IEC 60077-1

Edition 2.0 2017-07

REDLINE VERSION

colour inside

Railway applications – Electric equipment for rolling stock – Part 1: General service conditions and general rules



IEC 60077-1:2017-07 RLV(en)



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2017 IEC, Geneva, Switzerland

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

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
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 corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub

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 It also gives information on projects, replaced and withdrawn publications.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 also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing 20 000 terms and definitions 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

65 000 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 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: csc@iec.ch.

IEC 60077-1

Edition 2.0 2017-07

REDLINE VERSION

colour inside

Railway applications – Electric equipment for rolling stock – Part 1: General service conditions and general rules

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ICS 45.060.01

ISBN 978-2-8322-4694-8

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

® Registered trademark of the International Electrotechnical Commission

CONTENTS

FOREWORD 5
INTRODUCTION 7
1 Scope ~~and object~~ 8
2 Normative references 8
3 Terms, definitions and abbreviated terms (see also Annex A) 10
3.1 General 10
3.2 Circuits 10
3.3 Battery supplied equipment 11
3.4 Test categories 11
3.5 Characteristic quantities 12
3.6 Terms related to lifetime 13
~~3.7 Insulations ..... 14~~
3.7 Abbreviated terms 14
4 Classification 14
5 Characteristics of the utilization category 15
5.1 General 15
5.2 Rated voltages 15
5.2.1 General 15
5.2.2 Rated operational voltage (~~U_e~~ U_r) 15
5.2.3 Rated insulation voltage (~~U_i~~ U_{Nm}) 15
5.2.4 ~~Rated~~ Power-frequency ~~withstand~~ test voltage (~~U_{50}~~ U_a) 16
5.2.5 Rated impulse ~~withstand~~ voltage (~~U_{imp}~~ U_{Ni}) 16
5.3 Rated voltages for electric equipment 16
5.3.1 ~~Supply from~~ Equipment supplied by a contact line 16
5.3.2 ~~Supply from~~ Equipment supplied by a transformer 16
5.3.3 Equipment supplied by DC low voltage sources 17
5.4 Rated currents for equipment 18
5.4.1 Rated operational current (~~I_e~~ I_r) 18
5.4.2 Rated short-time withstand current (I_{cw}) 18
5.5 Rated operational frequency (f_r) 18
5.6 Rated air pressure 18
6 Product information 18
6.1 Nature of information 18
6.2 Marking 19
6.3 Instructions for storage, installation, operation and maintenance 19
7 Normal service conditions 20
7.1 General 20
7.2 Altitude 20
7.3 Temperature 20
7.3.1 Ambient ~~air~~ temperature ~~(T_a)~~ 20
7.3.2 Reference temperature 21
7.4 Humidity 22
7.5 Biological conditions 22
7.6 Chemically active substances 22
7.7 Mechanically active substances 22

7.8 Vibration and shock 22
7.9 Exposure to pollution 22
7.10 Exposure to overvoltages 23
8 Constructional and performance requirements 24
8.1 Constructional requirements 24
8.1.1 Protective provisions against electrical hazards 26
8.1.2 Batteries 26
8.1.3 Fire protection 26
8.1.4 Other risks 26
8.2 Performance requirements 26
8.2.1 Operating conditions 26
8.2.2 Temperature ~~rise~~ limits 28
8.2.3 Operation following inactivity 34
8.2.4 Electromagnetic compatibility (EMC) 35
8.2.5 Acoustic noise emission 35
8.2.6 Clearances 41
8.2.7 Creepage distances 41
8.2.8 Switching overvoltages 41
8.2.9 Operational performance 41
8.2.10 Ability to withstand vibration and shock 42
9 Tests 42
9.1 Kinds of tests 42
9.1.1 General 42
9.1.2 Type tests 42
9.1.3 Routine tests 43
9.1.4 Sampling tests 43
9.1.5 Investigation tests 43
9.1.6 General test condition 43
9.1.7 Summary of tests 44
9.2 Verification of constructional requirements 44
9.2.1 General 44
9.2.2 Type tests 44
9.2.3 Routine tests 45
9.3 Verification of performance requirements 45
9.3.1 Operating limits and functional tests 45
9.3.2 Temperature rise test 46
9.3.3 Dielectric properties 49
9.3.4 Operational performance capability 53
9.3.5 Vibration and shock 55
9.3.6 Electromagnetic compatibility (EMC) 55
9.3.7 Acoustic noise emission 55
9.3.8 Climatic tests 55
~~Annex A (normative) Measurement of creepage distances and clearances .....~~
Annex A (informative) Coordination between definitions 62
Annex B (informative) Type and routine test of dielectric tests for equipment 68
B.1 General 68
B.2 General conditions 68
B.3 Test voltage 68

