SLOVENSKI STANDARD
oSIST prEN IEC 60310:2025

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Železniške naprave - Transformatorji in dušilke vlečnih tokokrogov na voznih sredstvih

Railway applications - Traction transformers and inductors on board rolling stock

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

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TITLE:

Railway applications – Traction transformers and inductors on board rolling stock

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NOTE FROM TC/SC OFFICERS:

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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RAILWAY APPLICATIONS –

TRANSFORMERS AND INDUCTORS ON BOARD ROLLING STOCK

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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 2016-01-27. 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;

e) temperature test for dry type transformer and dry type inductors are separated in different Sub-clauses;

f) requirements for shock and vibration tests are updated according to IEC 61373:202X.

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

Draft	Report on voting
XX/XX/FDIS	XX/XX/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,
- replaced by a revised edition, or
- amended.

RAILWAY APPLICATIONS –

TRANSFORMERS AND INDUCTORS ON BOARD ROLLING STOCK

1 Scope

This document specified the terms and definition, classification, service condition, 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 poly-phase 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 60060-1, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60060-2, *High-voltage test techniques – Part 2: Measuring systems*

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 60076-4, *Power transformers – Part 4: Guide to the lightning impulse and switching impulse testing – Power transformers and reactors*

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

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

IEC 60076-7, *Power transformers – Part 7: Loading guide for oil-immersed power transformers*

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

IEC 60076-11, *Power transformers – Part 11: Dry-type transformers*

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

IEC 60076-14*, Power transformers – Part 14: Liquid-immersed power transformers using high-temperature insulation materials*

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

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

IEC 60085*, Electrical insulation – Thermal evaluation and designation*

IEC 60270, *High-voltage test techniques – Partial discharge measurements*

IEC 60296, *Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear*

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

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

IEC 61039, *Classification of insulating liquids*

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

IEC 61373:2010, *Railway applications – Rolling stock equipment – Shock and vibration tests*

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

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

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 abbreviations

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.

3.1 General definitions

3.1.1
traction transformer

transformers intended to supply the traction circuits, and optionally also other equipment

3.1.2
auxiliary transformer

transformers intended to supply electrical equipment except traction circuits

Note 1 to entry: In the energy storage system, the transformer supplying traction circuit is traction transformer, and that supplying electrical equipment except traction circuit is auxiliary transformer.

3.1.3
inductor

two-terminal device characterized essentially by its inductance

[SOURCE: IEC 60050-151:2001, 151-13-25, modified – The notes to entry have been omitted.]

3.1.4
load profile

component output power / current versus time under specified conditions including voltage, rectifier, configuration, harmonic content, etc.

Note 1 to entry: Efficiency for the transformer has to be agreed between the manufacture and purchaser.

3.1.5
short time emergency loading

unusually heavy loading of a transient nature (less than one time constant of the transformer) occurring during degraded mode, such as a loss of one traction converter, etc.

[SOURCE: IEC 60076-12:2008, 3.2, modified]

3.1.6
cooling medium

medium used to extract the heat out of the transformer/inductor e.g. air, water, oil, heat sink, etc.

3.1.7
rated insulation voltage
U_{Nm}

RMS withstand voltage value assigned by the manufacturer to the equipment or a part of it, characterising the specified permanent (over 5 min) withstand capability of its insulation

Note 1 to entry: U_{Nm} is a voltage between a live part of equipment and earth or another live part. For rolling stock, earth refers to the car body.

Note 2 to entry: For circuits, systems and sub-systems in railway applications this definition is preferred to "highest voltage for equipment" which is widely used in international standards.

Note 3 to entry: U_{Nm} is higher than or equal to the working voltage. As a consequence, for circuits directly connected to the contact line, U_{Nm} is equal to or higher than U_{max1} as specified in IEC 60850. For circuits connected to electronic converter U_{Nm} is higher than or equal to the DC link voltage.

Note 4 to entry: U_{Nm} is not necessarily equal to the rated voltage which is primarily related to functional performance.

[SOURCE: IEC 60050-426:2020, 426-04-50, modified – “(long-term)” has been replaced with “permanent (over 5 min)”. The note 1 to entry has been adapted and renumbered as note 4 to entry. The notes 1, 2 and 3 to entry have been added.]

