IEC 60077-5

Edition 2.0 2019-10
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

Railway applications – Electric equipment for rolling stock – Part 5: Electrotechnical components – Rules for HV fuses

IEC 60077-5:2019-10 RLV(en)

IEC Central Office
3, rue de Varembé
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 It also gives information on projects, replaced and withdrawn publications.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.

Electropedia - www.electropedia.org
The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary
67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC 60077-5

Edition 2.0 2019-10
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

Railway applications – Electric equipment for rolling stock – Part 5: Electrotechnical components – Rules for HV fuses

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 45.060.01

ISBN 978-2-8322-7581-8

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

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

RAILWAY APPLICATIONS – ELECTRIC EQUIPMENT FOR ROLLING STOCK –

Part 5: Electrotechnical components – Rules for HV fuses

FOREWORD

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

This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

International Standard IEC 60077-5 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

This second edition cancels and replaces the first edition, issued in 2003. It constitutes a technical revision.

This edition includes the following main technical changes with regard to the previous edition:

a) test method of test duty III for verification of breaking capacity is reviewed.

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

FDIS	Report on voting
9/2539/FDIS	9/2555/RVD

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

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

This document should be read in conjunction with IEC 60077-1 and IEC 60077-2.

A list of all parts in the IEC 60077 series, published under the general title *Railway applications – Electric equipment for rolling stock*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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

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

RAILWAY APPLICATIONS – ELECTRIC EQUIPMENT FOR ROLLING STOCK –

Part 5: Electrotechnical components – Rules for HV fuses

1 Scope ~~and object~~

The purpose of this part of IEC 60077 is to give additional or amended rules for high voltage (HV) fuses as a supplement to those given by IEC 60077-2.

NOTE 1 In this document the term high voltage fuses is used in the context of the voltages used in the field of railway rolling stock.

The high voltage fuses concerned are those ~~to be~~ connected into power and/or auxiliary circuits. The nominal voltage of these circuits lies between 600 V DC and 3 000 V DC, according to IEC 60850. These fuses ~~may~~ can also be used in auxiliary AC circuits up to a nominal voltage of 1 500 V.

NOTE 2 Certain of these rules ~~may~~, after agreement between the user and the manufacturer, ~~be~~ are used for fuses installed on vehicles other than rail rolling stock such as mine locomotives, trolleybuses, etc.

This document together with IEC 60077-2 states specifically:

a) the characteristics of the fuses;

b) the service conditions with which the fuses ~~have to~~ comply with reference to:
   - operation and behaviour in normal service;
   - operation and behaviour in case of short circuit;
   - dielectric properties.

c) the tests intended for confirming the compliance of the fuse with the characteristics under the service conditions and the methods ~~to be~~ adopted for these tests;

d) the information ~~to be~~ marked on, or given with, the fuse.

This document does not cover parallel connection of fuses.

During preparation of this document, IEC 60269-1 and IEC 60282-1 have been considered and their requirements have been kept as far as possible.

This document makes reference to the general rules for electrotechnical components given in IEC 60077-2, but for general conditions reference is made directly to IEC 60077-1.

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 60050(441):1984, *International Electrotechnical Vocabulary (IEV) – Chapter 441: Switchgear, controlgear and fuses*~~

~~IEC 60050(811):1991, *International Electrotechnical Vocabulary (IEV) – Chapter 811: Electric traction*~~

IEC 60077-1:~~1999~~2017, *Railway applications – Electric equipment for rolling stock – Part 1: General service conditions and general rules*

IEC 60077-2:~~1999~~2017, *Railway applications – Electric equipment for rolling stock – Part 2: Electrotechnical components – General rules*

IEC 60269-1:~~1998~~2006, *Low-voltage fuses – Part 1: General* requirements
IEC 60269-1:2006/AMD1:2009
IEC 60269-1:2006/AMD2:2014

IEC 60282-1:~~2002~~2009, *High-voltage fuses – Part 1: Current-limiting fuses*
IEC 60282-1:2009/AMD1:2014

~~IEC 60850:2000, *Railway applications – Supply voltages of traction systems*~~

IEC 61373:~~1999~~, *Railway applications – Rolling stock equipment – Shock and vibration tests*

ISO 3:~~1973~~, *Preferred numbers – Series of preferred numbers*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the terms and definitions given in Clause 3 of IEC 60077-1:2017 and Clause 3 of IEC 60077-2:2017, and the following 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

3.1 Components

NOTE For terminologies of a fuse, see also Figure 1 in IEC 60282-1:2009/AMD1:2014.

3.1.1
fuse
device that, by the fusing of one or more of its specifically 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

Note 1 to entry: The fuse comprises all the parts that form the complete device.

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-01, modified – The second sentence has been changed to Note 1 to entry.]

3.1.2
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/AMD1:2000, 441-18-09]

3.1.3
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

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-08]

3.1.4
fuse-base
fixed part of a fuse provided with contacts and terminals

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-02]

3.1.5
indicating device, <of a fuse>
part of a fuse provided to indicate whether the fuse has operated

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-17]

3.1.6
open box type fuse
fuse installed in an open box equipped with an arc chute in order to reduce arc quickly

3.1.7
homogeneous series, <of fuse-links>
series of fuse-links, deviating from each other only in such characteristics that, for a given test, the testing of one or a reduced number of particular fuse-link(s) of that series can be taken as representative for all the fuse-links of the homogeneous series

Note 1 to entry: The relevant publications specify the characteristics by which the fuse-links of a homogeneous series may deviate, the particular fuse-links to be tested and the specific test concerned.

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-34, modified – "may" has been replaced with "can".]

3.2 Operational characteristics

3.2.1
prospective current, <of a circuit and with respect to a switching device or a fuse>
current that would flow in the circuit if each pole of the switching device or the fuse were replaced by a conductor of negligible impedance

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-17-01, modified – Note has been deleted.]

3.2.2
prospective peak current
peak value of a prospective current during the transient period following ~~fault current~~ initiation

Note 1 to entry: This term is commonly associated with short-circuit conditions.

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-17-02, modified – Note to entry has been replaced.]

3.2.3
pre-arcing 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/AMD1:2000, 441-18-21]

3.2.4
arcing time, <of a pole or a fuse>
interval of time between the instant of the initiation of the arc in a pole or a fuse and the instant of final arc extinction in that pole or that fuse

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-17-37~~, modified~~]

3.2.5
operating time
sum of the pre-arcing time and the arcing time

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-22]

3.2.6
arc voltage, <of a fuse>
instantaneous value of voltage which appears across the terminals of a fuse during the arcing time

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-30]

3.2.7
peak arc voltage, <of a fuse>
maximum instantaneous value of voltage which under prescribed conditions appears across the terminals of a fuse during the arcing time

Note 1 to entry: After extinction of the arc, an overvoltage (transient recovery voltage) may be present across the terminals. The value of this will depend on the circuit characteristics and the fuse. This overvoltage is not part of the peak arc voltage (see Figure D.2 and Figure D.3).

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-17-30, modified – "a pole of a switching device" has been replaced with "a fuse". Note 1 to entry has been added.]

3.2.8
DC~~ or power frequency~~ steady-state recovery voltage
recovery voltage in a DC. circuit after the transient voltage phenomena have subsided, expressed by the mean value where ripple is present

Note 1 to entry: This is shown as B_1 and B_2 in Figure D.2 and Figure D.3.

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-17-28, modified – Note 1 to entry has been added.]

3.2.9
peak let-through current
maximum instantaneous value of current attained during the operation of a fuse

~~[IEV 441-17-12, modified]~~

3.2.10
joule integral
I^2t
integral of the square of the current over a given time interval

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

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 liberated in one ohm of resistance in a circuit protected by a fuse is equal to the value of the operating I^2t expressed in A^2s.

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-23]

3.2.11
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

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-17-13]

3.2.12
conventional non-fusing current
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/AMD1:2000, 441-18-27]

3.2.13
conventional fusing current
value of current specified as that which causes operation of the fuse-link within a specified time (conventional time)

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-28]

3.2.14
rated value
~~quantity value, generally assigned by a manufacturer, for a specified operating condition of a fuse~~

value of a quantity used for specification purposes, established for a specified set of operating conditions of a component, device, equipment, or system

~~[IEV 811-11-02, modified]~~

Note 1 to entry: The rated values usually stated for fuses are voltage, current, breaking capacity and power dissipation.

[SOURCE: IEC 60050-151:2001, 151-16-08, modified – Note 1 to entry has been added.]

3.3 Abbreviated terms

AC Alternating Current

DC Direct Current

HV High Voltage

4 Classification

4.1 Breaking range ~~(see also Annex B)~~

Fuse-links are classified according to whether they are:

a) "g" fuse-link: with a full range breaking capacity, i.e. capable under specified conditions of breaking all currents which cause melting of the fuse-element up to its rated breaking capacity;

b) "a" fuse-link: with a partial range breaking capacity, i.e. capable of breaking under specified conditions all currents between their minimum breaking capacity and their rated breaking capacity. They may be used in conjunction with another switching device where protection is required against overcurrent below their minimum breaking capacity.

NOTE 1 Comparison between "a" and "g" fuse time current characteristics is shown in Figure B.1 of Annex B.

NOTE 2 Examples of "a" fuse-link protection ~~may~~ can be those for protection of semiconductor devices, motors, etc.

4.2 Utilisation category

Fuse-links may be categorised according to whether they are to be subjected in normal service to:

– current values which do not exceed their continuous rating;

– current values which briefly exceed their continuous rating on a regular basis, such as when starting a rotating machine;

– current values which do not exceed their continuous rating but which are switched or change significantly in a frequently repeated pattern;

or they have to provide a special protection as, for example:

– semiconductor conditions, where fast action is required in order to limit the peak let-through current and the operating I^2t;

– provide a time delayed operation.

5 Characteristics

The characteristics of a fuse shall be stated in terms of the following:

– rated voltage(s) DC and/or AC;

– rated current (I_n);

– rated frequency;

– rated breaking capacity;

– breaking range;

– rated power dissipation;

– time-current characteristics. The conventional times and currents for "g" fuse-links are given in Table 1;

– overload capability;

– I^2t characteristics (minimum pre-arcing I^2t and maximum operating I^2t);

– peak let-through current related to prospective current and time constant;

– current rating correction factors versus ambient temperature;

– peak arc voltage related to operating voltage;

– rated insulation voltage (U_{Nm}) for fuse-bases;

– rated impulse voltage (U_{Ni}) for fuse-bases.

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 co-ordinate axes.

Table 1 – Conventional times for "g" fuse-links

Rated current A	Specified time (conventional time) h
$I_n \leq 63$	1
$63 < I_n \leq 160$	2
$160 < I_n \leq 400$	3
$I_n > 400$	4

6 Product information

6.1 Documentation

This information shall be given in the manufacturer's catalogue or manual.

6.1 of IEC 60077-2:2017 applies, supplemented by the following:

– rated voltage;
– rated current;
– rated breaking capacity and time constant;
– suitable applications (see 4.2);
– I^2t characteristics (minimum pre-arcing I^2t and maximum operating I^2t);
– correction factors for current rating versus ambient temperature, varying load and overload;
– physical dimensions;
– special instructions for storage, installation, maintenance, if applicable.

6.2 Marking

Fuse-links and fuse-bases shall possess durable and legible nameplates or engraved markings in accordance with 6.2 of IEC 60077-2:2017.

For the open box type fuse nameplates or engraved markings shall be placed on the box.

The markings of the fuse-link and fuse-base shall include the following data:

– manufacturer's name or trade mark;
– manufacturer's type designation;
– rated voltage (DC and/or AC);
– rated current.

7 Normal service conditions

These conditions are given in Clause 7 of IEC 60077-1:2017.

8 Constructional and performance requirements

8.1 Constructional requirements

8.1.1 General

In addition to the requirements of 8.1 of IEC 60077-2:2017, the fuse shall comply with the following requirements.

8.1.2 Fuse-link

The fuse-link shall be sufficiently robust so that there shall be no damage to the surroundings e.g. by permanent arcing, flashover or any ejection of flames or materials during operation.

NOTE 1 For further details, see 8.5.8 of IEC 60269-1:2006/AMD1:2009/AMD2:2014.

It shall be possible to replace the fuse-links easily.

NOTE 2 For further details of replacement, see ~~8.5.8.~~ 7.1.1 of IEC 60269-1:2006/AMD1:2009/AMD2:2014.

8.1.3 Fuse-base

The fuse-base shall incorporate contacts which ensure that the connections to the fuse-link are adequate under all conditions of thermal cycling, vibration and shock during normal service and during the application of the electro-dynamic forces when the fuse-link is rupturing overload or short-circuit currents up to its rated breaking capacity value.

8.1.4 Spring-loaded contacts

Where the fuse-base incorporates spring-loaded contacts for electrical connection and mechanical retention of the fuse-link, these contacts shall withstand 100 cycles of insertions and removals of the fuse-link without deterioration of the electrical and mechanical properties.

8.1.5 External terminals

Terminals for external connection to the fuse-base shall provide a constant clamping force unaffected by variation in current through them. They shall be capable of enduring multiple connection and disconnection of the external conductors without deterioration. Terminal screw thread shall have a minimum size of M5.

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 a shape such that they cannot unduly damage the conductors.

No contact force on connections shall be transmitted through insulating material other than ceramic, or other material having mechanical characteristics no less suitable.

NOTE For further information, see 7.1.2 of IEC 60269-1:2006/AMD1:2009/AMD2:2014.

8.2 Performance requirements

8.2.1 Operating conditions

These requirements are given in 8.2.1 of IEC 60077-2:2017.

8.2.2 Temperature ~~rise~~ limits

These requirements are given in 8.2.2 of IEC 60077-2:2017.

8.2.3 Dielectric properties

Requirements of clearances are given in 8.2.6 of IEC 60077-1:2017.

Requirements of creepage distances are given in 8.2.7 of IEC 60077-1:2017.

8.2.4 Rated voltage

For fuses fed from the contact line, the rated voltage of the fuses shall be in accordance with Table 2. For fuses not fed from the contact line, the breaking test voltage shall be at least equal to the highest operational voltage of the circuit in which it is connected.

