



SLOVENSKI STANDARD SIST EN IEC 60310:2026

01-oktober-2026

Železniške naprave - Transformatorji vleke in dušilke na tirnih vozilih

Railway applications - Traction transformers and inductors on board rolling stock

Bahnanwendungen - Bahn-Transformatoren und Drosselspulen auf Schienenfahrzeugen

Applications ferroviaires - Transformateurs de traction et bobines d'inductance à bord du matériel roulant

Ta slovenski standard je istoveten z: EN IEC 60310:2026

ICS:

29.180	Transformatorji. Dušilke	Transformers. Reactors
45.060.10	Vlečna vozila	Tractive stock

SIST EN IEC 60310:2026

en

Sample Document

get full document from standards.iteh.ai

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN IEC 60310

July 2026

ICS 45.060.01

Supersedes EN 60310:2016; EN 60310:2016/AC:2018-03

English Version

**Railway applications - Transformers and inductors on board
rolling stock
(IEC 60310:2026)**

Applications ferroviaires - Transformateurs de traction et
bobines d'inductance à bord du matériel roulant
(IEC 60310:2026)

Bahnanwendungen - Transformatoren und Drosselspulen
auf Bahnfahrzeugen
(IEC 60310:2026)

This European Standard was approved by CENELEC on 2026-05-18. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and the United Kingdom.



European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

EN IEC 60310:2026 (E)**European foreword**

The text of document 9/3296/FDIS, future edition 5 of IEC 60310, prepared by TC 9 "Electrical equipment and systems for railways" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 60310:2026.

The following dates are fixed:

- latest date by which the document has to be implemented at national (dop) 2027-07-31 level by publication of an identical national standard or by endorsement
- latest date by which the national standards conflicting with the (dow) 2029-07-31 document have to be withdrawn

This document supersedes EN 60310:2016 and all of its amendments and corrigenda (if any).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC shall not be held responsible for identifying any or all such patent rights.

Any feedback and questions on this document should be directed to the users' national committee. A complete listing of these bodies can be found on the CENELEC website.

Endorsement notice

The text of the International Standard IEC 60310:2026 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standard indicated:

IEC 60060-1	NOTE	Approved as EN IEC 60060-1
IEC 60060-2	NOTE	Approved as EN IEC 60060-2
IEC 60076-4	NOTE	Approved as EN 60076-4
IEC 60076-11:2018	NOTE	Approved as EN IEC 60076-11:2018 (not modified)
IEC 60076-14	NOTE	Approved as EN 60076-14
IEC 60077-1	NOTE	Approved as EN 60077-1
IEC 60085	NOTE	Approved as EN 60085
IEC 60216-1	NOTE	Approved as EN IEC 60216-1
IEC 60216-5	NOTE	Approved as EN IEC 60216-5
IEC 60270	NOTE	Approved as EN IEC 60270
IEC 60505	NOTE	Approved as EN 60505
IEC 61287-1	NOTE	Approved as EN 61287-1

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

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.

NOTE 1 Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60076-1	2011	Power transformers - Part 1: General	EN 60076-1	2011
IEC 60076-2	-	Power transformers - Part 2: Temperature rise for liquid-immersed transformers	EN 60076-2	-
IEC 60076-3	-	Power transformers - Part 3: Insulation levels, dielectric tests and external clearances in air	EN 60076-3	-
IEC 60076-5	-	Power transformers - Part 5: Ability to withstand short circuit	EN 60076-5	-
IEC 60076-6	2007	Power transformers - Part 6: Reactors	EN 60076-6	2008
IEC 60076-10	-	Power transformers - Part 10: Determination of sound levels	EN 60076-10	-
IEC 60076-12	2008	Power transformers - Part 12: Loading guide for dry-type power transformers	-	-
IEC 60076-18	-	Power transformers - Part 18: Measurement of frequency response	EN 60076-18	-
IEC 60296	-	Fluids for electrotechnical applications - Mineral insulating oils for electrical equipment	EN IEC 60296	-
IEC 60836	-	Specifications for unused silicone insulating liquids for electrotechnical purposes	EN 60836	-
IEC 60850	-	Railway applications - Supply voltages of traction systems	-	-
IEC 61039	-	Classification of insulating liquids	EN IEC 61039	-
IEC 61099	-	Insulating liquids - Specifications for unused synthetic organic esters for electrical purposes	EN 61099	-

EN IEC 60310:2026 (E)

