

Railway applications — Traction transformers and inductors on board rolling stock

The European Standard EN 60310:2004 has the status of a
British Standard

ICS 45.060

National foreword

This British Standard is the official English language version of EN 60310:2004. It is identical with IEC 60310:2004. It supersedes BS EN 60310:1997 which is withdrawn.

The UK participation in its preparation was entrusted by Technical Committee GEL/9, Railway electrotechnical applications, to Subcommittee GEL/9/2, Rolling stock, which has the responsibility to:

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English version

**Railway applications –
Traction transformers and inductors on board rolling stock
(IEC 60310:2004)**

Applications ferroviaires -
Transformateurs de traction et bobines
d'inductance à bord du matériel roulant
(CEI 60310:2004)

Bahnanwendungen –
Transformatoren und Drosselspulen
auf Bahnfahrzeugen
(IEC 60310:2004)

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Comité Européen de Normalisation Electrotechnique
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Foreword

The text of document 9/780/FDIS, future edition 3 of IEC 60310, prepared by IEC TC 9, Electrical equipment and systems for railways, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60310 on 2004-03-01.

This European Standard supersedes EN 60310:1996.

This European Standard includes the following significant technical changes from EN 60310:1996: it takes into account the new generic railway standards, more specifically general service conditions and shock and vibration considerations, referring to EN 60077-1 and EN 61373.

The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
national standard or by endorsement (dop) 2004-12-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2007-03-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60310:2004 was approved by CENELEC as a European Standard without any modification.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**RAILWAY APPLICATIONS –
TRACTION TRANSFORMERS AND INDUCTORS
ON BOARD ROLLING STOCK****1 Scope**

This International Standard applies to traction transformers installed on board rolling stock and to the various types of inductors inserted in the power and auxiliary circuits of electric vehicles.

NOTE 1 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 60289.

The inductors mentioned in the first paragraph may be:

- filter inductors;
- smoothing inductors;
- commutation inductors;
- protection inductors in static power convertors;
- inductive shunts for traction motors;
- inductors used for transition between tap changer notches;
- braking circuit inductors;
- interference suppression inductors.

NOTE 2 The requirements of IEC 60076 are applicable to traction transformers where they do not conflict with this standard, or with the specialized IEC publications dealing with traction applications.

NOTE 3 For transformers and inductors for static power convertors, reference should also be made to IEC 61287.

This standard can also be applied, after agreement between user 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 polyphase auxiliary circuits of vehicles, except for instrument transformers and transformers of a rated output below 1 kVA single-phase or 5 kVA polyphase.

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

When tap changers are an integral part of the transformers, they cannot be separated while the latter are tested.

For service conditions, refer to IEC 60077-1, Clause 7.

2 Normative references

The following referenced documents are indispensable for the application 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 60076-1:1993, *Power transformers – Part 1: General*

IEC 60076-2:1993, *Power transformers – Part 2: Temperature rise*

IEC 60076-3:2000, *Power transformers – Part 3: Insulation levels, dielectric tests and external clearances in air*

IEC 60076-5:2000, *Power transformers – Part 5: Ability to withstand short circuit*

IEC 60077-1:1999, *Railway applications – Electric equipment for rolling stock – Part 1: General service conditions and general rules*

IEC 60085:1984, *Thermal evaluation and classification of electrical insulation*

IEC 60289:1988, *Reactors*

IEC 60850:2000, *Railway applications – Supply voltage of traction systems*

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

IEC 61287-1:1995, *Power convertors installed on board rolling stock – Part 1: Characteristics and test methods*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60076 and IEC 60289 together with the following definitions apply.

3.1 Definitions for transformers

3.1.1

classification of transformers

depending on arrangements made for on-load variation of the secondary voltage of the traction circuits, traction transformers can be classified as:

- fixed ratio transformers;
- transformers with low-voltage tapping;
- transformers with high-voltage tapping.

3.2 Definitions for inductors

3.2.1

classification of inductors

according to their utilisation, 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, etc.

