of samples			
		1	1	3	3
9.1.4	Dimensions	X		X	X
9.2	Insulating properties and suitability for isolation	X			
9.3	Temperature rise and acceptable power dissipation		X		
9.5	Peak withstand current		X		
9.8	Degree of protection	X			
9.9	Resistance to heat		X		
9.10	Non-deterioration of contacts				X
9.11.1	Mechanical strength	X	X	X	X
9.11.2.1	Freedom from season cracking ^{a)}			X	
9.11.2.2	Resistance to abnormal heat and fire	X			
9.11.2.3	Resistance to rusting		X		
^{a)} For fuse-holders with current-carrying parts made of rolled copper alloy with less than 83 % copper.					
Additional tests relating to special fuse systems which are mentioned in subsequent parts may be necessary. The number of samples depends on the system and the material.					

9.2 Verification of the insulating properties and of the suitability for isolation

9.2.1 Arrangement of the fuse-holder

In addition to the conditions of 9.1.4, the fuse-holder shall be fitted with fuse-links of the largest dimensions envisaged for the type of fuse-holder concerned.

When the fuse-base itself is depended upon for insulation, metal parts shall be placed at their fixing points in accordance with the conditions of installation of the fuse indicated by the manufacturer, and these parts shall be considered as part of the frame of the apparatus. Unless otherwise specified by the manufacturer, the fuse-base shall be fixed to a metal plate.

If the fuse-link is intended to be replaceable while live, the surfaces of the fuse-link, of the device for replacing it or of the fuse-carrier, if any, which may be touched in the course of a correct replacement, are considered as forming part of the fuse. Thus, these surfaces, if of insulating material, shall be provided with metal coverings connected during the tests to the frame of the apparatus; if of metal, they shall be connected direct to the frame.

If additional insulating means, for example, partition walls, are provided by the manufacturer, these insulating means shall be in position during the tests.

For the verification of the suitability of the fuse for isolation, it shall be in its normal open position, the fuse-link remaining inside the fuse-carrier, or the fuse-link, and, when applicable, the fuse-carrier shall be removed.

9.2.2 Verification of the insulating properties

9.2.2.1 Points of application of the test voltage

The test voltage for the verification of the insulating properties shall be applied

- a) between live parts and the frame with the fuse-link and the device for replacing it or the fuse-carrier, if any, in position;
- b) between the terminals when the fuse is in normal open position, the fuse-link remaining inside the fuse-carrier, or when the fuse-link and the device for replacing it or the fuse-carrier, if any, are removed;
- c) between live parts of different polarity in the case of a multipole fuse-holder with fuse-links of the maximum dimensions intended for that fuse-holder inserted and the device(s) for replacing the fuse-link(s) or the fuse-carrier(s), if any, in position;
- d) between live parts which, in the case of a multipole fuse-holder, can reach different potentials after the fuse-link has operated, with the fuse-carrier(s) or the device(s) for replacing the fuse-link(s) alone (without fuse-links) in position.

9.2.2.2 Value of test voltage

The values of test voltage are shown in Table 16 as a function of the rated voltage of the fuse-holder.

Table 16 – Test voltage

Rated voltage U_n of the fuse-holder V		AC test voltage (RMS) V	DC test voltage V
AC and DC	Up to and including 60	1 000	1 415
	61 to 300	1 500	2 120
	301 to 690	1 890	2 670
	691 to 800	2 000	2 830
	801 to 1 000	2 200	3 110
DC only	1 001 to 1 500		3 820

9.2.2.3 Test method

9.2.2.3.1 The test voltage shall be applied progressively and maintained at its full value given in Table 16 for 1 min.

The test voltage source should have a short-circuit current of at least 0,1 A at the setting corresponding to the test voltage on open circuit.

9.2.2.3.2 The fuse-holder shall be subjected to humid atmospheric conditions.

The humidity treatment shall be performed in a humidity cabinet containing air with a relative humidity maintained between 91 % and 95 %.

The temperature of the air, at the place where the sample is located, shall be maintained within 2 K of any convenient value T between 20 °C and 30 °C.

Before being placed in the humidity cabinet, the sample shall be brought to a temperature differing from the above-mentioned value T by not more than +2 K.

The sample shall be kept in the cabinet for 48 h.

Immediately after this treatment, and after wiping off any drops of water that result from condensation, the insulation resistance shall be measured between the points prescribed in 9.2.2.1 by applying a DC voltage of approximately 500 V.