Table 2 – Rated and test voltages for DC fuse-links supplied from the contact line

Nominal line voltage V	Rated voltage of the fuse V	Breaking test voltage V
600	720	800
750	900	1 000
1 500	1 800	1 950
3 000	3 600	3 900

8.2.5 Rated current of the fuse-link

~~The rated continuous current of the fuse-link shall be selected from the following preferred values given in R10 of ISO 3:~~

The rated current for the fuse-link, expressed in amperes (A), should be selected from the following values:

0,6; 1; 2; 3; 4; 6; 10; 12; 16; 20; 25; 32; 40; 50; 63; 80; 100; 125; 160; 200; 250; 315; 400; 500; 630; 800 and 1 000.

~~NOTE For intermediate values, see R20 of ISO 3.~~

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.

8.2.6 Rated current of the fuse-base

The rated current of the fuse-base shall be equal to or greater than that of the relevant fuse-link and should be selected from the series of rated currents of the fuse-links given in 8.2.5.

8.2.7 Breaking capacity

The fuse-link shall interrupt correctly any current within the range from minimum breaking capacity up to its rated breaking capacity at the appropriate test voltage given in Table 7. The peak arc voltage shall not exceed 3 times the test voltage.

~~NOTE~~ For low current ratings (lower than or equal to 6,3 A), the peak arc voltage may reach 4,5 times the test voltage.

8.2.8 Time-current characteristics

The manufacturer shall include in the technical documentation for the fuse-links the time-current characteristics at (20 ± 5) °C.

9 Tests

9.1 Kinds of tests

9.1.1 General

9.1.1 of IEC 60077-1:2017 applies, except that sampling tests are not applicable.

The tests to verify the characteristics of the fuses are:

– type tests (see 9.1.2);
– routine tests (see 9.1.3);
– ~~investigatory~~ investigation tests (see 9.1.4).

9.1.2 Type tests

The type tests comprise the following:

– verification of constructional requirements (see 9.2.2);
– verification of performance requirements (see 9.3).

For the type tests, the number of fuses or fuse-links shall be as indicated in Table 3, Table 4 and Table 5. They shall be randomly selected from the manufacturing production line. In all tests, the same fuse-base should be used.

The type test results shall be deemed to be compliant if the results of all the type tests listed in Table 3, Table 4 and Table 5 meet the requirements.

For the type tests, test certificates shall be provided for each fuse-link or fuse tested, to prove their general compliance with the technical documentation.

9.1.3 Routine tests

Routine tests shall be carried out on each fuse-link and fuse-base.

The routine tests comprise the following:

– verification of constructional requirements (see 9.2.3);
– verification of performance requirements (see 9.4).

The routine test results shall be deemed to be compliant if the results of all the routine tests listed in 9.2.3 and 9.4 meet the requirements.

9.1.4 ~~Investigatory~~ Investigation tests

These are supplementary tests to the type tests for a special application. They form the subject of a programme agreed between the fuse manufacturer and the user, and may concern:

– the influence of frequent current variation on the operating characteristics;
– the influence of frequent start current surges on the operating characteristics;

– the influence of the circuit time-constant on the behaviour of the fuse during the breaking capacity tests.

9.2 Tests for the verification of constructional requirements

9.2.1 General

The compliance of the fuse-link and fuse-base with the constructional requirements described in Clause 8 shall be verified generally in accordance with 9.2 of IEC 60077-1:2017, prior to the verification of performance requirements as detailed in 9.3 and 9.4.

9.2.2 Type tests

Verification of compliance with the constructional requirements for the type test of both fuse-link and fuse-base concerns:

– physical properties. A check shall be made that the fuse conforms to the drawings (e.g. dimensions, materials, electrical risks, etc.);

– clearance and creepage distances (see 9.3.3.2.1 and 9.3.3.2.43 of IEC 60077-1:2017).

9.2.3 Routine tests

The verification of compliance with the constructional requirements for the routine test of both fuse-link and fuse-base concerns visual examination (compliance of the manufacture with the drawing).

9.3 Type tests for the verification of performance requirements

9.3.1 Test sequence

Type tests are grouped in a number of test sequences as shown in Table 3, Table 4 and Table 5.

For fuse-links in a homogeneous series:

– the fuse-link having the highest rated current shall be tested according to Table 3;

– the fuse-link having the lowest rated current shall be tested according to Table 4;

– the fuse-link having a current rating between the largest and the lowest current shall be tested according to Table 5.

For fuse-links which are not part of a homogeneous series, the fuse shall be tested according to Table 3 and in addition, the verification of the ability to withstand vibration and shock according to 9.3.4.5 shall be tested.

For each sequence, the tests should preferably be carried out in the order listed.

A routine test (see 9.1.3) shall be carried out on every fuse-link before the type tests.

Table 3 – Sequence of tests for the highest rating of a homogeneous series

Subclause number	Test	"g" fuse-links									"a" fuse-links							
	Number of samples	3	3	2	2	1	1	1	1	1	3	3	2	2	1	1	1	1
9.2.2	Visual inspection (dimensions mm)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
9.4.2	Resistance measurement	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
9.3.4.1	Temperature rise measurement									X								X
9.3.4.3	Verification of breaking capacity I_1	X									X							
9.3.4.3	Verification of breaking capacity I_2		X									X						
9.3.4.3	Verification of breaking capacity I_3			X									X					
9.3.4.3	Verification of breaking capacity I_4				X									X				
9.3.4.4	Verification of time-current characteristic I_5					X									X			
9.3.4.4	Verification of time-current characteristic I_6						X									X		
9.3.4.4	Verification of time-current characteristic I_7							X									X	
9.3.4.2	Verification of conventional non-fusing current								X									
9.3.4.2	Verification of conventional fusing current								X									
9.3.4.6	Insertion and extraction performance [a]									X								X
9.3.4.7	Verification of dielectric withstand [a]									X								X

[a] This test is to be performed on the complete fuse when the fuse-link is used with a fuse-base.

Table 4 – Sequence of tests for the lowest rating of a homogeneous series

Subclause number	Test	"g" fuse-links									"a" fuse-links							
	Number of samples	1	3	2	2	1	1	1	1	1	1	3	2	2	1	1	1	1
9.2.2	Visual inspection (dimensions mm)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
9.4.2	Resistance measurement	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
9.3.4.1	Temperature rise measurement	X									X							
9.3.4.3	Verification of breaking capacity I_2		X									X						
9.3.4.3	Verification of breaking capacity I_3			X									X					
9.3.4.3	Verification of breaking capacity I_4				X									X				
9.3.4.4	Verification of time-current characteristic I_5					X									X			
9.3.4.4	Verification of time-current characteristic I_6						X									X		
9.3.4.4	Verification of time-current characteristic I_7							X									X	
9.3.4.2	Verification of conventional non-fusing current								X									
9.3.4.2	Verification of conventional fusing current								X									
9.3.4.5	Verification of ability to withstand vibration and shock	X									X							
9.3.4.7	Verification of dielectric withstand [a]									X								X
[a] This test is to be performed on the complete fuse when the fuse-link is used with a fuse-base.																		

Table 5 – Sequence of tests for the intermediate ratings of a homogeneous series

Subclause number	Test	"g" fuse-links								"a" fuse-links						
	Number of samples	3	2	2	1	1	1	1	1	3	2	2	1	1	1	1
9.2.2	Visual inspection (dimensions mm)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
9.4.2	Resistance measurement	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
9.3.4.1	Temperature rise measurement								X							X
9.3.4.3	Verification of breaking capacity I_2	X								X						
9.3.4.3	Verification of breaking capacity I_3		X								X					
9.3.4.3	Verification of breaking capacity I_4			X								X				
9.3.4.4	Verification of time-current characteristic I_5				X								X			
9.3.4.4	Verification of time-current characteristic I_6					X								X		
9.3.4.4	Verification of time-current characteristic I_7						X								X	
9.3.4.2	Verification of conventional non-fusing current							X								
9.3.4.2	Verification of conventional fusing current							X								
9.3.4.7	Verification of dielectric withstand [a]								X							X
[a] This test is to be performed on the complete fuse when the fuse-link is used with a fuse-base.																

9.3.2 General test conditions

The fuse to be tested shall comply in all details with its drawing.

The tests shall be performed at the rated values (current, voltage, frequency), unless otherwise stated. The fuse shall be mounted in the vertical position, unless otherwise specified. See Table 6.

Table 6 – Tolerances on test values

All tests	Tests for temperature rise and time-current characteristic verification	Tests under short-circuit conditions
Voltage: $^{+5}_{0}$ % Frequency: ±10 %	Current: $^{+3}_{0}$ %	Current: $^{+10}_{0}$ % Power factor: $^{0}_{-0,05}$ Time constant: $^{+15}_{0}$ %
NOTE These values apply unless otherwise specified in the test clause.		

9.3.3 Test sequence for the verification of general performance characteristics

The sequences shall include the tests and verifications listed in Table 3, Table 4 and Table 5.

9.3.4 Description of tests for the fuse-link

9.3.4.1 Temperature rise measurement

The tests required in 9.3.3.~~2~~4 of IEC 60077-2:2017 shall be carried out at the rated current.

The test circuit connection arrangement for the temperature rise measurement of the fuse is shown in Figure A.1, Annex A.

The test shall be made with the fuse mounted in free air in draught free surroundings. The ambient air temperature shall be within the 15 °C to 35 °C range.

For this test, the supply voltage shall be sufficient to maintain the required value of the test current.

The fuse shall be continuously loaded at the rated current (AC or DC as appropriate) of the fuse-link. For details of the conductors of the test circuit connected directly to the fuse, see Table ~~10~~ 17 of IEC 60269-1:2006/AMD1:2009/AMD2:2014.

The temperature rises shall not exceed the values specified in Table 2 of IEC 60077-2:2017.

9.3.4.2 Verification of conventional non-fusing and fusing current for “g” fuse-links

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

a) The fuse is subjected to its conventional non-fusing current stated by the manufacturer for a time equal to a time specified in Table 1. It shall not operate during this time.

b) The fuse after having cooled down to the ambient temperature is subjected to the conventional fusing current specified by the manufacturer. It shall operate within the conventional time as specified in Table 1.

~~NOTE~~ The above test b) may be avoided if the manufacturer and the user agree to verify the conventional fusing current during the breaking current test I_4 (see 9.3.4.3.2).

9.3.4.3 Verification of breaking capacity

9.3.4.3.1 General

Verification of breaking capacity shall be performed on the following fuse-links selected from a homogeneous series (see test duty below):

– fuse-links of the highest rated current for the test currents I_1, I_2, I_3, I_4;

– fuse-links of the lowest and the intermediate rated currents for the test currents I_2, I_3, I_4.

The homogeneous nature of the fuse-link series shall be documented by the manufacturer and shall be confirmed in the test report.

NOTE For further details of a homogeneous series, see 8.1.5.2 of IEC 60269-1:2006/AMD1:2009/AMD2:2014.

Fuses which are not part of a homogeneous series shall be tested with test currents I_1, I_2, I_3, I_4.

9.3.4.3.2 Test duty

The following test duties shall be carried out for verification of the breaking capacity:

a) test duty I: verification of the breaking capacity with test current I_1 equal to the rated breaking capacity;

b) test duty II: verification of the fuse-link operation with prospective current I_2 at which fuse arc energy is maximum. For DC tests, the prospective current shall be chosen such that the peak let-through current is between 0,6 and 0,8 of the prospective current;

c) test duty III: verification of the fuse-link operation in the overcurrent range I_3 and I_4. ~~During these tests, preliminary heating of the fuse-link is permitted using a low voltage. Prior to melting of the fuse element, the fuse-link shall be switched from the low-voltage circuit to the breaking test voltage within a dead time not longer than 0,2 s. The arc initiation shall occur while the fuse-link is connected to the breaking test voltage and after the prospective current value has been reached.~~

   – The test duty III tests may be conducted as a two-part test, using a low-voltage power source and a high-voltage power source.

   – For details, refer to 6.6.3.1 in IEC 60282-1:2009/AMD1:2014.

The test parameters are shown in Table 7.

I_n is the rated current of the fuse-link;

I_1 is the rated breaking capacity of the fuse assigned by the manufacturer;

I_2 shall be chosen as specified above;

I_3 is an intermediate value of breaking capacity of the fuse-link;

I_4 is the minimum breaking capacity of an “a” fuse-link or the conventional fusing current of a “g” fuse-link.

Table 7 – Parameters for breaking capacity tests of DC fuse-links

Parameter	Test duty I	Test duty II	Test duty III
Mean value of test voltage [a]	1,1 × the rated voltage of the fuse [b]		
Time constant	Refer to Table 8		
Prospective current	I_1 $^{+5}_{0}$ %	I_2	$I_3 = 5 \times I_n \pm 20$ % I_4 = conventional fusing current for a "g" fuse-link or minimum breaking capacity for an "a" fuse-link $^{+20}_{-0}$ %
Time to maintain test (recovery) voltage [c] following current rupture s	30	30	30
[a] In practice the test and recovery voltages are equal. [b] For test voltages for fuse-links supplied from contact line supply, see Table 2. [c] For fuse-links containing organic material, the time to maintain the recovery is increased to 5 min.			

Fuses of rated voltage 3 000 V DC intended for the protection of train heating circuits do not require additional tests with test currents from a 50 Hz/ 60 Hz and 16 2/3 Hz source ~~due to~~ because in AC the reduced voltage is used for the intended circuit; i.e. 1 500 V for 50 Hz/ 60 Hz and 1 000 V for 16 2/3 Hz.

For breaking capacity tests for AC fuses up to 1 000 V, see IEC 60269-1 and for over 1 000 V, see IEC 60282-1.

9.3.4.3.3 Test circuit

A recommended test circuit is shown in the schematic diagram given in Figure C.1, Annex C. The test circuit shall be adjusted to give the specified prospective current by using the removable link A.

The mechanical arrangement should take into account magnetic forces that may influence the test results.

