

This is a preview - click here to buy the full publication



IEC 62590

Edition 2.0 2019-08

REDLINE VERSION



Railway applications – Fixed installations – Electronic power converters for substations

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 45.060.01

ISBN 978-2-8322-7357-9

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

CONTENTS

FOREWORD	5
INTRODUCTION	7
1 Scope	8
2 Normative references	8
3 Terms and definitions	9
3.1 Semiconductor devices and combinations	10
3.2 Arms and connections	10
3.3 Controllability of converter arms and quadrants of operation	12
3.4 Commutation, quenching and commutation circuitry	12
3.5 Commutation characteristics	13
3.6 Rated values	17
3.7 Load capabilities	18
3.8 Specific voltages, currents and factors	19
3.9 Definitions related to virtual junction temperature	21
3.10 Cooling	21
3.11 Electromagnetic compatibility and harmonic distortion	22
4 Symbols	22
5 Operation of semiconductor power equipment and valve devices	23
5.1 Classification of traction supply power converters and valves	23
5.1.1 Types of traction supply power converters	23
5.1.2 Purpose of conversion	24
5.1.3 Classification of semiconductor valve devices	24
5.2 Basic calculation factors for line commutated converters	25
5.2.1 Voltage	25
5.2.2 Voltage characteristics and transition current	25
6 Service conditions	26
6.1 Code of identification of cooling method	26
6.1.1 Letter symbols to be used	26
6.1.2 Arrangement of letter symbols	27
6.2 Environmental conditions	27
6.2.1 Ambient air circulation	27
6.2.2 Normal service conditions	28
6.2.3 Special service conditions	29
6.3 Electrical service conditions	29
6.3.1 General	29
6.3.2 Limiting values as basis of rating	29
6.3.3 DC traction supply voltage	31
7 Converter equipment and assemblies	31
7.1 Losses and efficiency	31
7.1.1 General	31
7.1.2 Included losses	31
7.2 Power factor	31
7.3 Direct voltage harmonic content	31
7.3 Electromagnetic compatibility (EMC)	32
7.4 Rated values for converters	32

7.4.1	General	32
7.4.2	Current values	33
7.4.3	Capability for unsymmetrical load of a 12-pulse converter in parallel connection	35
7.4.4	Semiconductor device failure conditions	35
7.5	Mechanical characteristics	35
7.5.1	General	35
7.5.2	Earthing	36
7.5.3	Degree of protection	36
7.6	Insulation coordination	36
7.7	Specifics of line commutated rectifiers	37
7.7.1	Electrical connections	37
7.7.2	Calculation factors	38
7.7.3	Direct voltage harmonic content	39
8	Tests	39
8.1	General	39
8.1.1	Overview	39
8.1.2	Performance of tests	39
8.1.3	Test schedule	40
8.2	Test specifications	40
8.2.1	Insulation tests	40
8.2.2	Light load functional test	43
8.2.3	Load test	43
8.2.4	Power loss determination	43
8.2.5	Temperature-rise test	43
8.2.6	Checking of auxiliary devices	45
8.2.7	Checking of the properties of the control equipment	45
8.2.8	Checking of the protective devices	45
8.2.9	Short-time withstand current test	45
8.2.10	EMC test	46
8.2.11	Additional tests	46
9	Marking	46
9.1	Rating plate	46
9.2	Main circuit terminals	47
Annex A (informative)	Information required	48
A.1	General	48
A.2	Diode rectifiers	48
A.2.1	Procurement specification	48
A.2.2	Supplier's tender specification	49
A.2.3	Information and data to be given by the supplier during the delivery stage	49
A.3	Controlled converters and inverters	50
A.3.1	Procurement specification	50
A.3.2	Supplier's tender specification	51
A.4	Frequency converters (direct and DC link converters)	51
A.4.1	Procurement specification	51
A.4.2	Supplier's tender specification	52
A.5	DC converters	53
A.5.1	Procurement specification	53

