

Specification for

Traction transformers and inductors

Committees responsible for this British Standard

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- Association of Consulting Engineers
- British Cable Makers' Confederation
- British Railways Board
- Bus and Coach Council
- Department of Transport (Railways Inspectorate)
- London Regional Transport
- Power Supply Manufacturers' Association (PSMA (BEAMA Ltd.))
- Railway Industry Association of Great Britain

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National foreword

This British Standard has been prepared under the direction of the Power Electrical Engineering Standards Policy Committee.

It is identical with IEC 310 'Traction transformers and inductors', published by the International Electrotechnical Committee (IEC).

Cross-references

International standard	Corresponding British Standard
IEC 76-3 : 1980	BS 171 Power transformers Part 3 : 1987 Specification for insulation levels and dielectric tests (Technically equivalent)
IEC 76-4 : 1976	Part 4 : 1978 Specification for tappings and connections (Identical)
IEC 76-5 : 1976	Part 5 : 1978 Specification for ability to withstand short circuit (Identical)
IEC 85 : 1984	BS 2757 : 1986 Method for determining the thermal classification of electrical insulation (Identical)
IEC 349 : 1971	BS 173 : 1980 Method of specifying performance of rotating electrical machines for rail and road vehicles (Technically equivalent)

Compliance with a British Standard does not of itself confer immunity from legal obligations.

TRACTION TRANSFORMERS AND INDUCTORS

CHAPTER I: SCOPE AND SERVICE CONDITIONS

1 Scope

This International Standard applies to traction transformers on single-phase a.c. line-side powered vehicles and to the various types of inductors inserted in the power or auxiliary circuits of electric vehicles, such as:

- 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.

NOTES

1 The requirements of IEC 76 are applicable to traction transformers where they do not conflict with this standard, or with the specialized IEC publications dealing with traction applications.

2 For transformers and inductors for static power convertors, reference should also be made to IEC 411.

1.1 *Extension of the scope*

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 the vehicles, except for instrument transformers and transformers of a rated output below 1 kVA single-phase or 5 kVA polyphase.

1.2 *Exclusions*

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.

1.3 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 76-1: 1976, *Power transformers - Part 1: General.*

IEC 76-2: 1976, *Power transformers - Part 2: Temperature rise.*

IEC 76-3: 1980, *Power transformers - Part 3: Insulation levels and dielectric tests. Amendment No. 1 (1981).*

IEC 76-4: 1976, *Power transformers - Part 4: Tappings and connections.*

IEC 76-5: 1982, *Power transformers - Part 5: Ability to withstand short circuits.*

IEC 85: 1984, *Thermal evaluation and classification of electrical insulation.*

IEC 165: 1973, *Rules for the testing of electric rolling stock on completion of construction and before entry into service.*

IEC 349: 1971: *Rules for rotating electrical machines for rail and road vehicles.*

IEC 411, *Power convertors for electric traction.*

IEC 850: 1988, *Supply voltage of traction systems.*

2 Service conditions

2.1 This standard applies to equipment used in the following conditions:

2.1.1 Altitude

Unless otherwise specified, the height above sea level at which the equipment is to work in normal operation is assumed not to exceed 1 200 m.

2.1.2 Temperature

Unless otherwise agreed upon between user and manufacturer in line with national temperature conditions, the ambient temperature at which the equipment is to work in normal operation lies between $-25\text{ }^{\circ}\text{C}$ and $+40\text{ }^{\circ}\text{C}$ with a yearly average not exceeding $25\text{ }^{\circ}\text{C}$.

If external ambient air is heated before entering the transformer (or inductor) heat exchanger, this information and the temperature of the entering air shall be given to the manufacturer.

2.1.3 Shock and vibration

In the absence of information concerning the degree of vibration and shock to which the transformers and inductors are likely to be subjected in service, it is to be assumed:

- that the vibrations are sinusoidal, that the frequency f of vibration is between 1 Hz and 50 Hz, and that the amplitude a , expressed in millimetres, is given as a function of f , by the equations:

$$a = 25/f \text{ for } 1 \text{ Hz} < f < 10 \text{ Hz}$$

$$a = 250/f^2 \text{ for } 10 \text{ Hz} < f < 50 \text{ Hz}$$

- that the maximum shock accelerations are:
 - . horizontally (in the direction of motion of the vehicle) 30 m/s²
 - . transversely 20 m/s²
 - . vertically 10 m/s²

NOTES

- 1 In addition to vibrations arising from the mechanical environment, consideration should be given to vibrations that could also occur as a result of the electrical environment.
- 2 The above requirements are given as guidance only and should be considered as under consideration. A Working Group has been entrusted with the study of vibration and shock requirements for all traction equipment.

2.2 Special service conditions

Special arrangements shall be agreed between user and manufacturer when conditions differ from those mentioned in 2.1, for example:

- altitude exceeding 1 200 m;
- ambient temperature above +40 °C or below –25 °C;
- high average temperature plus high air humidity;
- torrential rains, sand or snow storms, etc.

Checking on the effectiveness of such arrangements could, if required, form the subject of optional type tests which could be carried out on the vehicle itself in accordance with methods to be agreed between user and manufacturer.

CHAPTER II: DEFINITIONS

Section 1 – Definition for transformers

NOTE - Unless otherwise specified in this section, the general definitions given in IEC 76 are valid for the transformers covered by this standard.

3 Classification of transformers

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

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

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.

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 850 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 kilovoltampere, of each winding defined as the product of the rated voltage of this winding and its rated current.

The rating of a transformer is its continuous rating.

The rated current of a winding is the current this winding can sustain permanently without exceeding the temperature-rise limit stated in clause 12. 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 convertor or for a traction transformer having a secondary for train heating which is only used during the cold season.

Section 2 – Definitions for inductors

7 Classification of Inductors

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

- *Inductors for alternating current*

Inductors that carry alternating current, such as transition inductors used for transition between tapplings 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 or protection.

8 Definitions of Inductance

Values of inductance for inductors are related to the different classes of utilization 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.

8.1 A.C. inductance

Is 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.

A.C. inductance is the value to take into account for both inductors for alternating current and inductors for convertor.

8.2 Transient inductance

Is 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.