During the test, oscillograph records or digital test records of the following parameters, as a minimum, shall be taken:

– short-circuit current;
– voltage between ends of the fuse-link under test, during the short-circuit and operating period;
– arc voltage. A record of the arc voltage by a high-speed oscillograph is required in order to determine the peak value of the over-voltage. Typical oscillograms are illustrated in Figure D.2 and Figure D.3, Annex D showing this overvoltage occurring during arcing above the steady state circuit voltage (recovery voltage). See also 3.2.7.

Table 8 – Time constant of the test circuit

Prospective current I_w kA	Time constant ms
$I_w \leq 5$	30 ± 3 [a]
$5 < I_w < 25$	20 ± 2
$I_w \geq 25$	10 ± 1
[a] Inductance of the test circuit should not exceed 50 mH.	

If necessary, larger values of time constants may be defined by agreement between the manufacturer and the user.

9.3.4.3.4 Test procedure

Calibration of the test circuit for values of current, voltage and time constant shall be carried out from oscillograms as follows:

– test circuit adjusted for prospective current with the fuse-link replaced by a link of negligible resistance. The test circuit prospective current shall be applied for a duration greater than the breaking time of the fuse-link;

– test circuit voltage adjusted with fuse-link removed.

The actual test with the fuse-link inserted into the test circuit as in Figure C.1 is performed by closing the making switch.

If a low voltage is used during the pre-arcing period (see 9.3.4.3.2), this shall be such that the required test current shall be maintained at a constant value within ±5 %.

For a pre-arcing time exceeding 1 min continuous adjustment of the test current is permitted. To avoid overloading the fuse-link element during current setting, the fuse-link may be replaced with a link while the calibration adjustment is made.

For times shorter than 0,5 s, the current and pre-arcing time shall be measured by means of an oscillograph. For longer times, these may be measured by ammeter and stop-watch.

The recovery voltage shall be maintained across the fuse-link contacts after operation for the duration given in Table 7.

The recovery voltage is determined from oscillograms recorded during the breaking test (see Figure D.2 and Figure D.3).

The value of prospective current is determined by comparison of oscillograms recorded during calibration (Figure D.1) and oscillograms recorded during the breaking tests (Figure D.2 and Figure D.3).

If the instant of arc initiation is prior to the peak value of the current (Figure D.3), then the value of the prospective breaking current is equal to the peak value of the current recorded during calibration (A_2 of Figure D.1). Alternatively, if the instant of arc initiation occurs after the peak value of the current (A_1 of Figure D.2), the value of the prospective breaking current is equal to the instantaneous value of the current recorded during calibration for the time corresponding to that of the arc initiation.

The time constant of the current is determined as the time interval from the moment of commencement of current flow in the circuit to the moment when the current reaches 0,632 of the peak value of the current (Figure D.1).

The correct operation of indicating devices shall be verified, if applicable. If during the test the indicating device 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 is due to a fault of the individual tested sample.

9.3.4.4 Verification of time-current characteristics

For verification of the time-current characteristics, see 8.4.3.3.1 of IEC 60269-1:2006/AMD1:2009/AMD2:2014.

Three values of current, I_5, I_6 and I_7 shall be chosen in such a way as to verify the pre-arcing time-current characteristic in the area which is not covered by the currents I_1, I_2, I_3 and I_4 (see 9.3.4.3).

9.3.4.5 Verification of the ability to withstand vibration and shock

The vibration tests, followed by the shock tests, shall be carried out in accordance with the relevant methods of IEC 61373.

Before these tests, the same fuse shall be subjected to the temperature rise test (see 9.3.4.1).

Compliance shall then be verified by a further temperature rise test. The values shall not be more than 5 K above or exceed by 5 % (whichever is the greater) the values obtained during the temperature rise test prior to the commencement of the vibration and shock test.

This test shall be performed on a fuse having the lowest current rating of the particular homogeneous series.

9.3.4.6 Insertion and extraction performance

The fuse-base contacts shall withstand 100 cycles of insertions and extractions of a fuse-link without deterioration of the mechanical and electrical properties of the contacts.

Before these tests, the same fuse shall be subjected to a temperature rise test (see 9.3.4.1).

Compliance shall then be verified by a further temperature rise test. The values shall not be more than 5 K above or exceed by 5 % (whichever is the greater) the values obtained during the temperature rise test prior to the commencement of the insertion and extraction test.

This test shall be performed on a fuse having the highest current rating of the particular homogeneous series.

9.3.4.7 Verification of dielectric withstand

This test shall be carried out on the complete fuse. The test voltage shall be applied between one terminal and the mounting plate and between the terminal and auxiliary contacts if fitted. For values to be used, see 9.3.3.~~3~~5 of IEC 60077-2:2017.

9.4 Routine tests for the verification of performance requirements

9.4.1 General

The following routine tests shall be carried out on each fuse-link:

– resistance measurement between ends (see 9.4.2);
– measurement of weight.

On each fuse-base, a dielectric withstand test (see 9.3.4.7) shall be carried out.

9.4.2 Resistance measurement

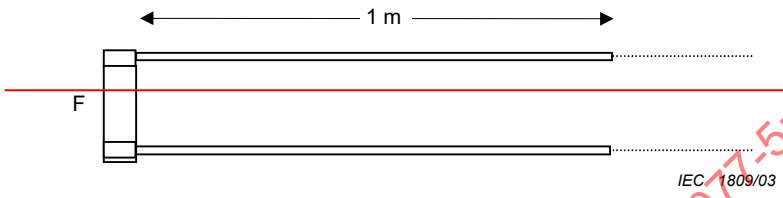
The internal resistance of all fuse-links shall be measured at an ambient-air temperature of (20 ± 5) °C with a measuring current of not more than 0,1 of the rated current. The measurement shall be performed using a suitable resistance measuring method. The result of the measurement shall be considered to be successful if the difference between the value measured and that specified by the manufacturer does not exceed ±20 %. The value of resistance shall be recorded in the test report.

Annex A
(normative)

Connection diagram for temperature rise tests

Test connection to the fuse under test for the temperature rise measurement is shown in Figure A.1.

The connecting conductors on either side of each single fuse or fuse link shall be not less than 1 m in length.



~~Key~~

~~F fuse-link or fuse~~

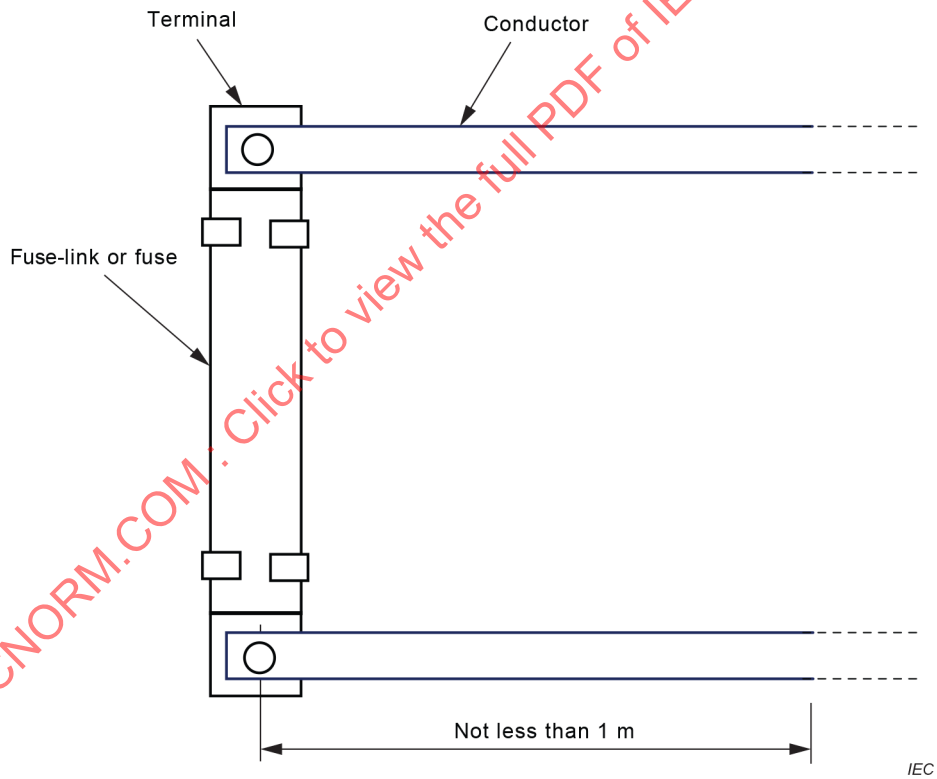


Figure A.1 – Connection diagram for temperature rise tests

Annex B
(informative)

Comparison between “a” and “g” fuse time current characteristics

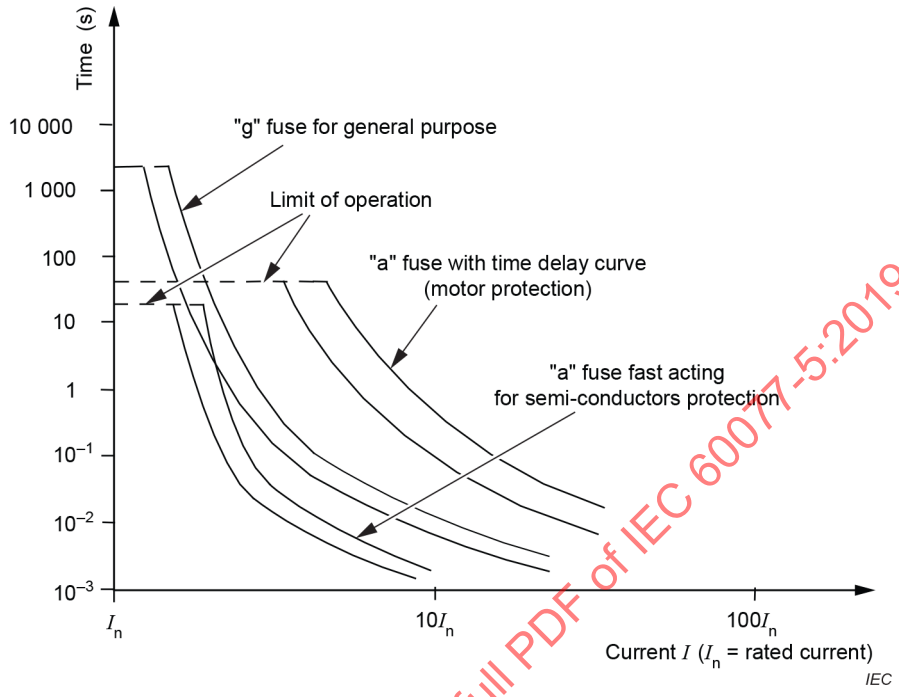
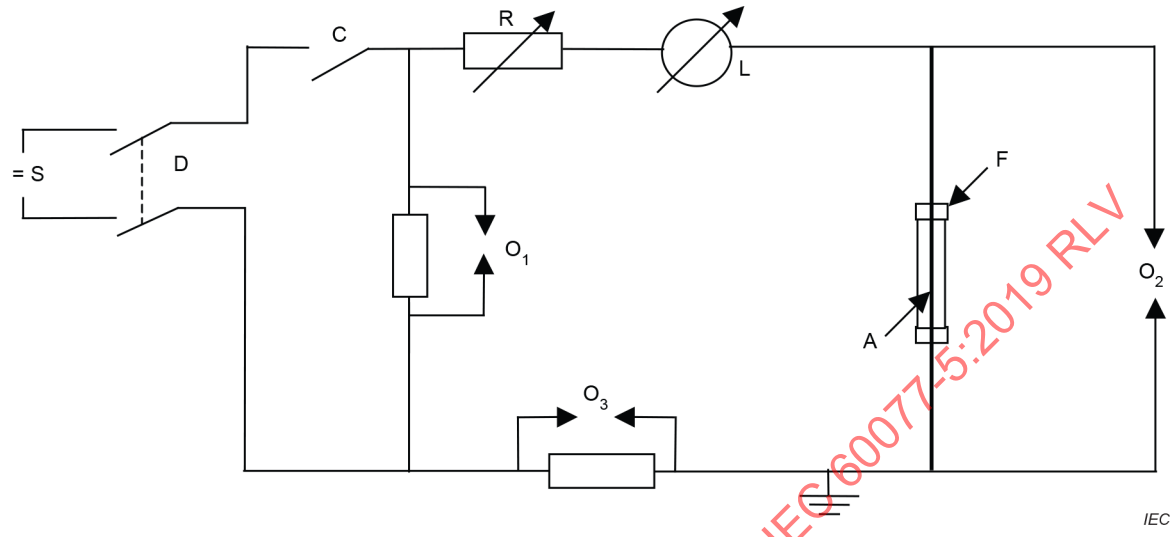


Figure B.1 – Comparison between “a” and “g” fuse time current characteristics

Annex C
(informative)

Diagram of the test circuit for breaking capacity tests



Key

S AC/DC power source
C making switch
R adjustable resistor
L adjustable inductor
A removable link for calibration
O_1 source voltage measurement
O_2 arc and recovery voltage measurement
O_3 current measurement
F fuse-link/fuse under test
D protective device for source

Figure C.1 – Diagram of the test circuit for breaking capacity tests

Annex D
(informative)

Verification of breaking capacity

This annex gives examples of oscillograms which are recorded during the calibration of the circuit and breaking operation of the fuse.

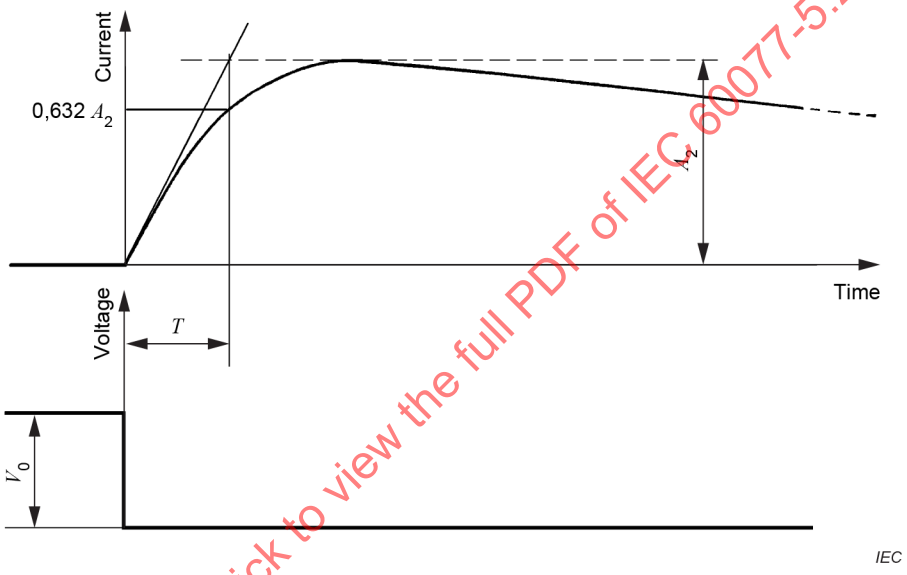
A_1 breaking current;

A_2 prospective peak current;

T time constant;

V_0 test~~ing~~ voltage;

B_1, B_2 recovery voltage.