A.5.2	Supplier's tender specification	54
Annex B (informative)	Determination of the current capability through calculation of the virtual junction temperature	56
B.1	General.....	56
B.2	Approximation of the shape of power pulses applied to the semiconductor device	56
B.3	Superposition method for the calculation of temperature	57
B.4	Calculation of virtual junction temperature for continuous load	58
B.4.1	General	58
B.4.2	Calculation of mean value of virtual junction temperature	58
B.4.3	Calculation of maximum instantaneous virtual junction temperature	58
B.5	Calculation of virtual junction temperature for cyclic loads	59
B.6	Examples for typical applications	60
Annex C (informative)	Index of definitions	62
Bibliography	64
Figure 1	– Illustration of angles	16
Figure 2	– Voltage drop regulation	26
Figure 3	– AC voltage waveform	30
Figure B.1	– Approximation of the shape of power pulses	57
Figure B.2	– Calculation of the virtual junction temperature for continuous load	58
Figure B.3	– Calculation of the virtual junction temperature for cyclic load	59
Table 1	– Letter symbols for cooling mediums and heat transfer agents.....	26
Table 2	– Letter symbols for methods of circulation	26
Table 3	– Standardized duty classes.....	33
Table 4	– Semiconductor device failure conditions.....	35
Table 5	– Insulation levels for AC/DC and DC converters.....	37
Table 6	– Connections and calculation factors for line commutated converters	37
Table 7	– Summary of tests	40
Table 8	– Insulation levels for AC/DC and DC converters.....	42
Table B.1	– Examples for typical applications	60

INTERNATIONAL ELECTROTECHNICAL COMMISSION

RAILWAY APPLICATIONS – FIXED INSTALLATIONS – ELECTRONIC POWER CONVERTERS FOR SUBSTATIONS

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 Standard and is intended to provide the user with an indication of what changes have been made to the previous version. Only the IEC International Standard provided in this package is to be considered the official Standard.

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 62590 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

This standard is based on EN 50328.

This second edition cancels and replaces the first edition published in 2010. This edition constitutes a technical revision.

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

- a) Incorporation of DC converters.
- b) Correction of the clearances and withstand voltages due to erroneous use of PD in former edition.
- c) Adaption to current ISO/IEC directive part 2, adaption of structure, adaption of vocabulary, removal of unused term and abbreviations.

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

FDIS	Report on voting
9/2502/FDIS	9/2516/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.

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.

INTRODUCTION

Semiconductor converters for traction power supply differ from other converters for industrial use due to special electrical service conditions and due to the large range of load variation and the peculiar characteristics of the load.

For these reasons IEC 60146-1-1 does not fully cover the requirements of railway applications and the decision was taken to have a specific standard for this use.

Converter transformers for fixed installations of railway applications are covered by ~~EN 50329~~ IEC 62695.

Harmonization of the rated values and tests of the whole converter group are covered by IEC 62589.

RAILWAY APPLICATIONS – FIXED INSTALLATIONS – ELECTRONIC POWER CONVERTERS FOR SUBSTATIONS

1 Scope

This document specifies the requirements for the performance of all fixed installations electronic power converters, using controllable and/or non-controllable electronic valves, intended for traction power supply.

The devices can be controlled by means of current, voltage or light. Non-bistable devices are assumed to be operated in the switched mode.

This document applies to fixed installations of the following electric traction systems:

- railways,
- guided mass transport systems such as: tramways, light rail systems, elevated and underground railways, mountain railways, trolleybuses.

This document does not apply to:

- cranes, transportable platforms and similar transportation equipment on rails,
- suspended cable cars,
- funicular railways.

This document applies to diode rectifiers, controlled rectifiers, DC converters, inverters and frequency converters.

The equipment covered in this document is the converter itself.

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 60050-551:1998, International Electrotechnical Vocabulary (IEV) – Part 551: Power Electronics~~

IEC 60050-811:1994/2017, International electrotechnical vocabulary – Part 811: Electric traction

IEC 60146 (all parts), Semiconductor convertors

IEC TR 60146-1-2:1994/2011, Semiconductor converters – General requirements and line commutated converters – Part 1-2: Application guide

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

IEC 60721 (all parts), Classification of environmental conditions

IEC 60721-3-3:1994, Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 3: Stationary use at

weatherprotected locations

AMD1:1995

AMD2:1996

IEC 60721-3-4:1995, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 4: Stationary use at non-weatherprotected locations*

AMD1:1996

IEC 60850:~~2007~~2014, *Railway applications – Supply voltages of traction systems*

IEC 61000-2-4:2002, *Electromagnetic compatibility (EMC) – Part 2-4: Environment – Compatibility levels in industrial plants for low-frequency conducted disturbances*

IEC 61000-2-12:2003, *Electromagnetic compatibility (EMC) – Part 2-12: Environment – Compatibility levels for low-frequency conducted disturbances and signalling in public medium-voltage power supply systems*

IEC 61992-7-1:2006, *Railway applications – Fixed installations – DC switchgear – Part 7-1: Measurement, control and protection devices for specific use in DC traction systems – Application guide*

IEC 62236 (all parts), *Railway applications – Electromagnetic compatibility*

IEC 62236-5:~~2008~~2018, *Railway applications – Electromagnetic compatibility – Part 5: Emission and immunity of fixed power supply installations and apparatus*