IEC 61373	— ¹	Railway applications - Rolling stock equipment - Shock and vibration tests	EN 61373	—
IEC 61378-1	2011	Converter transformers - Part 1: Transformers for industrial applications	EN 61378-1	2011
IEC 62497-1	2010	Railway applications - Insulation coordination - Part 1: Basic requirements - Clearances and creepage distances for all electrical and electronic equipment	-	-
+ A1	2013		-	-
IEC 62498-1	-	Railway applications - Environmental conditions for equipment - Part 1: Equipment on board rolling stock	-	-
ISO 3746	-	Acoustics - Determination of sound power levels and sound energy levels of noise sources using sound pressure - Survey method using an enveloping measurement surface over a reflecting plane	EN ISO 3746	-
ISO 9614-1	-	Acoustics - Determination of sound power levels of noise sources using sound intensity - Part 1: Measurement at discrete points	EN ISO 9614-1	-
ISO 9614-2	-	Acoustics - Determination of sound power levels of noise sources using sound intensity - Part 2: Measurement by scanning	EN ISO 9614-2	-

Sample Document

get full document from standards.iteh.ai

¹ Under preparation. Stage at the time of publication: IEC FDIS 61373:2024



IEC 60310

Edition 5.0 2026-04

INTERNATIONAL STANDARD

Railway applications - Transformers and inductors on board rolling stock

Sample Document

get full document from standards.iteh.ai

CONTENTS

FOREWORD	5
1 Scope	7
2 Normative references	7
3 Terms, definitions and abbreviated terms	8
3.1 Terms and definitions	9
3.1.1 General definitions	9
3.1.2 Definitions for transformers	11
3.1.3 Definitions for inductors	11
3.1.4 Definitions of thermal endurance	12
3.1.5 Definitions of thermal endurance calculations	12
3.2 Abbreviated terms	13
4 Classification	13
4.1 General	13
4.2 Classification of transformers	15
4.3 Classification of inductors	16
5 Service conditions	16
6 Rated current and load profile	16
6.1 Load profile	16
6.2 Rated current	16
7 Rated voltage and power of transformer windings	17
7.1 Rated line-side voltage	17
7.2 Rated secondary voltage	17
7.3 Rated power of transformer	17
8 Transformer tappings	17
9 Cooling	17
9.1 Identification of transformers and inductors according to cooling method	17
9.2 Arrangement of symbols	18
9.2.1 Enclosed transformers and inductors	18
9.2.2 Non-enclosed transformers and inductors	19
9.2.3 Air cooling	19
10 Temperature limits	19
10.1 Classification of insulating materials	19
10.2 Temperature limits of solid insulation	19
10.3 Temperature limits for liquid	20
10.4 Temperature limits for other parts	21
11 Mechanical design	21
12 Fire protection	21
13 Rating plates	21
13.1 General	21
13.2 Rating plates for transformer	22
13.3 Rating plates for inductor	22
14 Tests	22
14.1 Categories of tests	22
14.1.1 General	22
14.1.2 Type tests	23

IEC 60310:2026 © IEC 2026

14.1.3	Routine tests	23
14.1.4	Investigation tests.....	23
14.2	List of checks and tests	23
14.3	Tolerances.....	25
14.3.1	Tolerances for transformer	25
14.3.2	Tolerance for inductors	26
14.4	Test items	26
14.4.1	Visual checks	26
14.4.2	Functional tests	26
14.4.3	Mass	27
14.4.4	Measurement of winding resistance	27
14.4.5	Measurement of voltage ratio, polarities and vector groups.....	28
14.4.6	Measurement of impedance voltages or short-circuit impedances	28
14.4.7	Measurement of inductance	29
14.4.8	Measurement of no-load primary current and losses	32
14.4.9	Measurement of fundamental load losses	33
14.4.10	Determination of losses	33
14.4.11	Temperature-rise test	34
14.4.12	Insulation resistance test	39
14.4.13	Dielectric test	40
14.4.14	Partial discharge test.....	46
14.4.15	Short-circuit withstand test	48
14.4.16	Shock and vibration test	51
14.4.17	Vibration test with current flowing	52
14.4.18	Voltage Transmission Ratio (VTR).....	53
14.4.19	Noise measurement.....	54
14.4.20	Leakage magnetic flux density measurement.....	54
14.4.21	Electrical frequency response analysis (FRA)	54
14.4.22	Inrush current measurement	54
Annex A (informative) List of items subject to agreement between purchaser and manufacturer, and list of information from purchaser or manufacturer		56
A.1	Items subject to agreement between purchaser and manufacturer	56
A.1.1	Transformers and inductors	56
A.1.2	Transformers	57
A.1.3	Inductors	58
A.2	Information from purchaser to manufacturer.....	59
A.2.1	Transformers and inductors	59
A.2.2	Transformers	60
A.2.3	Inductors	60
A.3	Information from manufacturer to purchaser.....	60
A.3.1	Transformers and inductors	60
A.3.2	Transformers	61
A.3.3	Inductors	61
Annex B (informative) Thermal ageing and insulation lifetime		62
B.1	Insulation lifetime and thermal ageing	62
B.2	Special considerations for thermal design and test.....	63
B.2.1	General	63
B.2.2	Cooling medium temperature at the external interface	63

