IEC 60310

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Railway applications – Traction transformers and inductors on board rolling stock

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

IEC 60310:2016-01(en-fr)

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

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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RAILWAY APPLICATIONS – TRACTION 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.
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International Standard IEC 60310 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

This fourth edition cancels and replaces the third edition issued in 2004 and constitutes a technical revision.

This edition takes into account the new generic railway standards, more specifically general service conditions referring to IEC 62498-1 and shock and vibration considerations referring to IEC 61373. It also includes the following significant technical changes with regard to the previous edition:

– temperature limits;
– temperature-rise test;
– dielectric tests;
– partial discharge test;

– inductance measurement methods;
– voltage between terminals withstand test;
– thermal ageing and insulation lifetime (informative);
– examples of thermal endurance calculation (informative);
– wet dielectric tests (informative);
– load profiles (informative).

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

FDIS	Report on voting
9/2080/FDIS	9/2117/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.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site 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.

The contents of the corrigendum of February 2018 have been included in this copy.

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.

RAILWAY APPLICATIONS – TRACTION TRANSFORMERS AND INDUCTORS ON BOARD ROLLING STOCK

1 Scope

This International Standard applies 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.

NOTE The requirements of IEC 60076 (all parts) are applicable to transformers and inductors where they do not conflict with this standard, or with the specialized IEC publications dealing with traction applications.

This standard can also be applied, after agreement between purchaser and manufacturer, to the traction transformers of three-phase a.c. line-side powered vehicles and to the transformers inserted in the single-phase or poly-phase auxiliary circuits of vehicles, except instrument transformers and transformers of a rated output below 1 kVA single-phase or 5 kVA poly-phase.

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

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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, *International Electrotechnical Vocabulary (IEV) – Chapter 811: Electric traction*

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 and definitions

For the purposes of this document, the terms and definitions given in IEC 60076-1 and IEC 60050-811 together with the following apply.

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

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

The term “inductor” is used in this standard 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
load profile
current/power versus time under specified conditions including voltage

3.1.2
cooling medium
cooling medium used to extract the heat out of the transformer/inductor e.g. air, water, oil, heat sink, etc.

3.1.3
rated insulation voltage
U_{Nm}
r.m.s. 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 d.c. link voltage.

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

3.1.4
nominal voltage
U_n
suitable approximate voltage used to designate or identify a given supply system

3.1.5
rated voltage
U_r
value of voltage assigned for a specific operating condition

3.1.6
rated impulse voltage
U_{Ni}
impulse voltage value, characterizing the specified withstand capability of its insulation against transient over-voltages

3.1.7
test voltage
U_a
r.m.s. value derived from U_{Nm} used for separate source voltage, induced voltage, voltage between terminals withstand, depending on test carried out

3.1.8
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 a.c. square voltage is applied on the primary.

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.

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

Note 1 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

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
a.c. 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 a.c. 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.

4 Classification

4.1 Classification of transformers

The transformers mentioned above may be:

– traction transformers to supply the propulsion circuits, and optionally also other equipment;

– auxiliary transformers to supply electrical equipment except propulsion circuits.

Windings mentioned in the standard may be:

– line side windings which are directly connected to the power supply line;

– traction windings which supply the propulsion circuits;

– auxiliary windings which are used for other purposes.

4.2 Classification of inductors

According to their use, inductors can be classified as follows:

– inductors for alternating current:

  inductors that carry alternating current, such as transition inductors used for transition between tappings of tap changers, inductors for a.c. commutator motor braking circuits, interference suppression inductors, tuned filter inductors, etc.;

– inductors for direct current:

  inductors that carry direct current with small or negligible a.c. components, such as d.c. line filter inductors, inductive shunts for traction motors, inductors for d.c. motor braking circuits, etc.;

– inductors for pulsating current:

  inductors that carry direct or alternating current with a significant periodic ripple, such as smoothing inductors for traction motors, sinusoidal filter inductors in auxiliary converters, etc.

5 Service conditions

The normal service conditions for transformers and inductors shall be in accordance to IEC 62498-1. Special service conditions shall be agreed between the purchaser and manufacturer.

6 Rated current and load profile

6.1 Load profile

A transformer/inductor is designed to operate on the train in steady-state and transient (surge) conditions, both in normal and overload conditions.

The purchaser should specify the load profile according to Annex E (informative). The current frequency spectrum shall be specified by the responsible party.

6.2 Rated current

The rated current of a winding is the current this winding can sustain permanently at the reference temperature for continuous load.

The rated current shall be calculated according to either of following methods:

a) r.m.s. current derived from the load profiles;

b) considering thermal ageing of insulating materials according to Annex B (informative).

Special attention should be paid to varying cooling modes and to the averaging time window.

The reference temperature for continuous load is the cooling medium temperature at the external interface of the transformer/inductor. It shall:

c) either be directly specified by the purchaser;

   Specified values should be based on the air temperature external to vehicle as defined in IEC 62498-1.

d) or calculated by the manufacturer based on the temperature histogram provided by the purchaser and the method of Annex B (informative): see cooling medium reference temperature for lifetime calculation in B.4.2.

For a traction winding, the rated current shall correspond to the principal tapping. This definition of rated current applies when other windings, which are normally on load, deliver their rated loads.

7 Rated voltage and power of transformer windings

7.1 Rated line-side voltage

The rated line-side voltage is the r.m.s. voltage applicable in normal operating conditions to the line-side winding group. If this winding has tappings, the rated voltage shall be referred to the principal tapping.

Unless otherwise agreed between purchaser and manufacturer, the rated line-side voltage is specified as being equal to the nominal voltage of the traction system.

NOTE IEC 60850 gives the list of the nominal voltages of traction systems.

7.2 Rated secondary voltage

The rated voltage of a secondary winding of a transformer is the r.m.s. no-load voltage at the terminals of the winding when the principal tapping of the line-side winding of the transformer is fed at its rated voltage and frequency.