IEC 62497-1:2010, *Railway applications – Insulation coordination – Part 1: Basic requirements – Clearances and creepage distances for all electrical and electronic equipment*

~~EN 50329:2003, Railway applications – Fixed installations – Traction transformers~~

INTERNATIONAL STANDARD

Railway applications – Fixed installations – Electronic power converters for substations



CONTENTS

FOREWORD	5
INTRODUCTION	7
1 Scope	8
2 Normative references	8
3 Terms and definitions	9
3.1 Semiconductor devices and combinations	9
3.2 Arms and connections	10
3.3 Controllability of converter arms	11
3.4 Commutation, quenching and commutation circuitry	11
3.5 Commutation characteristics	12
3.6 Rated values	15
3.7 Load capabilities	16
3.8 Specific voltages, currents and factors	17
3.9 Definitions related to virtual junction temperature	18
3.10 Cooling	18
3.11 Electromagnetic compatibility and harmonic distortion	19
4 Symbols	19
5 Operation of semiconductor power equipment and valve devices	21
5.1 Classification of traction supply power converters and valves	21
5.1.1 Types of traction supply power converters	21
5.1.2 Purpose of conversion	21
5.1.3 Classification of semiconductor valve devices	21
5.2 Basic calculation factors for line commutated converters	22
5.2.1 Voltage	22
5.2.2 Voltage characteristics and transition current	22
6 Service conditions	23
6.1 Code of identification of cooling method	23
6.1.1 Letter symbols to be used	23
6.1.2 Arrangement of letter symbols	24
6.2 Environmental conditions	24
6.2.1 Ambient air circulation	24
6.2.2 Normal service conditions	25
6.2.3 Special service conditions	26
6.3 Electrical service conditions	26
6.3.1 General	26
6.3.2 Limiting values as basis of rating	26
6.3.3 DC traction supply voltage	28
7 Converter equipment and assemblies	28
7.1 Losses and efficiency	28
7.1.1 General	28
7.1.2 Included losses	28
7.2 Power factor	28
7.3 Electromagnetic compatibility (EMC)	29
7.4 Rated values for converters	29
7.4.1 General	29

7.4.2	Current values	29
7.4.3	Capability for unsymmetrical load of a 12-pulse converter in parallel connection	31
7.4.4	Semiconductor device failure conditions	32
7.5	Mechanical characteristics	32
7.5.1	General	32
7.5.2	Earthing	32
7.5.3	Degree of protection	33
7.6	Insulation coordination	33
7.7	Specifics of line commutated rectifiers	33
7.7.1	Electrical connections	33
7.7.2	Calculation factors	35
7.7.3	Direct voltage harmonic content	35
8	Tests	35
8.1	General	35
8.1.1	Overview	35
8.1.2	Performance of tests	36
8.1.3	Test schedule	36
8.2	Test specifications	36
8.2.1	Insulation tests	36
8.2.2	Light load functional test	38
8.2.3	Load test	38
8.2.4	Power loss determination	39
8.2.5	Temperature-rise test	39
8.2.6	Checking of auxiliary devices	40
8.2.7	Checking of the properties of the control equipment	40
8.2.8	Checking of the protective devices	41
8.2.9	Short-time withstand current test	41
8.2.10	EMC test	41
8.2.11	Additional tests	41
9	Marking	41
9.1	Rating plate	41
9.2	Main circuit terminals	42
Annex A (informative)	Information required	43
A.1	General	43
A.2	Diode rectifiers	43
A.2.1	Procurement specification	43
A.2.2	Supplier's tender specification	44
A.2.3	Information and data to be given by the supplier during the delivery stage	44
A.3	Controlled converters and inverters	45
A.3.1	Procurement specification	45
A.3.2	Supplier's tender specification	46
A.4	Frequency converters (direct and DC link converters)	46
A.4.1	Procurement specification	46
A.4.2	Supplier's tender specification	47
A.5	DC converters	48
A.5.1	Procurement specification	48
A.5.2	Supplier's tender specification	49