9.2.3 Verification of the suitability for isolation**9.2.3.1 General**

Clearances and creepage distances shall be verified by dimensional measurement and by voltage test.

9.2.3.2 Points of application of the test voltage

The test voltage for the verification of the suitability for isolation shall be applied between the terminals when the fuse-link and the device for replacing it or the fuse-carrier, if any, are removed, or the equipment is in its normal open position with the fuse-link remaining inside the fuse-carrier.

9.2.3.3 Value of test voltage

The test voltage for the verification of the rated impulse withstand voltage is given in Table 17.

Table 17 – Test voltage across the poles for the verification of the suitability for isolation

Rated impulse withstand voltage U_{imp} kV	Test voltages and corresponding altitudes $U_{1,2/50}$ kV				
	Sea level	200 m	500 m	1000 m	2000 m
0,8	1,8	1,7	1,7	1,6	1,5
1,5	2,3	2,3	2,2	2,2	2
2,5	3,5	3,5	3,4	3,2	3
4,0	6,2	6,0	5,8	5,6	5
6,0	9,8	9,6	9,3	9,0	8
8,0	12,3	12,1	11,7	11,1	10
12,0	18,5	18,1	17,5	16,7	15

9.2.3.4 Test method

The 1,2/50 μ s impulse voltage according to Table 17 shall be applied five times for each polarity at intervals of 1 s minimum.

9.2.4 Acceptability of test results

9.2.4.1 Throughout the application of the test voltage according to Table 16, there shall be no breakdown of insulation or flashover. Glow discharges unaccompanied by a drop in voltage can be neglected.

There shall be no disruptive discharge during the test with the impulse voltage.

9.2.4.2 The insulation resistance measured according to 9.2.2.3.2 shall be not less than 1 M Ω .

9.3 Verification of temperature rise and power dissipation

9.3.1 Arrangement of the fuse

One fuse shall be used for the test unless otherwise stated by the manufacturer.

The fuse shall be mounted in free air as specified in 9.1.4 in order to make sure that the test results are not influenced by particular conditions of installation.

The test shall be performed at an ambient air temperature of $(20 \pm 5) ^\circ\text{C}$.

The connections on either side of each single fuse shall be not less than 1 m in length. In cases where it might be necessary or desirable to arrange more than one fuse in a combined test, the fuses may be connected in series. This would result in a total length of about 2 m between two fuse terminals in series. The cable should be as straight as possible.

Unless specified in subsequent parts, the cross-sectional area shall be selected in accordance with Table 18. For rated currents up to 400 A, single-core copper-conductor cables insulated with black polyvinyl chloride (PVC) shall be used as connections. For rated currents of 500 A to 800 A, either single-core copper conductors insulated with black PVC or bare copper bars can be used. For higher rated currents, matt black painted copper bars only are used. Torques for the screws connecting the cables to the terminals are given in subsequent parts.

9.3.2 Measurement of the temperature rise

The values of the temperature rise given in Table 6 for the contacts and terminals of the fuse shall be determined by means of measuring devices that appear most suitable, provided that the measuring device cannot appreciably influence the temperature of the fuse part. The method used shall be indicated in the test report.

9.3.3 Measurement of the power dissipation of the fuse-link

The fuse-link shall be mounted in the fuse-holder or test rig as specified in subsequent parts. The test arrangement shall be as specified in 9.3.1.

The power dissipation shall be measured in watts, the points between which the measurement is taken being chosen on the fuse-link so as to give the maximum value. Points for the measurement are given in subsequent parts.

9.3.4 Test method

9.3.4.1 General

The tests (see 9.3.4.2 and 9.3.4.3) shall be continued until it becomes evident that the temperature rise would not exceed the specified limits if the tests were continued until a steady temperature were reached. A steady temperature shall be deemed to have been reached when the variation does not exceed 1 K per hour. The measurement shall be made during the last quarter hour of the test. It is permissible to make the test at reduced voltage.

9.3.4.2 Temperature rise of the fuse-holder

The test for temperature rise shall be made with AC by using a fuse-link which, at the rated current of the fuse-holder, attains a power dissipation equivalent to the rated acceptable power dissipation of the fuse-holder or with a dummy fuse-link where specified in subsequent parts. The current applied shall be the rated current of the fuse-holder.

9.3.4.3 Power dissipation of a fuse-link

The test shall be made with AC at the rated current of the fuse-link.