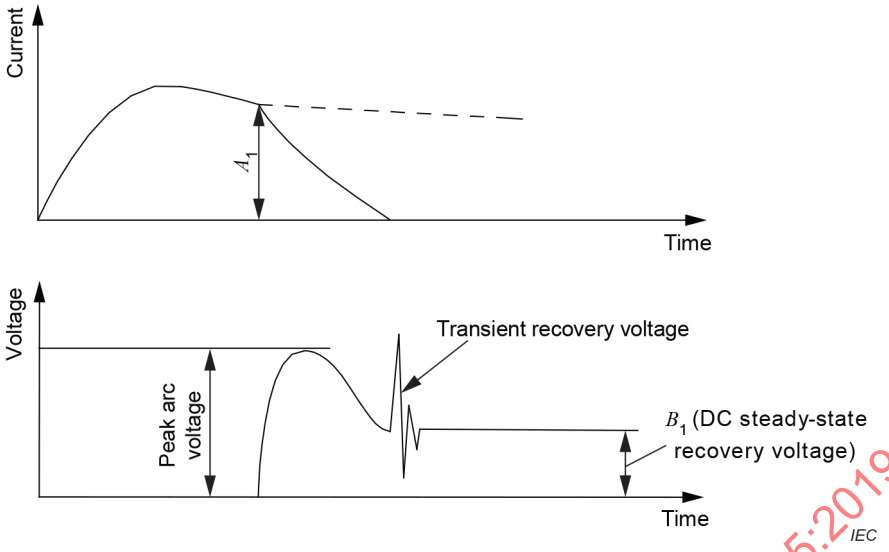
Key

A_2 prospective peak current

T time constant

V_0 test~~ing~~ voltage

Figure D.1 – Test circuit calibration

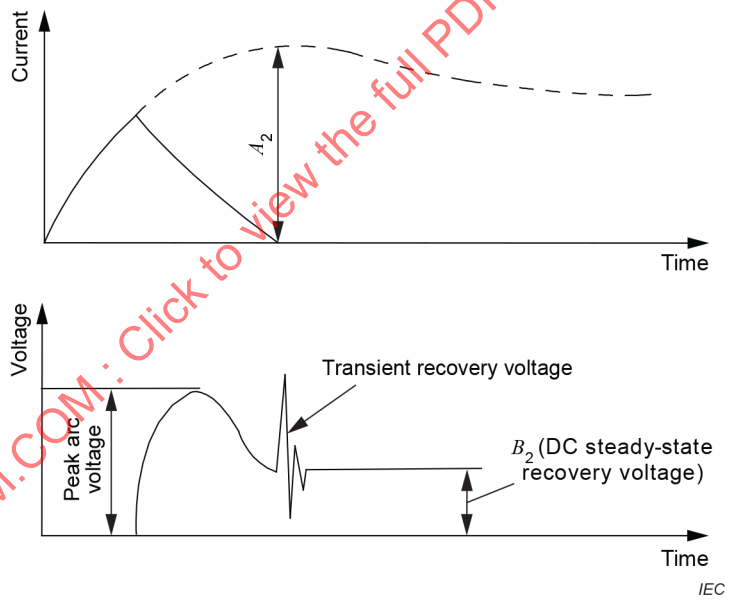


Key

A_1 breaking current

B_1 recovery voltage

Figure D.2 – Breaking operation when the instant of arc initiation is after the peak value of the current



Key

A_2 prospective peak current

B_2 recovery voltage

Figure D.3 – Breaking operation when the instant of arc initiation is prior to the peak value of the current

Bibliography

IEC 60050-441:1984, *International Electrotechnical Vocabulary (IEV) – Part 441: Switchgear, controlgear and* fuses
IEC 60050-441:1984/AMD1:2000

IEC 60050-811:2017, *International Electrotechnical Vocabulary (IEV) – Part 811: Electric traction*

IEC 60850, *Railway applications – Supply voltages of traction systems*

_____

IEC 60077-5

Edition 2.0 2019-10

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Railway applications – Electric equipment for rolling stock – Part 5: Electrotechnical components – Rules for HV fuses

Applications ferroviaires – Équipements électriques du matériel roulant – Partie 5: Composants électrotechniques – Règles pour les fusibles à haute tension

IEC 60077-5:2019-10(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

RAILWAY APPLICATIONS – ELECTRIC EQUIPMENT FOR ROLLING STOCK –

Part 5: Electrotechnical components – Rules for HV fuses

FOREWORD

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

International Standard IEC 60077-5 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

This second edition cancels and replaces the first edition, issued in 2003. It constitutes a technical revision.

This edition includes the following main technical changes with regard to the previous edition:

a) test method of test duty III for verification of breaking capacity is reviewed.

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

FDIS	Report on voting
9/2539/FDIS	9/2555/RVD

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

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

This document should be read in conjunction with IEC 60077-1 and IEC 60077-2.

A list of all parts in the IEC 60077 series, published under the general title *Railway applications – Electric equipment for rolling stock*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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

RAILWAY APPLICATIONS – ELECTRIC EQUIPMENT FOR ROLLING STOCK –

Part 5: Electrotechnical components – Rules for HV fuses

1 Scope

The purpose of this part of IEC 60077 is to give additional or amended rules for high voltage (HV) fuses as a supplement to those given by IEC 60077-2.

NOTE 1 In this document the term high voltage fuses is used in the context of the voltages used in the field of railway rolling stock.

The high voltage fuses concerned are those connected into power and/or auxiliary circuits. The nominal voltage of these circuits lies between 600 V DC and 3 000 V DC, according to IEC 60850. These fuses can also be used in auxiliary AC circuits up to a nominal voltage of 1 500 V.

NOTE 2 Certain of these rules, after agreement between the user and the manufacturer, are used for fuses installed on vehicles other than rail rolling stock such as mine locomotives, trolleybuses, etc.

This document together with IEC 60077-2 states specifically:

a) the characteristics of the fuses;

b) the service conditions with which the fuses comply with reference to:
   - operation and behaviour in normal service;
   - operation and behaviour in case of short circuit;
   - dielectric properties.

c) the tests intended for confirming the compliance of the fuse with the characteristics under the service conditions and the methods adopted for these tests;

d) the information marked on, or given with, the fuse.

This document does not cover parallel connection of fuses.

During preparation of this document, IEC 60269-1 and IEC 60282-1 have been considered and their requirements have been kept as far as possible.

This document makes reference to the general rules for electrotechnical components given in IEC 60077-2, but for general conditions reference is made directly to IEC 60077-1.

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 60077-1:2017, *Railway applications – Electric equipment for rolling stock – Part 1: General service conditions and general rules*

IEC 60077-2:2017, *Railway applications – Electric equipment for rolling stock – Part 2: Electrotechnical components – General rules*

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

IEC 60282-1:2009, *High-voltage fuses – Part 1: Current-limiting fuses*
IEC 60282-1:2009/AMD1:2014

IEC 61373, *Railway applications – Rolling stock equipment – Shock and vibration tests*

ISO 3, *Preferred numbers – Series of preferred numbers*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the terms and definitions given in Clause 3 of IEC 60077-1:2017 and Clause 3 of IEC 60077-2:2017, and the following 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

3.1 Components

NOTE For terminologies of a fuse, see also Figure 1 in IEC 60282-1:2009/AMD1:2014.

3.1.1
fuse
device that, by the fusing of one or more of its specifically 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

Note 1 to entry: The fuse comprises all the parts that form the complete device.

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-01, modified – The second sentence has been changed to Note 1 to entry.]

3.1.2
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/AMD1:2000, 441-18-09]

3.1.3
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

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-08]

3.1.4
fuse-base
fixed part of a fuse provided with contacts and terminals

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-02]

3.1.5
indicating device, <of a fuse>
part of a fuse provided to indicate whether the fuse has operated

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-17]

3.1.6
open box type fuse
fuse installed in an open box equipped with an arc chute in order to reduce arc quickly

3.1.7
homogeneous series, <of fuse-links>
series of fuse-links, deviating from each other only in such characteristics that, for a given test, the testing of one or a reduced number of particular fuse-link(s) of that series can be taken as representative for all the fuse-links of the homogeneous series

Note 1 to entry: The relevant publications specify the characteristics by which the fuse-links of a homogeneous series may deviate, the particular fuse-links to be tested and the specific test concerned.

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-34, modified – "may" has been replaced with "can".]

3.2 Operational characteristics

3.2.1
prospective current, <of a circuit and with respect to a switching device or a fuse>
current that would flow in the circuit if each pole of the switching device or the fuse were replaced by a conductor of negligible impedance

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-17-01, modified – Note has been deleted.]

3.2.2
prospective peak current
peak value of a prospective current during the transient period following initiation

Note 1 to entry: This term is commonly associated with short-circuit conditions.

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-17-02, modified – Note to entry has been replaced.]

3.2.3
pre-arcing 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/AMD1:2000, 441-18-21]

3.2.4
arcing time, <of a pole or a fuse>
interval of time between the instant of the initiation of the arc in a pole or a fuse and the instant of final arc extinction in that pole or that fuse

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-17-37]

3.2.5
operating time
sum of the pre-arcing time and the arcing time

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-22]

3.2.6
arc voltage, <of a fuse>
instantaneous value of voltage which appears across the terminals of a fuse during the arcing time

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-30]

3.2.7
peak arc voltage, <of a fuse>
maximum instantaneous value of voltage which under prescribed conditions appears across the terminals of a fuse during the arcing time

Note 1 to entry: After extinction of the arc, an overvoltage (transient recovery voltage) may be present across the terminals. The value of this will depend on the circuit characteristics and the fuse. This overvoltage is not part of the peak arc voltage (see Figure D.2 and Figure D.3).

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-17-30, modified – "a pole of a switching device" has been replaced with "a fuse". Note 1 to entry has been added.]

3.2.8
DC steady-state recovery voltage
recovery voltage in a DC circuit after the transient voltage phenomena have subsided, expressed by the mean value where ripple is present

Note 1 to entry: This is shown as B_1 and B_2 in Figure D.2 and Figure D.3.

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-17-28, modified – Note 1 to entry has been added.]

3.2.9
peak let-through current
maximum instantaneous value of current attained during the operation of a fuse

3.2.10
joule integral
I^2t
integral of the square of the current over a given time interval

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

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 liberated in one ohm of resistance in a circuit protected by a fuse is equal to the value of the operating I^2t expressed in A^2s.

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-23]

3.2.11
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

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-17-13]

3.2.12
conventional non-fusing current
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/AMD1:2000, 441-18-27]

3.2.13
conventional fusing current
value of current specified as that which causes operation of the fuse-link within a specified time (conventional time)

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-28]

3.2.14
rated value
value of a quantity used for specification purposes, established for a specified set of operating conditions of a component, device, equipment, or system

Note 1 to entry: The rated values usually stated for fuses are voltage, current, breaking capacity and power dissipation.

[SOURCE: IEC 60050-151:2001, 151-16-08, modified – Note 1 to entry has been added.]

3.3 Abbreviated terms

AC Alternating Current

DC Direct Current

HV High Voltage

4 Classification

4.1 Breaking range

Fuse-links are classified according to whether they are:

a) “g” fuse-link: with a full range breaking capacity, i.e. capable under specified conditions of breaking all currents which cause melting of the fuse-element up to its rated breaking capacity;

b) “a” fuse-link: with a partial range breaking capacity, i.e. capable of breaking under specified conditions all currents between their minimum breaking capacity and their rated breaking capacity. They may be used in conjunction with another switching device where protection is required against overcurrent below their minimum breaking capacity.

NOTE 1 Comparison between “a” and “g” fuse time current characteristics is shown in Figure B.1 of Annex B.

NOTE 2 Examples of “a” fuse-link protection can be those for protection of semiconductor devices, motors, etc.

4.2 Utilisation category

Fuse-links may be categorised according to whether they are to be subjected in normal service to:

– current values which do not exceed their continuous rating;
– current values which briefly exceed their continuous rating on a regular basis, such as when starting a rotating machine;
– current values which do not exceed their continuous rating but which are switched or change significantly in a frequently repeated pattern;

or they have to provide a special protection as, for example:

– semiconductor conditions, where fast action is required in order to limit the peak let-through current and the operating I^2t;
– provide a time delayed operation.

5 Characteristics

The characteristics of a fuse shall be stated in terms of the following:

– rated voltage(s) DC and/or AC;
– rated current (I_n);
– rated frequency;
– rated breaking capacity;
– breaking range;
– rated power dissipation;
– time-current characteristics. The conventional times and currents for “g” fuse-links are given in Table 1;
– overload capability;
– I^2t characteristics (minimum pre-arcing I^2t and maximum operating I^2t);
– peak let-through current related to prospective current and time constant;
– current rating correction factors versus ambient temperature;
– peak arc voltage related to operating voltage;
– rated insulation voltage (U_{Nm}) for fuse-bases;
– rated impulse voltage (U_{Ni}) for fuse-bases.

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 co-ordinate axes.

Table 1 – Conventional times for “g” fuse-links

Rated current A	Specified time (conventional time) h
$I_n \leq 63$	1
$63 < I_n \leq 160$	2
$160 < I_n \leq 400$	3
$I_n > 400$	4

6 Product information

6.1 Documentation

This information shall be given in the manufacturer's catalogue or manual.

