IEC 60077-3

Edition 2.0 2019-10

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Railway Applications – Electric equipment for rolling stock –
Part 3: Electrotechnical components – Rules for DC circuit-breakers

Applications ferroviaires – Équipements électriques du matériel roulant –
Partie 3: Composants électrotechniques – Règles pour disjoncteurs à courant continu

IEC 60077-3:2019-10(en-fr)

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 It also gives information on projects, replaced and withdrawn publications.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.

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

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

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

IEC Just Published - webstore.iec.ch/justpublished
Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

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

Electropedia - www.electropedia.org
Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 000 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 16 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

Glossaire IEC - std.iec.ch/glossary
67 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.

IEC 60077-3

Edition 2.0 2019-10

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Railway Applications – Electric equipment for rolling stock – Part 3: Electrotechnical components – Rules for DC circuit-breakers

Applications ferroviaires – Équipements électriques du matériel roulant – Partie 3: Composants électrotechniques – Règles pour disjoncteurs à courant continu

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

ICS 45.060.01

ISBN 978-2-8322-7507-8

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

**RAILWAY APPLICATIONS –
ELECTRIC EQUIPMENT FOR ROLLING STOCK –**

**Part 3: Electrotechnical components –
Rules for DC circuit-breakers**

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 60077-3 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 2001. It constitutes a technical revision.

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

a) procedure of verification of temperature rise is changed;
b) air-tightness test as type test, insulation resistance measurement are added.

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

FDIS	Report on voting
9/2537/FDIS	9/2553/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 3: Electrotechnical components – Rules for DC circuit-breakers

1 Scope

In addition to the general requirements of IEC 60077-2, this part of IEC 60077 gives the rules for circuit-breakers, the main contacts of which are connected to DC power and/or auxiliary circuits. The nominal voltage of these circuits does not exceed 3 000 V DC according to IEC 60850.

This part of IEC 60077, together with IEC 60077-2, states specifically:

a) the characteristics of the circuit-breakers;

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

c) the tests for confirming the compliance of the components 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 circuit breaker.

NOTE 1 Circuit-breakers which are dealt with in this document can be provided with devices for automatic opening under predetermined conditions other than those of overcurrent, for example, under-voltage and reversal of power flow direction. This document does not deal with the verification of operation under such predetermined conditions.

NOTE 2 The incorporation of electronic components or electronic sub-assemblies into electrotechnical components is now common practice.

Although this document is not applicable to electronic equipment, the presence of electronic components does not provide a reason to exclude such electrotechnical components from the scope.

Electronic sub-assemblies included in circuit-breakers comply with the relevant document for electronics (IEC 60571).

NOTE 3 Certain of these rules, after agreement between the user and the manufacturer, are used for electro-technical components installed on vehicles other than rail rolling stock such as mine locomotives, trolleybuses, etc. In this case, particular additional requirements can be necessary.

This document does not cover:

e) multi-connection of electro-technical components to achieve a particular duty;

f) industrial circuit-breakers which complies with IEC 60947-2;

g) DC circuit-breakers for fixed installations which complies with IEC 61992-2.

For f) and g), in order to ensure satisfactory operation, this document is used to specify only the particular requirements for rolling stock. In such cases, a specific document states the additional requirements with which the industrial or fixed installations circuits breakers comply, for example:

- either to be adapted (for example, for control voltage, environmental conditions, etc.);
- or to be installed and used in such a way that they do not have to endure specific rolling stock conditions;

– or to be additionally tested to prove that these components can withstand satisfactorily the rolling stock conditions.

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

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

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

3.1.1
polarized circuit-breaker
circuit-breaker for which the breaking characteristics are defined for only one prescribed direction of current in the main circuit

3.1.2
bi-directional circuit-breaker
circuit-breaker for which the breaking characteristics are the same for both directions of current in the main circuit

3.1.3
air circuit-breaker
circuit-breaker in which the contacts open and close in air at atmospheric pressure

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-14-27]

3.1.4
vacuum circuit-breaker
circuit-breaker in which the contacts open and close within a highly evacuated envelope

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-14-29]

3.1.5
semiconductor circuit-breaker
circuit-breaker designed to make and break the current in an electric circuit by means of the controlled conductivity of a semiconductor

Note 1 to entry: There can be mechanical contacts associated with these semiconductor devices.

[SOURCE: IEC 60050-811:2017, 811-29-42]

3.1.6
hybrid circuit-breaker
circuit-breaker with mechanical contacts for isolation associated with a semiconductor for switching

Note 1 to entry: Semiconductor circuit-breakers without mechanical isolation are not used on rolling stock.