Table 18 – Cross-sectional area of copper conductors for tests corresponding to Subclauses 9.3 and 9.4

Rated current A	Cross-sectional area mm ² or mm × mm
2	1
4	1
6	1
8	1,5
10	1,5
12	1,5
13	1,5
16	2,5
20	2,5
25	4
32	6
35	6
40	10
50	10
63	16
80	25
100	35
125	50
160	70
200	95
224	95
250	120
315	185
355	185
400	240
425	240
500	2 × 185 or 2 × (40 × 5) ^{a)}
630	2 × 240 or 2 × (50 × 5) ^{a)}
800	2 × (60 × 5) ^{a)}
1 000	2 × (80 × 5) ^{a)}
1 250	2 × (80 × 5) ^{a)}
1 600	2 × (100 × 5) ^{a)}
^{a)} Recommended cross-sectional areas for fuses designed to be connected to copper bars. The type and arrangement of the connections used shall be stated in the test report. For matt black painted bars, the distance between the two parallel bars of the same polarity should be approximately 5 mm.	

The values given in Table 18, as well as the temperature-rise limits fixed in Table 6, should be considered as a convention which is valid for the temperature-rise test specified in 9.3.4. A fuse used or tested according to conditions which correspond to a given installation may have connections of a type, nature and disposition which are different from these test conditions. In consequence, another temperature-rise limit may result, be required or accepted.

9.3.5 Acceptability of test results

The temperature rises shall not exceed the values specified in Table 6.

The power dissipation of the fuse-link shall not exceed its rated power dissipation or the value specified in subsequent parts. The acceptable power dissipation of the fuse-holder shall be not less than the rated power dissipation of the fuse-links intended to be used in that fuse-holder, or the values specified in subsequent parts.

After the test, the fuse shall be in a satisfactory condition. In particular, the insulating parts of the fuse-holders shall withstand the test voltage according to 9.2 after having cooled down to ambient temperature (see Table 16); in addition, they shall not have suffered any deformation that would impair their correct operation.

9.4 Verification of operation

9.4.1 Arrangement of the fuse

The test arrangement is that specified in 9.1.4.

Length and cross-sectional area of conductors connected shall correspond to those specified in 9.3.1 and shall be selected according to the rated current of the fuse-link. See Table 18.

9.4.2 Ambient air temperature

The ambient air temperature during these tests shall be $(20 \pm 5) ^\circ\text{C}$.

9.4.3 Test method and acceptability of test results

9.4.3.1 Verification of conventional non-fusing and fusing current

It is permissible to make the following tests at a reduced voltage.

- a) The fuse-link is subjected to its conventional non-fusing current (I_{nf}) for a time equal to the conventional time specified in Table 3. It shall not operate during this time.
- b) 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 3.

9.4.3.2 Verification of rated current of "g" fuse-links

For the verification of the rated current of a fuse-link the following tests are performed, the fuse being mounted as specified in 9.4.1. It is permissible to make these tests at a reduced voltage.

One fuse-link is submitted to a pulse test for 100 h, in which the fuse-link will be cyclically loaded. Each cycle with an on-period of the conventional time and an off-period of 0,1 of the conventional time, the test current being equal to 1,05 of the rated current of the fuse-link. After the test the fuse-link shall not have changed its characteristics. Verification shall be carried out by the test as described in item a) of 9.4.3.1.

9.4.3.3 Verification of time-current characteristics and gates

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 test according to 9.5.

The following periods are determined:

- 1) from the instant of closing the circuit until the instant when the voltage measurement shows the beginning of the arc;
- 2) from the instant of closing the circuit until the instant when the circuit is definitely broken.

The values of pre-arcing and operating times so determined, referred to the abscissa corresponding to the value of prospective current, shall be within the time-current zone indicated by the manufacturer, or specified in subsequent parts.

When for the fuse-links of a homogeneous series (see 9.1.6.3) the complete test according to 9.5 is only made on that fuse-link having the largest rated current, it shall be sufficient for the smaller current ratings to verify only the pre-arcing time. In this case, the supplementary tests shall be made at an ambient air temperature of $(20 \pm 5) ^\circ\text{C}$ and at the following values of prospective current only:

- for "g" fuse-links, with the exception of "gD", "gG" and "gM", as adequate tests are carried out in connection with verification of the gates (see 9.4.3.3.2):
 - test 3a) between 10 and 20 times;
 - test 4a) between 5 and 8 times;
 - test 5a) between 2,5 and 4 times the rated current of the fuse-link;
- for "a" fuse-links:
 - test 3a) between $5 k_2$ and $8 k_2$ times;
 - test 3b) between $2 k_2$ and $3 k_2$ times;
 - test 5a) between k_2 and $1,5 k_2$ times the rated current of the fuse-link (see Figure 2).