6.1 of IEC 60077-2:2017 applies, supplemented by the following:

– rated voltage;
– rated current;
– rated breaking capacity and time constant;
– suitable applications (see 4.2);
– I^2t characteristics (minimum pre-arcing I^2t and maximum operating I^2t);
– correction factors for current rating versus ambient temperature, varying load and overload;
– physical dimensions;
– special instructions for storage, installation, maintenance, if applicable.

6.2 Marking

Fuse-links and fuse-bases shall possess durable and legible nameplates or engraved markings in accordance with 6.2 of IEC 60077-2:2017.

For the open box type fuse nameplates or engraved markings shall be placed on the box.

The markings of the fuse-link and fuse-base shall include the following data:

– manufacturer's name or trade mark;
– manufacturer's type designation;
– rated voltage (DC and/or AC);
– rated current.

7 Normal service conditions

These conditions are given in Clause 7 of IEC 60077-1:2017.

8 Constructional and performance requirements

8.1 Constructional requirements

8.1.1 General

In addition to the requirements of 8.1 of IEC 60077-2:2017, the fuse shall comply with the following requirements.

8.1.2 Fuse-link

The fuse-link shall be sufficiently robust so that there shall be no damage to the surroundings e.g. by permanent arcing, flashover or any ejection of flames or materials during operation.

NOTE 1 For further details, see 8.5.8 of IEC 60269-1:2006/AMD1:2009/AMD2:2014.

It shall be possible to replace the fuse-links easily.

NOTE 2 For further details of replacement, see 7.1.1 of IEC 60269-1:2006/AMD1:2009/AMD2:2014.

8.1.3 Fuse-base

The fuse-base shall incorporate contacts which ensure that the connections to the fuse-link are adequate under all conditions of thermal cycling, vibration and shock during normal service and during the application of the electro-dynamic forces when the fuse-link is rupturing overload or short-circuit currents up to its rated breaking capacity value.

8.1.4 Spring-loaded contacts

Where the fuse-base incorporates spring-loaded contacts for electrical connection and mechanical retention of the fuse-link, these contacts shall withstand 100 cycles of insertions and removals of the fuse-link without deterioration of the electrical and mechanical properties.

8.1.5 External terminals

Terminals for external connection to the fuse-base shall provide a constant clamping force unaffected by variation in current through them. They shall be capable of enduring multiple connection and disconnection of the external conductors without deterioration. Terminal screw thread shall have a minimum size of M5.

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 a shape such that they cannot unduly damage the conductors.

No contact force on connections shall be transmitted through insulating material other than ceramic, or other material having mechanical characteristics no less suitable.

NOTE For further information, see 7.1.2 of IEC 60269-1:2006/AMD1:2009/AMD2:2014.

8.2 Performance requirements

8.2.1 Operating conditions

These requirements are given in 8.2.1 of IEC 60077-2:2017.

8.2.2 Temperature limits

These requirements are given in 8.2.2 of IEC 60077-2:2017.

8.2.3 Dielectric properties

Requirements of clearances are given in 8.2.6 of IEC 60077-1:2017.

Requirements of creepage distances are given in 8.2.7 of IEC 60077-1:2017.

8.2.4 Rated voltage

For fuses fed from the contact line, the rated voltage of the fuses shall be in accordance with Table 2. For fuses not fed from the contact line, the breaking test voltage shall be at least equal to the highest operational voltage of the circuit in which it is connected.

Table 2 – Rated and test voltages for DC fuse-links supplied from the contact line

Nominal line voltage V	Rated voltage of the fuse V	Breaking test voltage V
600	720	800
750	900	1 000
1 500	1 800	1 950
3 000	3 600	3 900

8.2.5 Rated current of the fuse-link

The rated current for the fuse-link, expressed in amperes (A), should be selected from the following values:

0,6; 1; 2; 3; 4; 6; 10; 12; 16; 20; 25; 32; 40; 50; 63; 80; 100; 125; 160; 200; 250; 315; 400; 500; 630; 800 and 1 000.

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.

8.2.6 Rated current of the fuse-base

The rated current of the fuse-base shall be equal to or greater than that of the relevant fuse-link and should be selected from the series of rated currents of the fuse-links given in 8.2.5.

8.2.7 Breaking capacity

The fuse-link shall interrupt correctly any current within the range from minimum breaking capacity up to its rated breaking capacity at the appropriate test voltage given in Table 7. The peak arc voltage shall not exceed 3 times the test voltage.

For low current ratings (lower than or equal to 6,3 A), the peak arc voltage may reach 4,5 times the test voltage.

8.2.8 Time-current characteristics

The manufacturer shall include in the technical documentation for the fuse-links the time-current characteristics at (20 ± 5) °C.

9 Tests

9.1 Kinds of tests

9.1.1 General

9.1.1 of IEC 60077-1:2017 applies, except that sampling tests are not applicable.

The tests to verify the characteristics of the fuses are:

– type tests (see 9.1.2);
– routine tests (see 9.1.3);
– investigation tests (see 9.1.4).

9.1.2 Type tests

The type tests comprise the following:

– verification of constructional requirements (see 9.2.2);

– verification of performance requirements (see 9.3).

For the type tests, the number of fuses or fuse-links shall be as indicated in Table 3, Table 4 and Table 5. They shall be randomly selected from the manufacturing production line. In all tests, the same fuse-base should be used.

The type test results shall be deemed to be compliant if the results of all the type tests listed in Table 3, Table 4 and Table 5 meet the requirements.

For the type tests, test certificates shall be provided for each fuse-link or fuse tested, to prove their general compliance with the technical documentation.

9.1.3 Routine tests

Routine tests shall be carried out on each fuse-link and fuse-base.

The routine tests comprise the following:

– verification of constructional requirements (see 9.2.3);

– verification of performance requirements (see 9.4).

The routine test results shall be deemed to be compliant if the results of all the routine tests listed in 9.2.3 and 9.4 meet the requirements.

9.1.4 Investigation tests

These are supplementary tests to the type tests for a special application. They form the subject of a programme agreed between the fuse manufacturer and the user, and may concern:

– the influence of frequent current variation on the operating characteristics;

– the influence of frequent start current surges on the operating characteristics;

– the influence of the circuit time-constant on the behaviour of the fuse during the breaking capacity tests.

9.2 Tests for the verification of constructional requirements

9.2.1 General

The compliance of the fuse-link and fuse-base with the constructional requirements described in Clause 8 shall be verified generally in accordance with 9.2 of IEC 60077-1:2017, prior to the verification of performance requirements as detailed in 9.3 and 9.4.

9.2.2 Type tests

Verification of compliance with the constructional requirements for the type test of both fuse-link and fuse-base concerns:

– physical properties. A check shall be made that the fuse conforms to the drawings (e.g. dimensions, materials, electrical risks, etc.);

– clearance and creepage distances (see 9.3.3.2.1 and 9.3.3.2.3 of IEC 60077-1:2017).

9.2.3 Routine tests

The verification of compliance with the constructional requirements for the routine test of both fuse-link and fuse-base concerns visual examination (compliance of the manufacture with the drawing).

9.3 Type tests for the verification of performance requirements

9.3.1 Test sequence

Type tests are grouped in a number of test sequences as shown in Table 3, Table 4 and Table 5.

For fuse-links in a homogeneous series:

– the fuse-link having the highest rated current shall be tested according to Table 3;

– the fuse-link having the lowest rated current shall be tested according to Table 4;

– the fuse-link having a current rating between the largest and the lowest current shall be tested according to Table 5.

For fuse-links which are not part of a homogeneous series, the fuse shall be tested according to Table 3 and, in addition, the verification of the ability to withstand vibration and shock according to 9.3.4.5 shall be tested.

For each sequence, the tests should preferably be carried out in the order listed.

A routine test (see 9.1.3) shall be carried out on every fuse-link before the type tests.

Table 3 – Sequence of tests for the highest rating of a homogeneous series

Subclause number	Test	"g" fuse-links									"a" fuse-links							
	Number of samples	3	3	2	2	1	1	1	1	1	3	3	2	2	1	1	1	1
9.2.2	Visual inspection (dimensions mm)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
9.4.2	Resistance measurement	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
9.3.4.1	Temperature rise measurement									X								X
9.3.4.3	Verification of breaking capacity I_1	X									X							
9.3.4.3	Verification of breaking capacity I_2		X									X						
9.3.4.3	Verification of breaking capacity I_3			X									X					
9.3.4.3	Verification of breaking capacity I_4				X									X				
9.3.4.4	Verification of time-current characteristic I_5					X									X			
9.3.4.4	Verification of time-current characteristic I_6						X									X		
9.3.4.4	Verification of time-current characteristic I_7							X									X	
9.3.4.2	Verification of conventional non-fusing current								X									
9.3.4.2	Verification of conventional fusing current								X									
9.3.4.6	Insertion and extraction performance [a]									X								X
9.3.4.7	Verification of dielectric withstand [a]									X								X

[a] This test is to be performed on the complete fuse when the fuse-link is used with a fuse-base.

Table 4 – Sequence of tests for the lowest rating of a homogeneous series

Subclause number	Test	"g" fuse-links									"a" fuse-links							
	Number of samples	1	3	2	2	1	1	1	1	1	1	3	2	2	1	1	1	1
9.2.2	Visual inspection (dimensions mm)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
9.4.2	Resistance measurement	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
9.3.4.1	Temperature rise measurement	X									X							
9.3.4.3	Verification of breaking capacity I_2		X									X						
9.3.4.3	Verification of breaking capacity I_3			X									X					
9.3.4.3	Verification of breaking capacity I_4				X									X				
9.3.4.4	Verification of time-current characteristic I_5					X									X			
9.3.4.4	Verification of time-current characteristic I_6						X									X		
9.3.4.4	Verification of time-current characteristic I_7							X									X	
9.3.4.2	Verification of conventional non-fusing current								X									
9.3.4.2	Verification of conventional fusing current								X									
9.3.4.5	Verification of ability to withstand vibration and shock	X									X							
9.3.4.7	Verification of dielectric withstand [a]									X								X
[a] This test is to be performed on the complete fuse when the fuse-link is used with a fuse-base.																		

Table 5 – Sequence of tests for the intermediate ratings of a homogeneous series

Subclause number	Test	"g" fuse-links								"a" fuse-links						
	Number of samples	3	2	2	1	1	1	1	1	3	2	2	1	1	1	1
9.2.2	Visual inspection (dimensions mm)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
9.4.2	Resistance measurement	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
9.3.4.1	Temperature rise measurement								X							X
9.3.4.3	Verification of breaking capacity I_2	X								X						
9.3.4.3	Verification of breaking capacity I_3		X								X					
9.3.4.3	Verification of breaking capacity I_4			X								X				
9.3.4.4	Verification of time-current characteristic I_5				X								X			
9.3.4.4	Verification of time-current characteristic I_6					X								X		
9.3.4.4	Verification of time-current characteristic I_7						X								X	
9.3.4.2	Verification of conventional non-fusing current							X								
9.3.4.2	Verification of conventional fusing current							X								
9.3.4.7	Verification of dielectric withstand [a]								X							X
[a] This test is to be performed on the complete fuse when the fuse-link is used with a fuse-base.																

9.3.2 General test conditions

The fuse to be tested shall comply in all details with its drawing.

The tests shall be performed at the rated values (current, voltage, frequency), unless otherwise stated. The fuse shall be mounted in the vertical position, unless otherwise specified. See Table 6.

Table 6 – Tolerances on test values

All tests	Tests for temperature rise and time-current characteristic verification	Tests under short-circuit conditions
Voltage: $^{+5}_{0}$ % Frequency: ±10 %	Current: $^{+3}_{0}$ %	Current: $^{+10}_{0}$ % Power factor: $^{0}_{-0,05}$ Time constant: $^{+15}_{0}$ %
NOTE These values apply unless otherwise specified in the test clause.		

9.3.3 Test sequence for the verification of general performance characteristics

The sequences shall include the tests and verifications listed in Table 3, Table 4 and Table 5.

9.3.4 Description of tests for the fuse-link

9.3.4.1 Temperature rise measurement

The tests required in 9.3.3.4 of IEC 60077-2:2017 shall be carried out at the rated current.

The test circuit connection arrangement for the temperature rise measurement of the fuse is shown in Figure A.1, Annex A.

The test shall be made with the fuse mounted in free air in draught free surroundings. The ambient air temperature shall be within the 15 °C to 35 °C range.

For this test, the supply voltage shall be sufficient to maintain the required value of the test current.

The fuse shall be continuously loaded at the rated current (AC or DC as appropriate) of the fuse-link. For details of the conductors of the test circuit connected directly to the fuse, see Table 17 of IEC 60269-1:2006/AMD1:2009/AMD2:2014.

The temperature rises shall not exceed the values specified in Table 2 of IEC 60077-2:2017.

9.3.4.2 Verification of conventional non-fusing and fusing current for “g” fuse-links

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

a) The fuse is subjected to its conventional non-fusing current stated by the manufacturer for a time equal to a time specified in Table 1. It shall not operate during this time.

b) The fuse after having cooled down to the ambient temperature is subjected to the conventional fusing current specified by the manufacturer. It shall operate within the conventional time as specified in Table 1.

The above test b) may be avoided if the manufacturer and the user agree to verify the conventional fusing current during the breaking current test I_4 (see 9.3.4.3.2).

9.3.4.3 Verification of breaking capacity

9.3.4.3.1 General

Verification of breaking capacity shall be performed on the following fuse-links selected from a homogeneous series (see test duty below):

– fuse-links of the highest rated current for the test currents I_1, I_2, I_3, I_4;

– fuse-links of the lowest and the intermediate rated currents for the test currents I_2, I_3, I_4.

The homogeneous nature of the fuse-link series shall be documented by the manufacturer and shall be confirmed in the test report.

NOTE For further details of a homogeneous series, see 8.1.5.2 of IEC 60269-1:2006/AMD1:2009/AMD2:2014.

Fuses which are not part of a homogeneous series shall be tested with test currents I_1, I_2, I_3, I_4.