3.2 Component parts

3.2.1
release, <for a circuit-breaker>
device which releases the holding means and permits the opening or closing of the circuit-breaker

Note 1 to entry: A circuit-breaker can be activated by several releases each becoming operational according to specified conditions.

Note 2 to entry: These releases can be mechanically or electrically connected to the switching device.

[SOURCE: IEC 60050-811:2017, 811-29-44]

3.2.2
overcurrent release
release which permits a mechanical switching device to open with or without time-delay when the current in the release exceeds a predetermined value

Note 1 to entry: This value can in some cases depend upon the rate-of-rise of current.

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-16-33]

3.2.3
direct overcurrent release
overcurrent release directly energized by the current in the main circuit of a mechanical switching device

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-16-36]

3.2.4
indirect overcurrent release, <for a circuit-breaker>
overcurrent release initiated by the current in the main circuit of a mechanical switching device through a current sensor

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-16-37, modified – "energized" and "a current transformer or a shunt" have been replaced with "initiated" and "a current sensor".]

3.2.5
anti-pumping device
device which prevents reclosing after a close-open operation as long as the device initiating closing is maintained in the position for closing

Note 1 to entry: The opening operation may be either an opening command or a tripping operation.

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-16-48, modified – Note 1 to entry has been added.]

3.2.6
enclosure, <of an assembly>
part of an assembly providing a specified degree of protection of equipment against external influences and a specified degree of protection against approach to or contact with live parts and against contact with moving parts

Note 1 to entry: The enclosure may also provide a protection of adjacent parts against the influence of the circuit-breaker (for example, arcing).

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-13-01, modified – Note 1 to entry has been added.]

3.2.7
integral enclosure
enclosure forming an integral part of the circuit-breaker

3.3 Operational features

3.3.1
current-limiting circuit-breaker
circuit-breaker with a break-time short enough to prevent the short-circuit current reaching its otherwise attainable peak value

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-14-21]

3.3.2
trip-free circuit-breaker

circuit-breaker in which the moving contacts return to and remain in the open position when the tripping operation is initiated after the initiation of the closing operation, even if the closing command is maintained

Note 1 to entry: To ensure proper breaking of the current which may have been established, it may be necessary that the contacts momentarily reach the closed position.

[SOURCE: IEC 61992-1:2006/AMD1:2014, 3.4.11]

3.3.3
current setting, <of an overcurrent release>
value of the operating current for which the release is adjusted and in accordance with which its operating conditions are defined

Note 1 to entry: A release may have more than one current setting.

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-16-46, modified – Note 1 to entry has been added.]

3.3.4
current setting range, <of an overcurrent release>
range between the minimum and maximum values over which the current setting of the release can be adjusted

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-16-47]

3.3.5
tripping operation
opening operation of a circuit-breaker initiated by a release

3.4 Breaking characteristics

3.4.1
opening time, <of a mechanical switching device>
interval of time between the specified instant of initiation of the opening operation and the instant when the arcing contacts have separated in all poles

Note 1 to entry: The instant of initiation of the opening operation is specified by the manufacturer for all the opening commands other than overcurrent.

Note 2 to entry: The opening time includes the operating time of any auxiliary equipment necessary to open the circuit-breaker and forming an integral part of the circuit-breaker.

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-17-36, modified – Note 1 to entry has been modified and Note 2 to entry has been added.]

3.4.2
overcurrent opening time
interval of time between the instant when the current in the main circuit reaches the current setting value of the overcurrent release and the instant when the arcing contacts have separated

3.4.3
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

Note 1 to entry: This term is commonly associated with fault conditions.

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

3.4.4
prospective peak current
peak value of a prospective current during the transient period following initiation

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

3.4.5
prospective breaking current, <for a pole of a switching device or a fuse>
prospective current evaluated at a time corresponding to the instant of the initiation of the breaking process

Note 1 to entry: The instant of initiation of the breaking process is usually defined as the beginning of the arc.

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-17-06, modified – Note 1 to entry has been replaced.]

3.4.6
cut-off current
maximum instantaneous value of current attained during the breaking operation of a switching device or a fuse

Note 1 to entry: This concept is of particular importance when the switching device or the fuse operates in such a manner that the prospective peak current of the circuit is not reached.

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-17-12, modified – In note 1 to entry "is" has been added between "concept" and "of particular".]

3.4.7
recovery voltage
voltage which appears across the terminals of a pole of a switching device or a fuse after the breaking of the current

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-17-25, modified – Note has been deleted.]

3.4.8
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]

3.4.9
break-time
interval of time between the beginning of the opening time of a mechanical switching device (or the pre-arcing time of a fuse) and the end of the arcing time

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-17-39]

3.4.10
joule integral, <for a circuit-breaker>
I^2t

integral of the square of the current in a circuit-breaker during a breaking process, over the break-time

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

t_0 = beginning of the opening time

t_1 = end of the arcing time

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-23, modified – "in a circuit-breaker during a breaking process," has been added. "a given time interval" has been replaced with "the break-time". Notes have been deleted, keys for t_0 and t_1 have been added.]