These supplementary tests may be performed at a reduced voltage. In this case, where the pre-arcing time exceeds 0,02 s, the value of the current measured during the test shall be considered to be the value of the prospective current.

9.4.3.3.2 Verification of gates

The following tests may be made at a reduced voltage. Additional to the above-mentioned tests, the following shall be verified for "gG" and "gM" fuse-links.

- a) A fuse-link is subjected to the current of Table 4, column 2 for 10 s. It shall not operate.
- b) A fuse-link is subjected to the current of Table 4, column 3. It shall operate within 5 s.
- c) A fuse-link is subjected to the current of Table 4, column 4 for 0,1 s. It shall not operate.
- d) A fuse-link is subjected to the current of Table 4, column 5. It shall operate within 0,1 s.

Additional to the tests of 9.4.3.3.1, "aM" fuse-links shall comply the following tests which can be made at a reduced voltage.

- e) A fuse-link is subjected to the current of Table 5, column 2, for 60 s. It shall not operate.
- f) A fuse-link is subjected to the current of Table 5, column 3. It shall operate within 60 s.
- g) A fuse-link is subjected to the current of Table 5, column 5, for 0,2 s. It shall not operate.
- h) A fuse-link is subjected to the current of Table 5, column 7. It shall operate within 0,10 s.

Tests f) and g) may be verified with the breaking capacity tests Nos. 4 and 5, respectively.

These tests for "aM" fuses shall be conducted with the conductor cross-section areas defined in Table 19.

Table 19 – Cross-section areas of the copper conductors for the test of "aM" fuses

Rated current A	Cross-section area mm ² or mm × mm
2	1,5
4	1,5
6	1,5
8	2,5
10	2,5
12	2,5
16	4
20	6
25	10
32	16
35	16
40	25
50	25
63	35
80	50
100	70
125	95
160	120
200	185
250	240
315	2 × 150 or 2 × (30 × 5)
400	2 × 185 or 2 × (40 × 5)
500	2 × 240 or 2 × (50 × 5)
630	2 × (60 × 5)
800	2 × (80 × 5)
1 000	2 × (100 × 5)
1 250	2 × (100 × 5)

9.4.3.4 Overload

The test arrangement is the same as that for the temperature-rise test (see 9.3.1). Three fuse-links shall be submitted to 50 pulses having the same duration and the same test current.

For "g" fuse-links, the test current shall be 0,8 times the current determined from the manufacturer's minimum pre-arcing time-current characteristics for a pre-arcing time of 5 s. The duration of each pulse shall be 5 s and the time interval between pulses shall be 20 % of the conventional time specified in Table 2.

For "a" fuse-links, the test current shall be equal to $k_1 I_n \pm 2\%$. The pulse duration shall correspond to that indicated on the overload curve for $k_1 I_n$ as stated by the manufacturer. The intervals between pulses shall be 30 times the pulse duration.

This test may be carried out at a reduced voltage.

NOTE With the manufacturer's consent, the interval between pulses may be reduced.

After having been allowed to cool down to ambient air temperature, the fuse-links shall be subjected to a current equal to that used during the overload test. The pre-arcing time, when passing this current, shall be shown to lie within the manufacturer's time-current zone.

9.4.3.5 Conventional cable overload protection test (for "gG" fuse-links only)

In order to verify that fuse-links are capable of protecting cables against overload, one fuse-link is submitted to the following conventional test. The fuse-link is mounted in its appropriate fuse-holder or test rig as specified in 9.4.1, but provided with PVC insulated copper conductors of a cross-sectional area as specified in Table 20. The fuse and the conductor connected to it shall be preheated with the rated current of the fuse-link for a time equal to the conventional time.

The test current is then increased to a value of $1,45 I_z$ (I_z being specified in Table 20). The fuse-link shall operate in a time less than the conventional time.

NOTE It is not necessary to perform this test if the product $1,45 I_z$ is greater than the conventional fusing current.

This test may be carried out at a reduced voltage.