3.1.8
nominal voltage
U_n
suitable approximate voltage used to designate or identify a given supply system

3.1.9
rated voltage
U_r
value of voltage assigned for a specific operating condition

3.1.10
rated impulse voltage
U_{Ni}
impulse voltage value, characterizing the specified withstand capability of its insulation against transient over-voltages

3.1.11
test voltage
U_a
RMS value derived from U_{Nm} used for separate source voltage, induced voltage, voltage between terminals withstand, depending on test carried out

3.1.12
recurring peak voltage
U_{mT}, U_{mG}
maximum peak value of periodic excursions of the voltage waveform between terminals (U_{mT}) or between terminals and ground (U_{mG})

3.2 Definitions for transformers

3.2.1
voltage transmission ratio
VTR
ratio between the secondary voltage and the primary voltage when a specified impulse or AC square voltage is applied on the primary

Note 1 to entry: The VTR is expressed as a percentage of this applied voltage.

3.2.2
impedance voltage
voltage applied to reach the rated current in short-circuit

Note 1 to entry: This is expressed as a percentage of this applied voltage to the rated voltage at reference temperature.

Note 2 to entry: When expressed as a percentage or per unit, this is equal to the short circuit impedance referred in IEC 60076-1:2011, 3.7.

3.2.3
tolerance
permitted deviation between the declared value of a quantity and the measured value

[SOURCE: IEC 60050-411:2007, 411-36-19]

3.3 Definitions for inductors

NOTE Values of inductance for inductors are related to the different classes of utilisation and are defined as follows, with the understanding that they include an indication of the nature and value of the current used in their measurement.

3.3.1
AC inductance
inductance derived from the measurement of the alternating current carried by the inductor when it is supplied by a sinusoidal alternating voltage of specified value and frequency

3.3.2
differential inductance
inductance defined from the derivative of the linked flux as a function of current (equal to the slope of the magnetic characteristic)

Note 1 to entry: It is derived from the transient record of instantaneous voltage and current in the inductor or from the measurement of the variation of magnetic flux.

3.3.3
incremental inductance
inductance seen by the AC current of a particular value and frequency superimposed on a direct current through the inductor

Note 1 to entry: It should be mentioned that the ripple factor of a pulsating current, expressed as a percentage, is conventionally defined by the formula:

$$\frac{I_{\max} - I_{\min}}{I_{\max} + I_{\min}} \times 100$$

where $I_{\max}$ and $I_{\min}$ respectively represent the maximum and minimum values of the current wave.

Note 2 to entry: It is derived from a record of the terminal voltage.

3.4 Definitions of thermal endurance

3.4.1
thermal endurance
time taken for the deterioration of a selected property (electrical, mechanical, etc.) to reach a specified end-point at a given temperature

Note 1 to entry: An insulation material mainly ensures the electric performance (dielectric strength) of the conductor insulation, while the impregnation, casting, sealing, coating, etc., materials mainly ensure the mechanical performance of the windings (water tightness, resistance to thermal cycling and shock, resistance to vibration or shocks, thermal conduction, etc.).

Note 2 to entry: An end-point of 50 % of the initial value of the property is used (unless otherwise specified).

3.4.2
temperature Index
TI
numerical value of the temperature (in degrees Celsius) derived from the thermal endurance relationship at a time of 20 000 h (unless otherwise specified)

Note 1 to entry: TI is referring to the RTE (Relative Thermal Endurance) or ATE (Assessed Thermal Endurance) indexes used in IEC 60216-5.

3.4.3
halving Interval
HIC
numerical value of the temperature interval (in Kelvins) which expresses the halving of the time to end-point taken at the temperature equal to TI

[SOURCE: IEC 60050-212:2010, 212-12-11, modified – “corresponding to the temperature index or the relative temperature index” has been replaced with ”equal to TI”.]

3.5 Definitions of thermal endurance calculations

NOTE As far as thermal endurance calculations are concerned, IEC 60076-12 provides an explanation of ageing fundamentals and the means to estimate ageing rate and consumption of lifetime of the transformer/inductor insulation as a function of operating temperature, time and loading. The hot-spot temperature is used to estimate the number of hours of life time consumed during a particular time period of loading.