~~Annex C (informative) Clearance and creepage determination~~

Annex C (informative) Example of thermal endurance calculation to demonstrate the suitability of an insulation system for a specified application 71

C.1 General 71

C.2 Example 1 – Temperature limits for an electric insulation system 71

C.3 Example 2 – Thermal endurance calculation 72

C.3.1 General 72

C.3.2 Operating conditions provided by the purchaser 72

C.3.3 Thermal endurance characteristics provided by the manufacturer 73

C.3.4 Temperature rise test results 73

C.3.5 Extrapolations 74

C.3.6 Lifetime calculation based on thermal endurance 74

C.3.7 Equivalent continuous duty and rated continuous duty 75

Bibliography 76

Figure A.1 – Example of relation of limiting values 64

Figure A.2 – Example of utilization category 64

Figure A.3 – Example of coordination of operational conditions 64

Table 1 – Voltage ranges for control circuits and auxiliary circuits 17

Table 2 – Classes of air temperatures 21

Table 3 – Temperature limits of electrical insulating system 32

~~Table 4 – Determination of rated impulse withstand voltage~~ .....

Table 4 – Temperature limits of terminals 33

~~Table 5 – Minimum clearances in air~~ .....

Table 5 – Temperature limits of accessible parts 34

~~Table 6a – Creepages for rated insulation voltages up to 1 000 V~~ .....

~~Table 6b – Creepages for rated insulation voltages above 1 000 V~~ .....

Table 6 – List of tests (as appropriate) 44

~~Table 7 – Test voltages for verification of clearances~~ .....

Table B.1 – Dielectric tests on single pieces of equipment 69

Table B.2 – Dielectric tests for equipment connected to AC contact line 70

Table C.1 – Temperature limits and expected lifetime for a dry-type insulation system (examples) 72

Table C.2 – Ambient temperature distribution 73

Table C.3 – Temperature rise test results 73

Table C.4 – Extrapolation to other ambient temperature 74

Table C.5 – Lifetime calculation based on thermal endurance 74

Table C.6 – Equivalent continuous duty and rated continuous duty 75

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

RAILWAY APPLICATIONS – ELECTRIC EQUIPMENT FOR ROLLING STOCK –

Part 1: General service conditions and general rules

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.

DISCLAIMER
This Redline version is not an official IEC Standard and is intended only to provide the user with an indication of what changes have been made to the previous version. Only the current version of the standard is to be considered the official document.

This Redline version provides you with a quick and easy way to compare all the changes between this standard and its 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 60077-1 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

This second edition cancels and replaces the first edition of IEC 60077-1, issued in 1999. It constitutes a technical revision.

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

a) Descriptions regarding insulation coordination, environmental conditions and those of current return and protective bonding are deleted and replaced by references to IEC 62497-1, IEC 62498-1 and IEC 61991, except classes of air temperature, which are copied from Table 2 in IEC 62498-1:2010.
b) Classification of equipment type is introduced.
c) Temperature limits and temperature rise tests are reviewed.
d) Example of lifetime calculation: Annex C (informative) is introduced.

The text of this standard is based on the following documents:

FDIS	Report on voting
9/2266/FDIS	9/2278/RVD

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

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

A list of all parts 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 publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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

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

INTRODUCTION

Although this document specifies the general service conditions and general rules for electric equipment for railway rolling stock, further ~~special~~ details ~~of~~ for certain types of ~~traction~~ electric equipment may be given in other IEC standards. ~~In particular, product standards give further details and the product standards to be part of the traction series are~~

~~IEC 60077: *Railway applications – Electric equipment for rolling stock*~~

IEC 60077 series consists of the following parts:

- Part 1 – General service conditions and general rules
- Part 2 – Electrotechnical components – General rules
- Part 3 – Electrotechnical components – Rules for DC circuit-breakers
- Part 4 – Electrotechnical components – Rules for AC circuit-breakers
- Part 5 – Electrotechnical components – Rules for HV fuses

Although all circuits of power or control electronic equipment connected to battery or contact line ~~voltages, and all circuits comprising switchgear or controlgear~~ are covered by this document, internal circuits of these may be subject to special requirements covered by relevant product standards.