Table 20 – Table for test in Subclause 9.4.3.5

I_n of fuse-link	Nominal cross-sectional area of copper conductors	I_z^a
A	mm ²	A
12	1	15
16 ^b	1,5	19,5
20 ^b and 25	2,5	27
32 ^b and 35	4	36
40 ^b	6	46
50 ^b and 63	10	63
80	16	85
100 ^b	25	112
125 ^b	35	138
160	50	168
200	70	213
250 ^b	120	299
315 ^b	185	392
400 ^b	240	461
^a Current-carrying capacity I_z for two loaded conductors (see Table A52-2 of IEC 60364-5-52:2001).		
^b For this current rating it is not necessary to perform this test as the product $1,45 I_z$ is greater than the conventional fusing current I_f .		

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:

- I_4 (see Table 21 and Table 22) in the case of "g" fuse-links;
- $2 k_1 I_n$ in the case of "a" fuse-links (see Figure 2);

and at a recovery voltage of:

- 20 V for rated voltages not exceeding 500 V;
- $0,04 U_n$ for rated voltages exceeding 500 V.

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

The striker shall operate during all tests made at a recovery voltage of

- at least 20 V.

If during one of these tests, the indicating device or striker fails, the test shall not be considered as negative on this account, if the manufacturer can furnish evidence that such failure is not typical of the fuse type, but it is due to a fault of the individual tested sample.

9.5 Verification of the breaking capacity

9.5.1 Arrangement of the fuse

The test arrangement is that specified in 9.1.5.

Suitable conductors shall be arranged for a length of approximately 0,2 m on either side of the complete fuse in the plane of the connecting device and in the direction of the connecting line between the terminals of the fuse. At this distance, they shall be rigidly supported. Beyond this point, they shall be bent at right angles towards the back. This arrangement is considered to be met when using test rigs as specified in subsequent parts.

9.5.2 Characteristics of the test circuit

The test circuit is shown by way of example in Figure 5.

The test circuit shall be of the single-pole type, i.e. one fuse shall be tested at a voltage based on its rated voltage.

NOTE The single-phase test is deemed to give sufficient information also for application in three-phase circuits.

The source of energy supplying the test circuit shall be of sufficient power to enable the specified characteristics to be proved.

The source of energy shall be protected by a circuit-breaker or other suitable apparatus D; an adjustable resistor R in series with an adjustable inductor L shall allow the characteristics of the test circuit to be adjusted. The circuit shall be closed by means of a suitable apparatus C.

The values to be considered are indicated in Table 21 and Table 22.

– For AC:

When the rated frequency of the fuse is 50 Hz or 60 Hz or is not indicated (see 5.4), the test shall be made at a supply frequency between 45 Hz and 62 Hz. If other frequencies are indicated, the tests shall be performed at these frequencies with a tolerance of $\pm 20\%$.

The inductor L shall be an air-cored inductor for tests nos. 1 and 2.

The peak value of the power-frequency recovery voltage within the first full half-cycle after clearing and for the next five successive peaks shall correspond to the peak value relating to the RMS value specified in Table 21.

– For DC:

Breaking capacity tests shall be made with DC on an inductive circuit with series resistance for the adjustment of the prospective current. The inductance can be made up by series and parallel connection of suitable inductance coils. They may have iron cores, provided they do not saturate during the test.

The time constant shall lie between the limits indicated in Table 22.

The mean value of DC recovery voltage during 100 ms after final arc extinction shall be not less than the value specified in Table 22.

9.5.3 Measuring instruments

The current trace shall be recorded by one of the measuring circuits O_1 of an oscillograph connected to the terminals of an appropriate measuring device. Another measuring circuit O_2 of the oscillograph shall be connected by means of resistors or a voltage transformer, as the case may be, to the terminals of the source of energy during the calibration test, and to the terminals of the fuse during the test of the latter.

The arc voltages occurring during tests nos. 1 and 2 shall be measured by means of a measuring circuit (i.e. transducer, transmission and recording device) which has adequate sensitivity and frequency response. An oscillograph may be used provided it meets these requirements.

9.5.4 Calibration of test circuit

The test circuit shall be calibrated with a provisional connection A of a negligible impedance compared with that of the test circuit (see Figure 5) in place of the fuse to be tested.

The resistors R and the inductors L shall be so adjusted as to obtain at the desired instant the desired value of current, and,

- in the case of AC, the desired power factor at a power-frequency recovery voltage $105^{+5}_0\%$ of the rated voltage for a 690 V fuse and $110^{+5}_0\%$ of the rated voltage for all other fuses. The power factor shall be determined by one of the methods specified in Annex A or by other methods giving improved accuracy;
- in the case of DC, the desired time constant at a mean value of recovery voltage $115^{+5}_{-9}\%$ of the rated voltage of the fuse to be tested.