IEC 60310:2026 © IEC 2026

B.2.3	Rated current.....	63
B.2.4	Temperature rise test of a dry-type transformer or inductor.....	64
B.3	Thermal conformity of the insulation system.....	64
B.4	End of life criterion.....	64
Annex C (informative) Example of thermal endurance calculation to demonstrate the suitability of an insulation system for a specified application		65
C.1	Preliminary	65
C.2	Example 1 – Temperature limits for a dry-type transformer or inductor.....	65
C.3	Example 2 – Thermal endurance calculation	65
C.3.1	General	65
C.3.2	Operating conditions to be provided by the purchaser.....	66
C.3.3	Thermal endurance characteristics to be provided by the manufacturer	66
C.3.4	Temperature rise test results	66
C.3.5	Calculations.....	67
Annex D (informative) Wet dielectric tests for dry-type transformers and inductors		69
D.1	General.....	69
D.2	Wet test 1 (optional type test or optional routine test): short soaking.....	69
D.3	Wet test 2 (investigation test or optional type test): misting.....	70
D.4	Wet test 3 (investigation test): thermal shock – long soaking – misting	70
D.4.1	General	70
D.4.2	Temperature conditioning	70
D.4.3	Thermal shock.....	70
D.4.4	Dielectric test	70
D.5	Common test procedure and criteria for wet dielectric tests	70
Annex E (informative) Load profiles		72
Annex F (informative) Background of reference temperature and dielectric test voltage in IEC 60310.....		73
F.1	General.....	73
F.2	Reference temperature	73
F.3	Dielectric test voltage	73
Bibliography.....		75
Figure 1 – Traction transformer with auxiliary windings fed by AC power supply system		14
Figure 2 – Traction transformer without auxiliary windings fed by AC power supply system.....		14
Figure 3 – DC locomotive typical circuit diagram.....		15
Figure 4 – Energy storage system typical circuit diagram.....		15
Figure 5 – Examples of set up for induced voltage withstanding tests		43
Figure 6 – Examples of set up for separate source voltage withstanding tests		43
Figure 7 – Examples of impulse test connections for traction, inductor and auxiliary transformers		44
Figure 8 – Partial discharge test: voltage versus time		47
Figure 9 – Configurations for VTR test.....		53
Figure 10 – Example of test circuit.....		55
Table 1 – Letter symbols for cooling method.....		18
Table 2 – Order of symbols.....		18

Table 3 – Temperature limits of solid insulation	20
Table 4 – Temperature limits for liquid	20
Table 5 – List of checks and tests to be made on transformers or inductors	24
Table 6 – Tolerances for transformer	25
Table 7 – Tolerances for inductors	26
Table 8 – Reference temperatures	27
Table 9 – Dielectric test voltage	41
Table 10 – Test method of voltage between terminals withstand test	45
Table 11 – Partial discharge measurements	47
Table C.1 – Temperature limits and expected lifetime for a dry-type transformer or inductor (examples)	65
Table C.2 – Load cycle histogram	66
Table C.3 – Temperature histogram	66
Table C.4 – Temperature rise test results	67
Table C.5 – Thermal endurance calculation	67
Table C.6 – Equivalent current and temperatures	68
Table F.1 – Reference temperatures in IEC 60310:2016	73
Table F.2 – Dielectric test voltage in IEC 60310:2016	74

Sample Document

get full document from standards.iteh.ai

INTERNATIONAL ELECTROTECHNICAL COMMISSION

Railway applications - Transformers and inductors on board rolling stock

FOREWORD

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

IEC 60310 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways. It is an International Standard.