9.3.4.3.2 Test duty

The following test duties shall be carried out for verification of the breaking capacity:

a) test duty I: verification of the breaking capacity with test current I_1 equal to the rated breaking capacity;

b) test duty II: verification of the fuse-link operation with prospective current I_2 at which fuse arc energy is maximum. For DC tests, the prospective current shall be chosen such that the peak let-through current is between 0,6 and 0,8 of the prospective current;

c) test duty III: verification of the fuse-link operation in the overcurrent range I_3 and I_4.

   – The test duty III tests may be conducted as a two-part test, using a low-voltage power source and a high-voltage power source.

   – For details, refer to 6.6.3.1 in IEC 60282-1:2009/AMD1:2014.

The test parameters are shown in Table 7.

I_n is the rated current of the fuse-link;

I_1 is the rated breaking capacity of the fuse assigned by the manufacturer;

I_2 shall be chosen as specified above;

I_3 is an intermediate value of breaking capacity of the fuse-link;

I_4 is the minimum breaking capacity of an “a” fuse-link or the conventional fusing current of a “g” fuse-link.

Table 7 – Parameters for breaking capacity tests of DC fuse-links

Parameter	Test duty I	Test duty II	Test duty III
Mean value of test voltage [a]	1,1 × the rated voltage of the fuse [b]		
Time constant	Refer to Table 8		
Prospective current	I_1 $^{+5}_{0}$ %	I_2	$I_3 = 5 \times I_n \pm 20$ % I_4 = conventional fusing current for a "g" fuse-link or minimum breaking capacity for an "a" fuse-link $^{+20}_{-0}$ %
Time to maintain test (recovery) voltage [c] following current rupture s	30	30	30

[a] In practice the test and recovery voltages are equal.

[b] For test voltages for fuse-links supplied from contact line supply, see Table 2.

[c] For fuse-links containing organic material, the time to maintain the recovery is increased to 5 min.

Fuses of rated voltage 3 000 V DC intended for the protection of train heating circuits do not require additional tests with test currents from a 50 Hz/ 60 Hz and 16 2/3 Hz source because in AC the reduced voltage is used for the intended circuit; i.e. 1 500 V for 50 Hz/ 60 Hz and 1 000 V for 16 2/3 Hz.

For breaking capacity tests for AC fuses up to 1 000 V, see IEC 60269-1 and for over 1 000 V, see IEC 60282-1.

9.3.4.3.3 Test circuit

A recommended test circuit is shown in the schematic diagram given in Figure C.1, Annex C. The test circuit shall be adjusted to give the specified prospective current by using the removable link A.

The mechanical arrangement should take into account magnetic forces that may influence the test results.

During the test, oscillograph records or digital test records of the following parameters, as a minimum, shall be taken:

– short-circuit current;

– voltage between ends of the fuse-link under test, during the short-circuit and operating period;

– arc voltage. A record of the arc voltage by a high-speed oscillograph is required in order to determine the peak value of the over-voltage. Typical oscillograms are illustrated in Figure D.2 and Figure D.3, Annex D showing this overvoltage occurring during arcing above the steady state circuit voltage (recovery voltage). See also 3.2.7.

Table 8 – Time constant of the test circuit

Prospective current I_w kA	Time constant ms
$I_w \leq 5$	30 ± 3 [a]
$5 < I_w < 25$	20 ± 2
$I_w \geq 25$	10 ± 1
[a] Inductance of the test circuit should not exceed 50 mH.	

If necessary, larger values of time constants may be defined by agreement between the manufacturer and the user.

9.3.4.3.4 Test procedure

Calibration of the test circuit for values of current, voltage and time constant shall be carried out from oscillograms as follows:

– test circuit adjusted for prospective current with the fuse-link replaced by a link of negligible resistance. The test circuit prospective current shall be applied for a duration greater than the breaking time of the fuse-link;

– test circuit voltage adjusted with fuse-link removed.

The actual test with the fuse-link inserted into the test circuit as in Figure C.1 is performed by closing the making switch.

If a low voltage is used during the pre-arcing period (see 9.3.4.3.2), this shall be such that the required test current shall be maintained at a constant value within ±5 %.

For a pre-arcing time exceeding 1 min continuous adjustment of the test current is permitted. To avoid overloading the fuse-link element during current setting, the fuse-link may be replaced with a link while the calibration adjustment is made.

For times shorter than 0,5 s, the current and pre-arcing time shall be measured by means of an oscillograph. For longer times, these may be measured by ammeter and stop-watch.

The recovery voltage shall be maintained across the fuse-link contacts after operation for the duration given in Table 7.

The recovery voltage is determined from oscillograms recorded during the breaking test (see Figure D.2 and Figure D.3).

The value of prospective current is determined by comparison of oscillograms recorded during calibration (Figure D.1) and oscillograms recorded during the breaking tests (Figure D.2 and Figure D.3).

If the instant of arc initiation is prior to the peak value of the current (Figure D.3), then the value of the prospective breaking current is equal to the peak value of the current recorded during calibration (A_2 of Figure D.1). Alternatively, if the instant of arc initiation occurs after the peak value of the current (A_1 of Figure D.2), the value of the prospective breaking current is equal to the instantaneous value of the current recorded during calibration for the time corresponding to that of the arc initiation.

The time constant of the current is determined as the time interval from the moment of commencement of current flow in the circuit to the moment when the current reaches 0,632 of the peak value of the current (Figure D.1).

The correct operation of indicating devices shall be verified, if applicable. If during the test the indicating device 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 is due to a fault of the individual tested sample.

9.3.4.4 Verification of time-current characteristics

For verification of the time-current characteristics, see 8.4.3.3.1 of IEC 60269-1:2006/AMD1:2009/AMD2:2014.

Three values of current, I_5, I_6 and I_7 shall be chosen in such a way as to verify the pre-arcing time-current characteristic in the area which is not covered by the currents I_1, I_2, I_3 and I_4 (see 9.3.4.3).

9.3.4.5 Verification of the ability to withstand vibration and shock

The vibration tests, followed by the shock tests, shall be carried out in accordance with the relevant methods of IEC 61373.

Before these tests, the same fuse shall be subjected to the temperature rise test (see 9.3.4.1).

Compliance shall then be verified by a further temperature rise test. The values shall not be more than 5 K above or exceed by 5 % (whichever is the greater) the values obtained during the temperature rise test prior to the commencement of the vibration and shock test.

This test shall be performed on a fuse having the lowest current rating of the particular homogeneous series.

9.3.4.6 Insertion and extraction performance

The fuse-base contacts shall withstand 100 cycles of insertions and extractions of a fuse-link without deterioration of the mechanical and electrical properties of the contacts.

Before these tests, the same fuse shall be subjected to a temperature rise test (see 9.3.4.1).

Compliance shall then be verified by a further temperature rise test. The values shall not be more than 5 K above or exceed by 5 % (whichever is the greater) the values obtained during the temperature rise test prior to the commencement of the insertion and extraction test.

This test shall be performed on a fuse having the highest current rating of the particular homogeneous series.

9.3.4.7 Verification of dielectric withstand

This test shall be carried out on the complete fuse. The test voltage shall be applied between one terminal and the mounting plate and between the terminal and auxiliary contacts if fitted. For values to be used, see 9.3.3.5 of IEC 60077-2:2017.

9.4 Routine tests for the verification of performance requirements

9.4.1 General

The following routine tests shall be carried out on each fuse-link:

– resistance measurement between ends (see 9.4.2);
– measurement of weight.

On each fuse-base, a dielectric withstand test (see 9.3.4.7) shall be carried out.

9.4.2 Resistance measurement

The internal resistance of all fuse-links shall be measured at an ambient-air temperature of (20 ± 5) °C with a measuring current of not more than 0,1 of the rated current. The measurement shall be performed using a suitable resistance measuring method. The result of the measurement shall be considered to be successful if the difference between the value measured and that specified by the manufacturer does not exceed ±20 %. The value of resistance shall be recorded in the test report.

Annex A
(normative)

Connection diagram for temperature rise tests

Test connection to the fuse under test for the temperature rise measurement is shown in Figure A.1.

The connecting conductors on either side of each single fuse or fuse link shall be not less than 1 m in length.

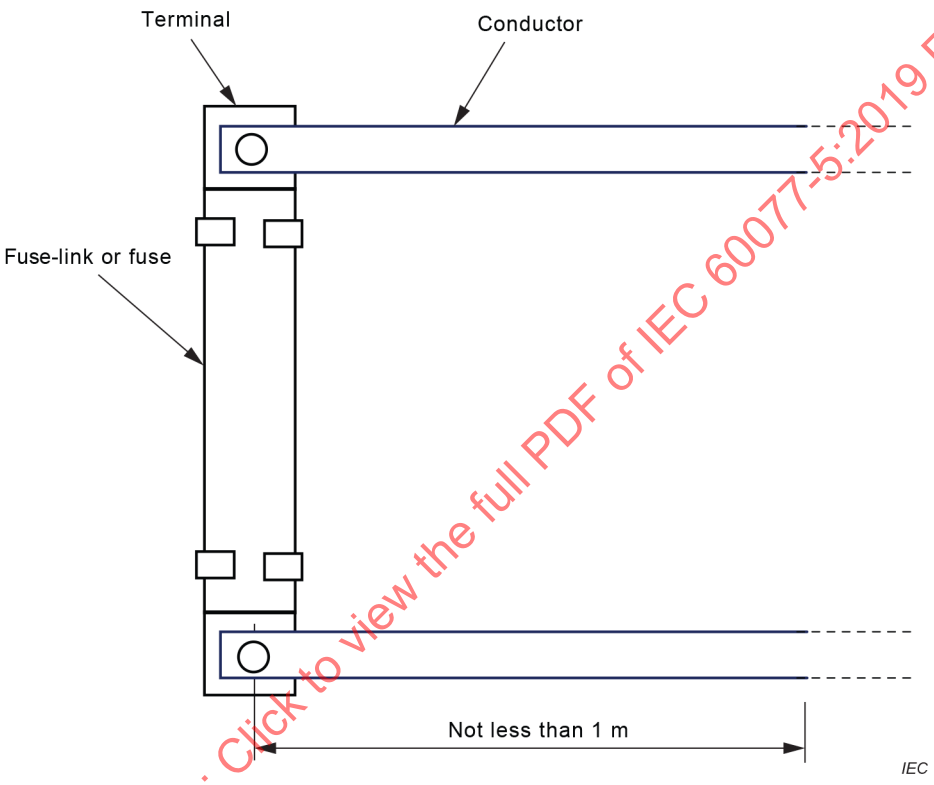


Figure A.1 – Connection diagram for temperature rise tests

Annex B
(informative)

Comparison between “a” and “g” fuse time current characteristics

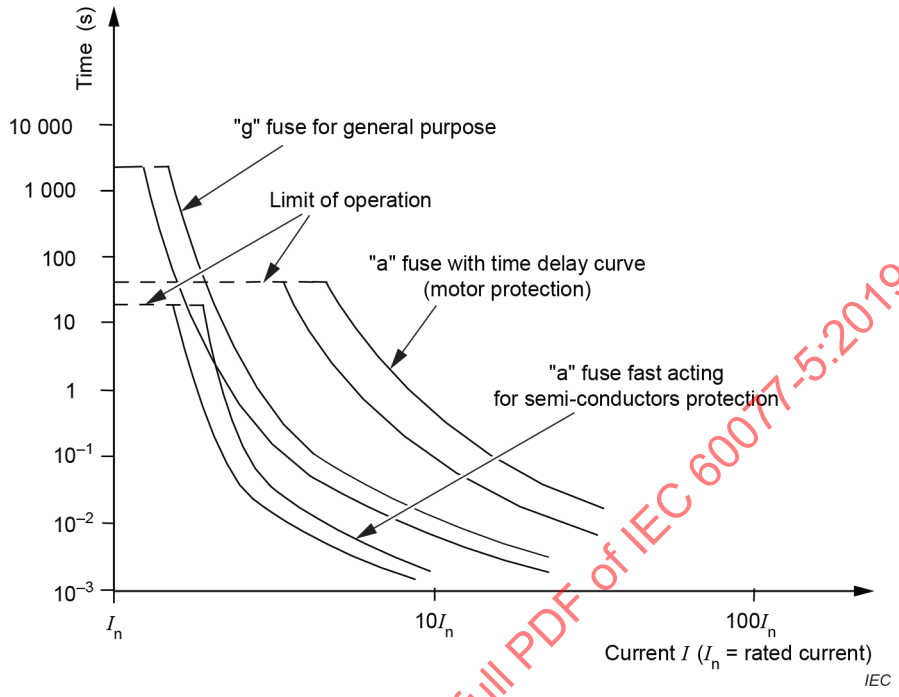
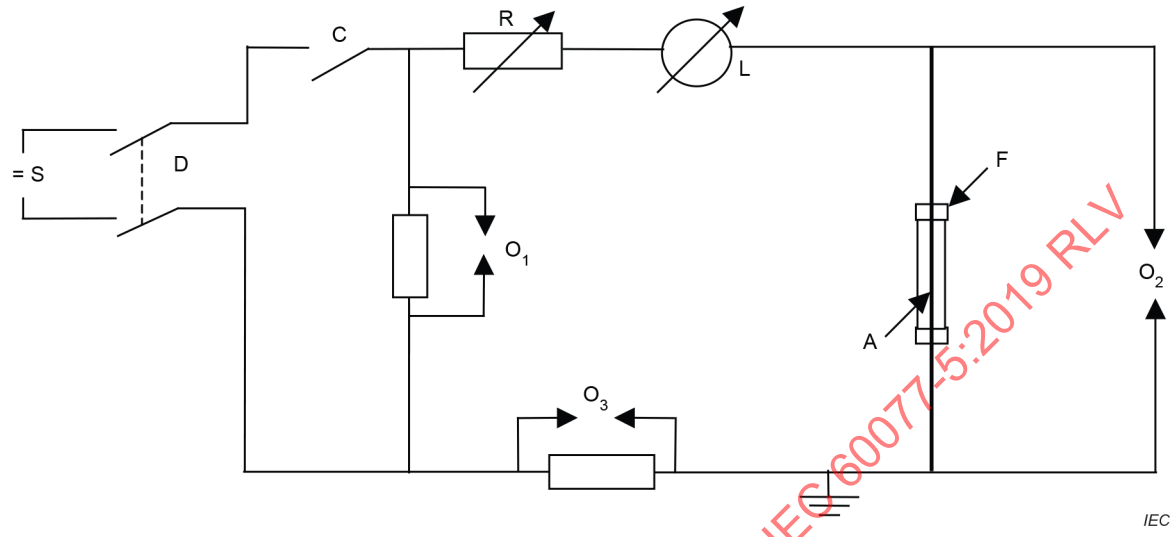


Figure B.1 – Comparison between “a” and “g” fuse time current characteristics

Annex C
(informative)

Diagram of the test circuit for breaking capacity tests



Key

S AC/DC power source
C making switch
R adjustable resistor
L adjustable inductor
A removable link for calibration
O_1 source voltage measurement
O_2 arc and recovery voltage measurement
O_3 current measurement
F fuse-link/fuse under test
D protective device for source

Figure C.1 – Diagram of the test circuit for breaking capacity tests

Annex D
(informative)

Verification of breaking capacity

This annex gives examples of oscillograms which are recorded during the calibration of the circuit and breaking operation of the fuse.