Annex B (informative) Determination of the current capability through calculation of the virtual junction temperature.....	51
B.1 General.....	51
B.2 Approximation of the shape of power pulses applied to the semiconductor device.....	51
B.3 Superposition method for the calculation of temperature.....	52
B.4 Calculation of virtual junction temperature for continuous load.....	53
B.4.1 General.....	53
B.4.2 Calculation of mean value of virtual junction temperature.....	53
B.4.3 Calculation of maximum instantaneous virtual junction temperature.....	53
B.5 Calculation of virtual junction temperature for cyclic loads.....	54
B.6 Examples for typical applications.....	55
Annex C (informative) Index of definitions.....	57
Bibliography.....	59
Figure 1 – Illustration of angles.....	14
Figure 2 – Voltage regulation.....	23
Figure 3 – AC voltage waveform.....	27
Figure B.1 – Approximation of the shape of power pulses.....	52
Figure B.2 – Calculation of the virtual junction temperature for continuous load.....	53
Figure B.3 – Calculation of the virtual junction temperature for cyclic load.....	54
Table 1 – Letter symbols for cooling mediums and heat transfer agents.....	23
Table 2 – Letter symbols for methods of circulation.....	23
Table 3 – Standardized duty classes.....	30
Table 4 – Semiconductor device failure conditions.....	32
Table 5 – Insulation levels for AC/DC and DC converters.....	33
Table 6 – Connections and calculation factors for line commutated converters.....	34
Table 7 – Summary of tests.....	36
Table 8 – Insulation levels for AC/DC and DC converters.....	38
Table B.1 – Examples for typical applications.....	55

INTERNATIONAL ELECTROTECHNICAL COMMISSION

RAILWAY APPLICATIONS – FIXED INSTALLATIONS – ELECTRONIC POWER CONVERTERS FOR SUBSTATIONS

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 62590 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

This standard is based on EN 50328.

This second edition cancels and replaces the first edition published in 2010. This edition constitutes a technical revision.

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

- a) Incorporation of DC converters.
- b) Correction of the clearances and withstand voltages due to erroneous use of PD in former edition.
- c) Adaption to current ISO/IEC directive part 2, adaption of structure, adaption of vocabulary, removal of unused term and abbreviations.

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

FDIS	Report on voting
9/2502/FDIS	9/2516/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.

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.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

Semiconductor converters for traction power supply differ from other converters for industrial use due to special electrical service conditions and due to the large range of load variation and the peculiar characteristics of the load.

For these reasons IEC 60146-1-1 does not fully cover the requirements of railway applications and the decision was taken to have a specific standard for this use.

Converter transformers for fixed installations of railway applications are covered by IEC 62695.

Harmonization of the rated values and tests of the whole converter group are covered by IEC 62589.

RAILWAY APPLICATIONS – FIXED INSTALLATIONS – ELECTRONIC POWER CONVERTERS FOR SUBSTATIONS

1 Scope

This document specifies the requirements for the performance of all fixed installations electronic power converters, using controllable and/or non-controllable electronic valves, intended for traction power supply.

The devices can be controlled by means of current, voltage or light. Non-bistable devices are assumed to be operated in the switched mode.

This document applies to fixed installations of the following electric traction systems:

- railways,
- guided mass transport systems such as: tramways, light rail systems, elevated and underground railways, mountain railways, trolleybuses.

This document does not apply to:

- cranes, transportable platforms and similar transportation equipment on rails,
- suspended cable cars,
- funicular railways.

This document applies to diode rectifiers, controlled rectifiers, DC converters, inverters and frequency converters.

The equipment covered in this document is the converter itself.

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 60050-811:2017, *International electrotechnical vocabulary – Part 811: Electric traction*

IEC 60146 (all parts), *Semiconductor convertors*

IEC TR 60146-1-2:2011, *Semiconductor converters – General requirements and line commutated converters – Part 1-2: Application guide*

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

IEC 60721 (all parts), *Classification of environmental conditions*

IEC 60721-3-3:1994, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 3: Stationary use at weatherprotected locations*

AMD1:1995

AMD2:1996

IEC 60721-3-4:1995, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 4: Stationary use at non-weatherprotected locations*
AMD1:1996

IEC 60850:2014, *Railway applications – Supply voltages of traction systems*

IEC 61000-2-4:2002, *Electromagnetic compatibility (EMC) – Part 2-4: Environment – Compatibility levels in industrial plants for low-frequency conducted disturbances*

IEC 61000-2-12:2003, *Electromagnetic compatibility (EMC) – Part 2-12: Environment – Compatibility levels for low-frequency conducted disturbances and signalling in public medium-voltage power supply systems*

IEC 61992-7-1:2006, *Railway applications – Fixed installations – DC switchgear – Part 7-1: Measurement, control and protection devices for specific use in DC traction systems – Application guide*

IEC 62236 (all parts), *Railway applications – Electromagnetic compatibility*

IEC 62236-5:2018, *Railway applications – Electromagnetic compatibility – Part 5: Emission and immunity of fixed power supply installations and apparatus*

IEC 62497-1:2010, *Railway applications – Insulation coordination – Part 1: Basic requirements – Clearances and creepage distances for all electrical and electronic equipment*