For electric equipment for rolling stock which conforms to an appropriate international standard, including items of industrial equipment, this document, plus the relevant ~~railway~~ equipment product standard for electric equipment where appropriate, specifies only those additional requirements to ensure satisfactory operation on rolling stock.

RAILWAY APPLICATIONS – ELECTRIC EQUIPMENT FOR ROLLING STOCK –

Part 1: General service conditions and general rules

1 Scope ~~and object~~

This part of IEC 60077 specifies the general service conditions and requirements for all electric equipment installed in power circuits, auxiliary circuits, control and indicating circuits etc., on railway rolling stock.

NOTE Some of these rules ~~may~~ can, after agreement between the user and the manufacturer, be used for electrical equipment installed on ~~other~~ vehicles other than railway rolling stock, such as mine locomotives, trolley buses, etc.

The purpose of this document is to harmonize as far as practicable all rules and requirements of a general nature applicable to electric equipment for rolling stock. This is in order to obtain uniformity of requirements and tests throughout the corresponding range of equipment to avoid the need for testing to different standards.

All requirements relating to:

- the environmental stresses expected during the normal service conditions;
- the construction;
- the performance and the associated tests which can be considered as general;

have therefore been gathered in this document together with specific subjects of wide interest and application, for example temperature rise, dielectric properties, etc.

In the event of there being a difference in requirements between this document and a railway rolling stock relevant product standard, then the product standard requirements take precedence.

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(151):1978, *International Electrotechnical Vocabulary (IEV) – Chapter 151: Electrical and magnetic devices*~~

~~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 60056:1987, *High-voltage alternating-current circuit-breakers*~~

IEC 60068-2-1~~:1990~~, *Environmental testing – Part 2-1: Tests – Tests A: Cold*

IEC 60068-2-2~~:1974~~, *Environmental testing – Part 2-2: Tests – Tests B: Dry heat*

~~IEC 60068-2-3:1969, *Environmental testing – Part 2: Tests – Test Ca: Damp heat, steady state*~~

IEC 60068-2-30, *Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60068-2-52~~:1996~~, *Environmental testing – Part 2-52: Tests – Test Kb: Salt mist, cyclic (sodium chloride solution)*

IEC 60068-2-78, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

~~IEC 60071-1:1993, *Insulation co-ordination – Part 1: Definitions, principles and rules*~~

IEC 60085~~:1984~~, *Electrical insulation – Thermal evaluation and ~~classification of electrical insulation~~ designation*

~~IEC 60112:1979, *Method for determining the comparative and the proof tracking indices of solid insulating materials under moist conditions*~~

IEC 60216-1, *Electrical insulating materials – Thermal endurance properties – Part 1: Ageing procedures and evaluation of test results*

~~IEC 60364-4-41:1992, *Electrical installations of buildings – Part 4: Protection for safety – Chapter 41: Protection against electric shock*~~

IEC 60505, *Evaluation and qualification of electrical insulation systems*

IEC 60529~~:1989~~, *Degrees of protection provided by enclosures (IP Code)*

~~IEC/TR 60536:1976, *Classification of electrical and electronic equipment with regard to protection against electric shock*~~

~~IEC 60587:1984, *Test method for evaluating resistance to tracking and erosion of electrical insulating materials used under severe ambient conditions*~~

~~IEC 60664-1:1992, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*~~

IEC 60721-3-5~~:1997~~, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 5: Ground vehicle installations*

IEC 60850~~:1988~~, *Railway applications – Supply voltages of traction systems*

IEC 61133:~~1992~~ 2016, ~~*Electric traction*~~ *Railway applications – Rolling stock – Testing ~~methods for electric and thermal/electric~~ of rolling stock on completion of construction and before entry into service*

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

IEC 61991, *Railway applications – Rolling stock – Protective provisions against electrical hazards*