– *Inductors for direct current*

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

– *Inductors for pulsating current*

Inductors that carry direct current with a significant periodic ripple, such as smoothing inductors for traction motors, etc.

– *Inductors for convertors*

Inductors inserted inside electronic power convertors for purposes of commutation, protection or filtering.

3.3 Definitions for inductance

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

3.3.1

a.c. 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

transient inductance

derived from the oscillographic record of current in the inductor or from the measurement of the variation of magnetic flux; for example, the test could be carried out with direct current either by means of a sudden closing of the circuit or by a sudden short-circuiting of the inductor

3.3.3

incremental inductance

derived from a record of the terminal voltage when a specified pulsating current is passing through the inductor

NOTE 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.

3.3.4

rated values of inductors

the rated values and service conditions (current, voltage, frequency, duration, duty cycle, ventilation, etc.) shall be either guaranteed by the manufacturer, or submitted by the manufacturer for the agreement of the user, before execution of the tests

3.3.5

rated voltage U_N

the voltage at rated frequency assigned to be applied between the line terminals of a winding

3.3.6

maximum operating voltage $U_{\max}$

the highest voltage at rated frequency at which the inductor shall be capable of operating continuously without exceeding the specified temperature rises

3.3.7

rated insulation voltage U_{Nm}

the voltage at rated frequency assigned to be applied between either terminal of a winding and any other circuit or conductive part external to the winding

3.3.8

rated power Q_N

the reactive power specified for operation at rated voltage and frequency

3.3.9

rated current I_N

the current of the inductor derived from rated power and rated voltage.

4 Tappings

In order to permit variation of the voltage ratio of the transformer, one or more of its windings may be equipped with intermediate tappings, which shall be indicated on the diagram and in the specification, with a statement of their maximum operating characteristics.

4.1 Principal tapping

The principal tapping is that which enables the rated traction motor voltage to be obtained at the terminals of the motors when they are taking their rated current, the transformer line-side winding being supplied at rated voltage and frequency.

When both line-side windings and traction windings have intermediate tappings, the principal tappings shall be indicated.

For multi-system vehicles, the principal tappings may be different for each system.

The no-load voltage ratio shall be defined for the principal tapping and for other tappings.

5 Rated voltages of transformer windings

5.1 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 user 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.

5.2 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.

6 Rated power

Traction transformers usually have several secondary windings (e.g. traction, auxiliaries, train heating). The specification of the transformer shall indicate the rated power, in kilovolt-amperes, of each winding defined as the product of the rated voltage of this winding and its rated current.

The rating of a transformer is referred to a continuous duty.

The rated current of a winding is the current this winding can sustain permanently without exceeding the temperature-rise limit stated in Clause 8. 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.

NOTE The rated power of the line-side winding of a transformer can be less than the sum of the rated powers of its various secondary windings; this is permissible, for example, for the transformer of a single way connected static converter or for a traction transformer having a secondary for train heating which is only used during the cold season.

7 Cooling

7.1 Identification of transformers and inductors according to cooling method

7.1.1 Identification symbols

Transformers and inductors shall be identified according to the cooling method employed. Letter symbols for use in connection with each cooling method shall be as given in Table 1.

Table 1 – Letter symbols

Kind of cooling medium	Symbol
Mineral oil or synthetic insulating liquid with fire-point $\leq 300\text{ }^{\circ}\text{C}$	O
Synthetic insulating liquid with fire-point $> 300\text{ }^{\circ}\text{C}$	K
Synthetic insulating liquid having a fire-point greater than its boiling-point	L
Gas	G
Water	W
Air	A
Kind of circulation	Symbol
Natural	N
Forced (non-directed oil)	F
Forced-directed oil	D

In transformers and inductors with forced-directed oil circulation, a certain proportion of the forced-oil flow is channelled so as to pass through the windings. Some windings, however, may have a non-directed oil flow, for instance separate tapping windings, auxiliary windings and stabilizing windings.