3.4.11
I^2t characteristic, <for a circuit-breaker>
information (generally a curve) giving the value of I^2t as a function of the prospective peak current for specified conditions such as the current setting of the release, the time constant of the test circuit, etc.

[SOURCE: IEC 60050-441:1984/AMD1:2000, 441-18-24, modified – "information (generally a curve) giving" has been added. "under prescribed conditions" has been deleted. "prospective current and/or voltage" has been replaced with "the prospective peak current ...". Note has been deleted.]

3.4.12
break-time – current characteristic
curve giving the break-time as a function of the prospective peak current for specified conditions such as the current setting of the release, the time constant of the test circuit, etc.

3.4.13
cut-off current characteristic, <for a circuit-breaker>
curve giving the cut-off current as a function of the prospective peak current for specified conditions such as the current setting of the release, the time constant of the test circuit, etc.

[SOURCE: IEC 60050-811:2017, 811-29-43, modified – "peak", "such" and ", etc." have been added.]

3.4.14
initial current rate of rise
d*i*/d*t*
rate of rate of rise at the beginning of the current flow

[SOURCE: IEC 61992-1:2006/AMD1:2014, 3.2.27, modified – "current" has been added in the term and symbol has been added.]

3.5 Abbreviated terms

DC Direct Current

EMC Electromagnetic Compatibility

4 Classification

This clause is intended to list the characteristics of a circuit-breaker on which information is given by the manufacturer and which shall be verified by testing where relevant.

The circuit breakers are classified:

a) according to their operational frequency C1, C2 or C3. The characteristics of these operational frequencies are given in 5.4;
b) according to the type of design:
   – open construction;
   – construction with an integral enclosure;
c) according to the degree of protection provided by the enclosure (see IEC 60529).

5 Characteristics

5.1 List of characteristics

The characteristics of a circuit-breaker shall be stated as applicable, among those of the following:

– type of circuit-breaker (5.2);
– rated values and limiting values for the main circuit (5.3);
– operational frequencies (5.4);
– electric and pneumatic control circuits (5.5);
– electric and pneumatic auxiliary circuits (5.6);
– overcurrent release (5.7);
– peak arc voltages (5.8).

5.2 Type of circuit-breaker

It is necessary to state:

– the kind of device (for example, air circuit-breaker, vacuum circuit-breaker, hybrid circuit-breaker, bi-directional or polarized circuit-breaker);
– the type of design (see Clause 4);
– the degree of protection provided by the enclosure (see Clause 4);
– operational features (for example, current-limiting circuit-breaker, trip-free circuit-breaker).

5.3 Rated values and limiting values for the main circuit

5.3.1 General

Rated values are assigned by the manufacturer but it is not necessary to establish all the ratings listed.

5.3.2 Rated voltages

A component is defined by the following rated voltages given in 5.2 of IEC 60077-1:2017:

– rated operational voltage (U_r);

NOTE 1 Certain types of circuit-breakers have several rated operational voltages or have a rated operational voltage range.

– rated insulation voltage (U_{Nm});

NOTE 2 When no rated insulation voltage has been assigned to a circuit-breaker, the rated insulation voltage is considered to be equal to the highest value of the rated operational voltage.

– rated impulse voltage (U_{Ni});

– power-frequency test voltage (U_a).

5.3.3 Rated currents

A component is defined by the following rated currents given in 5.4 of IEC 60077-1:2017 and 5.3.3 of IEC 60077-2:2017:

– rated operational current (I_r) at the rated time constant $T2$ (see 5.3.4);

NOTE Certain types of circuit-breakers have several rated operational currents or have a rated operational current range.

– conventional free air thermal current (I_{th});

– conventional enclosed thermal current (I_{the}).

5.3.4 Rated time constants

The time constants for the circuit-breaker are dependent on the electrical characteristics of the substation, the line and the load.

The four time constants given in Table 1 shall be used by the manufacturer to determine the short-circuit breaking and making capacities stated in 5.3.5.

If necessary the time constant values may be defined by agreement between the manufacturer and the user.

Table 1 – Rated time constants

Rated operational voltage U_r V		900	1 800	3 600
Time constant $T1$ (minimum)	ms	0	0	0
Time constant $T2$	ms	15	15	15
Time constant $T3$	ms	50	40	30
Time constant $T4$	ms	150	100	50
NOTE A time constant of 0 ms signifies that for the tests the load is made up of resistors without any voluntary adding of inductance.				