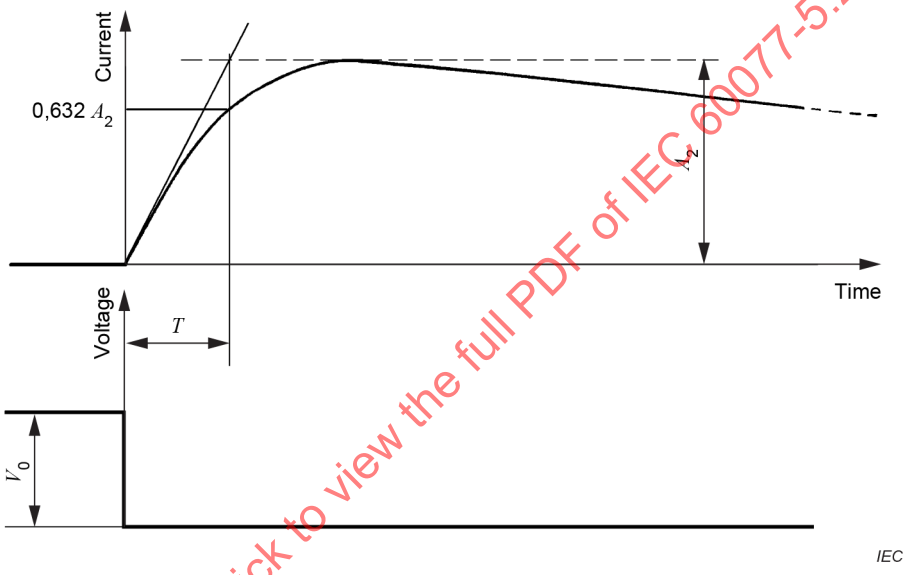
A_1 breaking current;

A_2 prospective peak current;

T time constant;

V_0 test voltage;

B_1, B_2 recovery voltage.



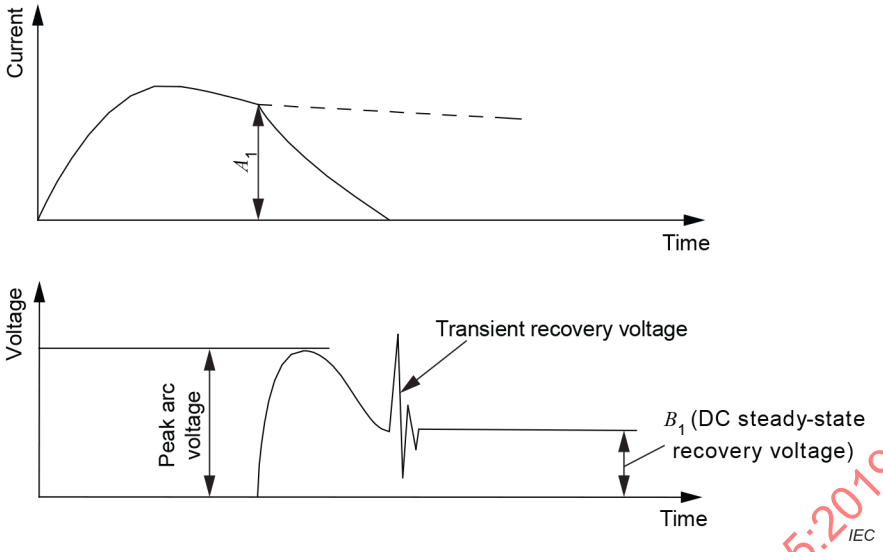
Key

A_2 prospective peak current

T time constant

V_0 test voltage

Figure D.1 – Test circuit calibration

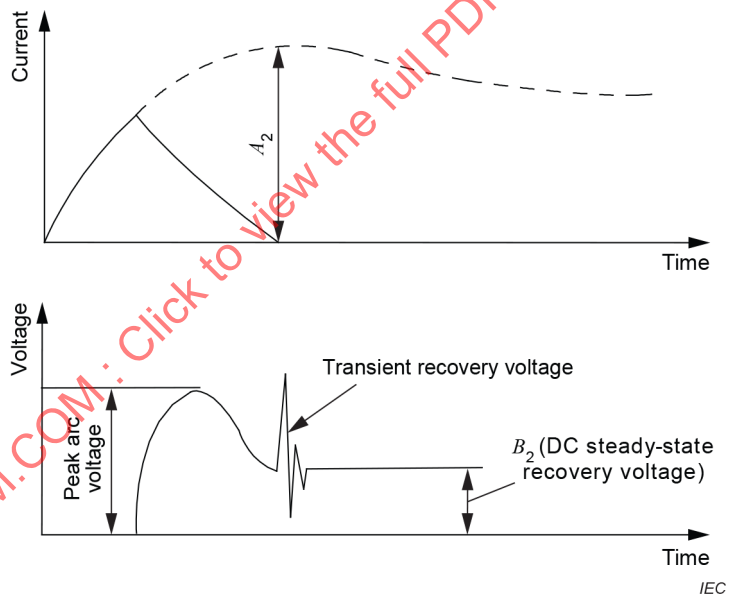


Key

A_1 breaking current

B_1 recovery voltage

Figure D.2 – Breaking operation when the instant of arc initiation is after the peak value of the current



Key

A_2 prospective peak current

B_2 recovery voltage

Figure D.3 – Breaking operation when the instant of arc initiation is prior to the peak value of the current

Bibliography

IEC 60050-441:1984, *International Electrotechnical Vocabulary (IEV) – Part 441: Switchgear, controlgear and* fuses
IEC 60050-441:1984/AMD1:2000

IEC 60050-811:2017, *International Electrotechnical Vocabulary (IEV) – Part 811: Electric traction*

IEC 60850, *Railway applications – Supply voltages of traction systems*

_____

SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

_____

APPLICATIONS FERROVIAIRES – ÉQUIPEMENTS ÉLECTRIQUES DU MATÉRIEL ROULANT –

Partie 5: Composants électrotechniques – Règles pour les fusibles à haute tension

AVANT-PROPOS

1) La Commission Electrotechnique Internationale (IEC) est une organisation mondiale de normalisation composée de l'ensemble des comités électrotechniques nationaux (Comités nationaux de l'IEC). L'IEC a pour objet de favoriser la coopération internationale pour toutes les questions de normalisation dans les domaines de l'électricité et de l'électronique. A cet effet, l'IEC – entre autres activités – publie des Normes internationales, des Spécifications techniques, des Rapports techniques, des Spécifications accessibles au public (PAS) et des Guides (ci-après dénommés «Publication(s) de l'IEC»). Leur élaboration est confiée à des comités d'études, aux travaux desquels tout Comité national intéressé par le sujet traité peut participer. Les organisations internationales, gouvernementales et non gouvernementales, en liaison avec l'IEC, participent également aux travaux. L'IEC collabore étroitement avec l'Organisation Internationale de Normalisation (ISO), selon des conditions fixées par accord entre les deux organisations.
2) Les décisions ou accords officiels de l'IEC concernant les questions techniques représentent, dans la mesure du possible, un accord international sur les sujets étudiés, étant donné que les Comités nationaux de l'IEC intéressés sont représentés dans chaque comité d'études.
3) Les Publications de l'IEC se présentent sous la forme de recommandations internationales et sont agréées comme telles par les Comités nationaux de l'IEC. Tous les efforts raisonnables sont entrepris afin que l'IEC s'assure de l'exactitude du contenu technique de ses publications; l'IEC ne peut pas être tenue responsable de l'éventuelle mauvaise utilisation ou interprétation qui en est faite par un quelconque utilisateur final.
4) Dans le but d'encourager l'uniformité internationale, les Comités nationaux de l'IEC s'engagent, dans toute la mesure possible, à appliquer de façon transparente les Publications de l'IEC dans leurs publications nationales et régionales. Toutes divergences entre toutes Publications de l'IEC et toutes publications nationales ou régionales correspondantes doivent être indiquées en termes clairs dans ces dernières.
5) L'IEC elle-même ne fournit aucune attestation de conformité. Des organismes de certification indépendants fournissent des services d'évaluation de conformité et, dans certains secteurs, accèdent aux marques de conformité de l'IEC. L'IEC n'est responsable d'aucun des services effectués par les organismes de certification indépendants.
6) Tous les utilisateurs doivent s'assurer qu'ils sont en possession de la dernière édition de cette publication.
7) Aucune responsabilité ne doit être imputée à l'IEC, à ses administrateurs, employés, auxiliaires ou mandataires, y compris ses experts particuliers et les membres de ses comités d'études et des Comités nationaux de l'IEC, pour tout préjudice causé en cas de dommages corporels et matériels, ou de tout autre dommage de quelque nature que ce soit, directe ou indirecte, ou pour supporter les coûts (y compris les frais de justice) et les dépenses découlant de la publication ou de l'utilisation de cette Publication de l'IEC ou de toute autre Publication de l'IEC, ou au crédit qui lui est accordé.
8) L'attention est attirée sur les références normatives citées dans cette publication. L'utilisation de publications référencées est obligatoire pour une application correcte de la présente publication.
9) L'attention est attirée sur le fait que certains des éléments de la présente Publication de l'IEC peuvent faire l'objet de droits de brevet. L'IEC ne saurait être tenue pour responsable de ne pas avoir identifié de tels droits de brevets et de ne pas avoir signalé leur existence.

La Norme internationale IEC 60077-5 a été établie par le comité d'études 9 de l'IEC: Matériels et systèmes électriques ferroviaires.

Cette deuxième édition annule et remplace la première édition, parue en 2003. Elle constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) révision de la méthode d'essai des conditions d'essai III pour la vérification du pouvoir de coupure.

Le texte de cette Norme internationale est issu des documents suivants:

FDIS	Rapport de vote
9/2539/FDIS	9/2555/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette Norme internationale.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

Il convient qu'il soit lu conjointement avec l'IEC 60077-1 et l'IEC 60077-2.

Une liste de toutes les parties de la série IEC 60077, publiées sous le titre général *Applications ferroviaires – Équipements électriques du matériel roulant*, peut être consultée sur le site web de l'IEC.

Le comité a décidé que le contenu de ce document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous «http://webstore.iec.ch» dans les données relatives au document recherché. A cette date, le document sera

- reconduit,
- supprimé,
- remplacé par une édition révisée, ou
- amendé.

APPLICATIONS FERROVIAIRES – ÉQUIPEMENTS ÉLECTRIQUES DU MATÉRIEL ROULANT –

Partie 5: Composants électrotechniques – Règles pour les fusibles à haute tension

1 Domaine d'application

L'objet de la présente partie de l'IEC 60077 est de fournir des règles complémentaires ou amendées pour les fusibles à haute tension, en plus de celles données dans l'IEC 60077-2.

NOTE 1 Dans le présent document, le terme fusible à haute tension est utilisé dans le contexte des tensions utilisées dans le domaine du matériel roulant pour le chemin de fer.

Les fusibles à haute tension concernés sont connectés dans les circuits de puissance et/ou auxiliaires. La tension nominale de ces circuits est située entre 600 V CC et 3 000 V CC, conformément à l'IEC 60850. Ces fusibles peuvent également être utilisés dans des circuits auxiliaires à courant alternatif jusqu'à une tension nominale de 1 500 V.

NOTE 2 Certaines de ces règles, après accord entre l'utilisateur et le constructeur, sont utilisées pour les fusibles installés dans des véhicules autres que ceux du matériel roulant ferroviaire, comme par exemple des locomotives de mine, des trolleybus, etc.

En complément de l'IEC 60077-2, le présent document précise particulièrement:

a) les caractéristiques des fusibles;

b) les conditions de service que les fusibles supportent du point de vue:
   - du fonctionnement et du comportement en service normal;
   - du fonctionnement et du comportement en cas de court-circuit;
   - des propriétés diélectriques.

c) les essais destinés à vérifier la conformité du fusible avec les caractéristiques dans les conditions de service ainsi que les méthodes à adopter pour ces essais;

d) les informations données avec ou marquées sur le fusible.

Le présent document ne couvre pas le montage en parallèle des fusibles.

Durant la préparation du présent document, l'IEC 60269-1 et l'IEC 60282-1 ont été consultées et leurs exigences ont été conservées dans la mesure du possible.

Le présent document fait référence aux règles générales pour les composants électrotechniques données dans l'IEC 60077-2, mais en ce qui concerne les conditions générales, il se réfère directement à l'IEC 60077-1.

2 Références normatives

Les documents suivants cités dans le texte constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60077-1:2017, *Applications ferroviaires – Equipements électriques du matériel roulant – Partie 1: Conditions générales de service et règles générales*

IEC 60077-2:2017, *Applications ferroviaires – Equipements électriques du matériel roulant – Partie 2: Composants électrotechniques – Règles générales*

IEC 60269-1:2006, *Fusibles basse tension – Partie 1: Exigences* générales
IEC 60269-1:2006/AMD1:2009
IEC 60269-1:2006/AMD2:2014

IEC 60282-1:2009, *Fusibles à haute tension – Partie 1: Fusibles limiteurs de courant*
IEC 60282-1:2009/AMD1:2014

IEC 61373, *Applications ferroviaires – Matériel roulant – Essais de chocs et vibrations*

ISO 3, *Nombres normaux – Séries de nombres normaux*

3 Termes, définitions et termes abrégés

Pour les besoins du présent document, les termes et définitions donnés à l'Article 3 de l'IEC 60077-1:2017, et à l'Article 3 de l'IEC 60077-2:2017, ainsi que les suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse http://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse http://www.iso.org/obp

3.1 Composants

NOTE Pour la terminologie applicable aux fusibles, voir également Figure 1 de l'IEC 60282-1:2009/AMD1:2014.