This fifth edition cancels and replaces the fourth edition published in 2016. This edition constitutes a technical revision.

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

- a) typical circuits for transformer and inductors are added;
- b) letter symbols for cooling methods are added;
- c) dielectric test table is modified;
- d) subclauses for the tests of transformers and inductors are restructured;

IEC 60310:2026 © IEC 2026

- e) temperature test for dry type transformer and dry type inductors are separated in different subclauses;
- f) requirements for shock and vibration tests are updated according to IEC 61373:20—.

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

Draft	Report on voting
9/3296/FDIS	9/3322/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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

- reconfirmed,
- withdrawn, or
- revised.

Sample Document

get full document from standards.iteh.ai

1 Scope

This document specifies the terms and definitions, classification, service conditions, characteristics and test methods for transformers and inductors on board rolling stock.

This document is applicable to traction and auxiliary power transformers installed on board rolling stock and to the various types of power inductors inserted in the traction and auxiliary circuits of rolling stock, of dry or liquid-immersed design.

This document is also applicable to the traction transformers of three-phase AC line-side powered vehicles and to the transformers inserted in the single-phase or polyphase auxiliary circuits of vehicles, after agreement between purchaser and manufacturer.

This document does not apply to instrument transformers, transformers of a rated output below 1 kVA single-phase or 5 kVA poly-phase, and inductors of a rated output below 1 kVAR single-phase or 5 kVAR poly-phase on board rolling stock.

This document does not cover accessories such as tap changers, resistors, heat exchangers, fans, etc., intended for mounting on transformers or inductors, which are tested separately according to the relevant rules.

NOTE Items requiring agreement between the delivery parties and items of supplementary information and specification particulars to be provided by the ordering party or manufacturer are given in Annex A.

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 60076-1:2011, *Power transformers - Part 1: General*

IEC 60076-2, *Power transformers - Part 2: Temperature rise for liquid-immersed transformers*

IEC 60076-3, *Power transformers - Part 3: Insulation levels, dielectric tests and external clearances in air*

IEC 60076-5, *Power transformers - Part 5: Ability to withstand short circuit*

IEC 60076-6:2007, *Power transformers - Part 6: Reactors*

IEC 60076-10, *Power transformers - Part 10: Determination of sound levels*

IEC 60076-12:2008, *Power transformers - Part 12: Loading guide for dry-type transformers*

IEC 60076-18, *Power transformers - Part 18: Measurement of frequency response*

IEC 60296, *Fluids for electrotechnical applications - Mineral insulating oils for electrical equipment*

IEC 60836, *Specifications for unused silicone insulating liquids for electrotechnical purposes*

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

IEC 60310:2026 © IEC 2026

IEC 61039, *Classification of insulating liquids*

IEC 61099, *Insulating liquids - Specifications for unused synthetic organic esters for electrical purposes*

IEC 61373:20—, *Railway applications - Rolling stock equipment - Shock and vibration tests*¹

IEC 61378-1:2011, *Converter transformers - Part 1: Transformers for industrial applications*

IEC 62497-1:2010, *Railway applications - Insulation coordination - Part 1: Basic requirements - Clearances and creepage distances for all electrical and electronic equipment*
IEC 62497-1:2010/AMD1:2013

IEC 62498-1, *Railway applications - Environmental conditions for equipment - Part 1: Equipment on board rolling stock*

ISO 3746, *Acoustics - Determination of sound power levels and sound energy levels of noise sources using sound pressure - Survey method using an enveloping measurement surface over a reflecting plane*

ISO 9614-1, *Acoustics - Determination of sound power levels of noise sources using sound intensity - Part 1: Measurement at discrete points*

ISO 9614-2, *Acoustics - Determination of sound power levels of noise sources using sound intensity - Part 2: Measurement by scanning*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the terms and definitions given in IEC 60076-1, IEC 62497-1 and the following apply.

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

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

NOTE 1 When the term "transformer" is used alone, it applies to both traction and auxiliary transformers.

NOTE 2 The term "transformer(s)/inductor(s)" appears in clauses applicable to both transformers and inductors to avoid duplication of text.

NOTE 3 The term "inductor" is used in this document with the same meaning as the term "reactor" mentioned in IEC 60050-421, IEC 60050-811 and IEC 60076-6.

¹ Under preparation. Stage at the time of publication: IEC FDIS 61373:2024.