3.1.1
fusible
appareil dont la fonction est d'ouvrir par la fusion d'un ou de plusieurs de ses éléments conçus et calibrés à cet effet le circuit dans lequel il est inséré en coupant le courant lorsque celui-ci dépasse pendant un temps suffisant une valeur donnée

Note 1 à l'article: Le fusible comprend toutes les parties qui constituent l'appareil complet.

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-01, modifié – La seconde phrase a été convertie en NOTE 1 à l'article.]

3.1.2
élément de remplacement
partie d'un fusible comprenant le (les) élément(s) fusible(s) et destinée à être remplacée après fonctionnement du fusible

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-09]

3.1.3
élément fusible
partie de l'élément de remplacement destiné à fondre sous l'action d'un courant dépassant une valeur déterminée pendant une durée déterminée

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-08]

3.1.4
socle
partie fixe d'un fusible munie de contacts et de bornes

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-02]

3.1.5
dispositif indicateur <d'un fusible>
partie d'un fusible destinée à indiquer si celui-ci a fonctionné

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-17]

3.1.6
fusible de type boîte ouverte
fusible installé dans une boîte ouverte équipée d'une boîte de soufflage afin de réduire l'arc rapidement

3.1.7
série homogène <d'éléments de remplacement>
série d'éléments de remplacement dont chacun ne diffère de l'autre que par des caractéristiques telles que, pour un essai donné, l'essai d'un ou d'un nombre réduit d'éléments de remplacement déterminés de la série puisse être considéré comme représentatif de tous les éléments de remplacement de la série

Note 1 à l'article: Les publications particulières spécifient les caractéristiques par lesquelles les éléments de remplacement d'une série homogène peuvent différer les uns des autres, les éléments de remplacement spécifiques à soumettre à l'essai et l'essai particulier à considérer.

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-34]

3.2 Caractéristiques d'exploitation

3.2.1
courant présumé <d'un circuit et relatif à un appareil de connexion ou à un fusible>
courant qui circulerait dans le circuit si chaque pôle de l'appareil de connexion ou le fusible était remplacé par un conducteur d'impédance négligeable

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-17-01, modifié – La NOTE a été supprimée.]

3.2.2
valeur de crête du courant présumé
valeur de crête d'un courant présumé pendant la période transitoire qui suit son établissement

Note 1 à l'article: Ce terme est communément associé aux conditions de court-circuit.

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-17-02, modifié – La NOTE à l'article a été remplacée.]

3.2.3
durée de préarc
intervalle de temps qui s'écoule à partir du moment où commence à circuler un courant suffisant pour provoquer une coupure dans le ou les éléments fusibles jusqu'à l'instant où un arc commence à se former

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-21]

3.2.4
durée d'arc <d'un pôle ou d'un fusible>
intervalle de temps entre l'instant de début de l'arc sur un pôle ou sur un fusible et l'instant de l'extinction finale de l'arc sur ce pôle ou ce fusible

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-17-37]

3.2.5
durée de fonctionnement
somme de la durée de préarc et de la durée d'arc

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-22]

3.2.6
tension d'arc <d'un fusible>
valeur instantanée de tension qui apparaît entre les bornes d'un fusible pendant la durée de l'arc

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-30]

3.2.7
tension d'arc <d'un fusible> <en valeur de crête>
valeur maximale instantanée de tension qui, dans des conditions prescrites, apparaît entre les bornes d'un fusible pendant la durée d'arc

Note 1 à l'article: Après l'extinction de l'arc, une surtension (tension transitoire de rétablissement) peut apparaître aux bornes du fusible. Sa valeur dépend des caractéristiques du circuit et de celles du fusible. Cette surtension n'est pas prise en compte dans la tension d'arc en valeur de crête (voir Figure D.2 et Figure D.3).

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-17-30, modifié – «pôle d'un appareil de connexion» a été remplacé par «fusible». La Note 1 à l'article a été ajoutée.]

3.2.8
tension de rétablissement en courant continu en régime établi
tension de rétablissement dans un circuit à courant continu après la disparition des phénomènes transitoires de tension, exprimée par sa valeur moyenne s'il y a des ondulations

Note 1 à l'article: Ceci est représenté par B_1 et B_2 à la Figure D.2 et la Figure D.3.

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-17-28, modifié – La NOTE 1 à l'article a été ajoutée.]

3.2.9
courant coupé limité
valeur instantanée maximale du courant atteinte au cours du fonctionnement d'un fusible

3.2.10
intégrale de Joule
I*²*t
intégrale du carré du courant pour un intervalle de temps donné:

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

Note 1 à l'article: L'I^2t de préarc est l'intégrale I^2t pour la durée de préarc du fusible.

Note 2 à l'article: L'I^2t de fonctionnement est l'intégrale I^2t pour la durée de fonctionnement du fusible.

Note 3 à l'article: L'énergie en joules libérée dans une portion ayant une résistance de un ohm d'un circuit protégé par un fusible est égale à la valeur de I^2t de fonctionnement exprimée en A^2s.

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-23]

3.2.11
caractéristique temps-courant
courbe donnant la durée, par exemple durée de préarc ou durée de fonctionnement, en fonction du courant présumé dans des conditions déterminées de fonctionnement

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-17-13]

3.2.12
courant conventionnel de non-fusion
valeur spécifiée du courant que peut supporter sans fondre l'élément de remplacement pendant un intervalle de temps spécifié, dit temps conventionnel

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-27]

3.2.13
courant conventionnel de fusion
valeur spécifiée qui provoque le fonctionnement de l'élément de remplacement avant la fin d'un intervalle de temps spécifié dit temps conventionnel

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-28]

3.2.14
valeur assignée
valeur d'une grandeur, utilisée à des fins de spécification, correspondant à un ensemble spécifié de conditions de fonctionnement d'un composant, dispositif, matériel ou système

Note 1 à l'article: Les valeurs assignées généralement définies pour les fusibles sont la tension, le courant, le pouvoir de coupure et la puissance dissipée.

[SOURCE: IEC 60050-151:2001, 151-16-08, modifié – La NOTE 1 à l'article a été ajoutée.]

4 Classification

4.1 Zone de coupure

Les éléments de remplacement sont classés de la façon suivante:

a) élément de remplacement «g»: avec un pouvoir de coupure pour toutes les surcharges, c'est-à-dire capable de couper, dans des conditions spécifiées, tous les courants provoquant la fonte de l'élément fusible jusqu'à son pouvoir de coupure assigné;

b) élément de remplacement «a»: avec un pouvoir de coupure partiel, c'est-à-dire capable de couper, dans des conditions spécifiées, tous les courants depuis son pouvoir de coupure minimal jusqu'à son pouvoir de coupure assigné. Il peut être utilisé en association avec un autre appareil de connexion lorsque la protection est exigée contre les surcharges inférieures à son pouvoir de coupure minimal.

NOTE 1 La comparaison des caractéristiques temps-courant des fusibles «a» et «g» est donnée dans la Figure B.1 de l'Annexe B.

NOTE 2 Les éléments de remplacement «a» de protection peuvent par exemple être utilisés pour protéger les dispositifs à semiconducteur, les moteurs, etc.

4.2 Catégorie d'utilisation

Les éléments de remplacement peuvent être classés par catégories, suivant qu'ils sont soumis, en conditions normales de service, à:

– des valeurs de courant qui n'excèdent pas leur valeur assignée permanente;

– des valeurs de courant qui, pendant de brèves périodes, excèdent régulièrement leur valeur assignée permanente, comme cela se produit lors du démarrage d'une machine rotative;
– des valeurs de courant qui n'excèdent pas leur valeur assignée permanente, mais qui sont commutées ou qui changent sensiblement et fréquemment;

ou qu'ils doivent fournir une protection particulière comme, par exemple:

– la protection des semiconducteurs, pour lesquels un fonctionnement rapide est exigé pour limiter le courant coupé limité et l'$I2t$ de fonctionnement;
– a nécessité d'un fonctionnement retardé.

5 Caractéristiques

Les caractéristiques d'un fusible doivent être définies en ce qui concerne:

– la (les) tension(s) assignée(s) en courant continu et/ou alternatif;
– le courant assigné (I_n);
– la fréquence assignée;
– le pouvoir de coupure assigné;
– la zone de coupure;
– la puissance dissipée assignée;
– la caractéristique temps-courant. Les temps et courants conventionnels pour les éléments de remplacement «g» sont donnés dans le Tableau 1;
– la capacité de surcharge;
– les caractéristiques I^2t (I^2t minimale de préarc et I^2t maximale de fonctionnement);
– le courant coupé limité relatif au courant présumé et à la constante de temps;
– les facteurs de correction du courant assigné en fonction de la température ambiante;
– la valeur de crête de la tension d'arc relative à la tension de fonctionnement;
– la tension d'isolement assignée (U_{Nm}) pour les socles;
– la tension assignée de choc (U_{Ni}) pour les socles.

Quand elles sont représentées graphiquement, les caractéristiques I^2t doivent être tracées avec le courant présumé en abscisse et les valeurs d'I^2t en ordonnée. Des échelles logarithmiques doivent être utilisées pour les deux axes de coordonnées.

Tableau 1 – Temps conventionnels pour les éléments de remplacement «g»

Courant assigné A	Temps spécifié (temps conventionnel) h
$I_n \leq 63$	1
$63 < I_n \leq 160$	2
$160 < I_n \leq 400$	3
$I_n > 400$	4

6 Informations sur le produit

6.1 Documentation

Les informations doivent être données dans le catalogue ou le manuel du constructeur.

Le Paragraphe 6.1 de l'IEC 60077-2:2017 s'applique, avec les informations complémentaires suivantes:

– tension assignée;
– courant assigné;
– pouvoir de coupure assigné et constante de temps;
– utilisation recommandée (voir 4.2);
– caractéristiques I^2t (I^2t minimale de préarc et I^2t maximale de fonctionnement);
– facteurs de correction du courant assigné en fonction de la température ambiante, de la charge variable ou de la surcharge;
– dimensions;
– instructions spéciales de stockage, d'installation et de maintenance, si applicable.

6.2 Marquage

Les éléments de remplacement et les socles doivent posséder des plaques lisibles et durables ou des marquages gravés en accord avec 6.2 de l'IEC 60077-2:2017.

Concernant les fusibles de type boîte ouverte, les plaques ou marquages gravés doivent être placés sur la boîte.

Le marquage de l'élément de remplacement et du socle doit comprendre les données suivantes:

– nom ou sigle du constructeur;
– désignation du type selon le constructeur;
– tension assignée (en courant continu et/ou alternatif);
– courant assigné.

7 Conditions normales de service

Ces conditions sont données à l'Article 7 de l'IEC 60077-1:2017.

8 Exigences relatives à la construction et au fonctionnement

8.1 Exigences relatives à la construction

8.1.1 Généralités

En complément des exigences de 8.1 de l'IEC 60077-2:2017, le fusible doit satisfaire aux exigences suivantes.

8.1.2 Elément de remplacement

L'élément de remplacement doit être suffisamment robuste pour éviter tout dommage au milieu environnant, par exemple par un arc permanent, un amorçage ou une éjection de flammes ou de matières durant son fonctionnement.

NOTE 1 Pour plus d'informations, voir 8.5.8 de l'IEC 60269-1:2006/AMD1:2009/AMD2:2014.

Il doit être possible de remplacer facilement l'élément de remplacement.

NOTE 2 Pour plus d'informations sur le remplacement, voir 7.1.1 de l'IEC 60269-1:2006/AMD1:2009/AMD2:2014.

8.1.3 Socle

Le socle doit comporter des contacts qui assurent des connexions acceptables à l'élément de remplacement dans toutes les conditions de cycles thermiques, vibration et choc durant le service normal, et durant l'application de forces électrodynamiques lorsque l'élément de remplacement interrompt des surcharges ou des courants de court-circuit jusqu'à son pouvoir de coupure assigné.

8.1.4 Contacts élastiques

Quand le socle comporte des contacts élastiques pour la connexion électrique et la rétention mécanique de l'élément de remplacement, ces contacts doivent supporter 100 cycles d'insertion–extraction de l'élément de remplacement sans détérioration des propriétés électriques et mécaniques.

8.1.5 Bornes

Les bornes de connexion externe du socle doivent assurer une force de serrage constante indépendante des variations du courant qui les traverse. Elles doivent être capables de supporter des connexions et déconnexions multiples des conducteurs externes sans détérioration. Les tiges filetées des bornes doivent avoir la dimension minimale M5.

Les bornes doivent être telles qu'elles ne puissent pas tourner ou être déplacées lors du serrage des vis de connexion, et telles que les conducteurs ne puissent pas être déplacés.

Les parties enserrant les conducteurs doivent être métalliques et doivent avoir une forme telle qu'ils n'endommagent pas indument les conducteurs.

Aucune force de contact ne doit être transmise aux connexions à travers un matériau isolant autre que la céramique ou un autre matériau de caractéristique mécanique au moins équivalente.

NOTE Pour plus d'informations, voir 7.1.2 de l'IEC 60269-1:2006/AMD1:2009/AMD2:2014.

8.2 Exigences relatives au fonctionnement

8.2.1 Conditions de fonctionnement

Ces exigences sont données en 8.2.1 de l'IEC 60077-2:2017.

8.2.2 Températures limites

Ces exigences sont données en 8.2.2 de l'IEC 60077-2:2017.

8.2.3 Propriétés diélectriques

Les exigences relatives aux distances d'isolement dans l'air sont données en 8.2.6 de l'IEC 60077-1:2017.

Les exigences relatives aux lignes de fuite sont données en 8.2.7 de l'IEC 60077-1:2017.