IEC 62695

Edition 1.0 2014-07

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Railway applications – Fixed installations – Traction transformers

Applications ferroviaires – Installations fixes – Transformateurs de traction

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CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

RAILWAY APPLICATIONS – FIXED INSTALLATIONS – TRACTION TRANSFORMERS

FOREWORD

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This standard is derived from EN 50329:2003 and its amendment 1(2010).

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

FDIS	Report on voting
9/1916FDIS	9/1943/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- withdrawn,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.

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INTRODUCTION

Transformers used in fixed installations of traction systems differ from other transformers. The transformer standards of IEC technical committee 14 deal mainly with three-phase transformers or single-phase units assembled to a three-phase bank.

Application of such standards to single- or bi-phase transformers as used in traction systems is not evident.

Moreover, IEC 61378-1 deals with converter transformers for industrial use which have loading characteristics different from traction transformers for converters.

Therefore, this standard is set up to clarify the particular aspects of traction transformers.

RAILWAY APPLICATIONS – FIXED INSTALLATIONS – TRACTION TRANSFORMERS

1 Scope

This International Standard covers specific characteristics of traction transformers as defined in 3.1.1, used in traction substations or along the track for the supply of power to a.c. and d.c. traction systems or to provide power to auxiliary services. Traction transformers are either

– single-phase traction transformers, or
– three-phase to two-phase traction transformers, or
– single-, three- or poly-phase rectifier-transformers or converter-/inverter-transformers for d.c. or a.c. traction systems, or
– single phase auto-transformers for traction power supply, or
– single-phase booster transformers, or
– single- or three-phase auxiliary transformers at traction supply voltage.

Traction transformers are generally covered by the Standards of the IEC 60076 series. The requirements given in IEC 60076 apply together with the additional requirements given in this standard.

Dependent on the selected technology specific parts of IEC 60076 apply:

– IEC 60076-1: Oil-immersed transformers
– IEC 60076-11: Dry-type transformers
– IEC 60076-15: Gas-filled transformers

For transformers feeding contact lines through static converters IEC 61378-1 may assist, but modified or additional requirements are given in this standard.

Transformers mounted on-board traction vehicles are covered by IEC 60310 and are excluded from the scope of this standard.

Electromagnetic compatibility is ruled by IEC 60076-1, which states that a transformer may be considered a passive element in this respect. Some accessories, however, are subject to EMC requirements given in IEC 62236-5.

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

IEC 60076-2:2011, *Power transformers – Part 2: Temperature rise for liquid-immersed transformers*

IEC 60076-3:2013, *Power transformers – Part 3: Insulation levels, dielectric tests and external clearances in air*

IEC 60076-5:2006, *Power transformers – Part 5: Ability to withstand short circuit*

IEC 60076-7:2005, *Power transformers – Part 7: Loading guide for oil-immersed power transformers*

IEC 60076-11:2004, *Power transformers – Part 11: Dry-type transformers*

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

IEC 60076-14:2013, *Power transformers – Part 14: Liquid-immersed power transformers using high-temperature insulation materials*

IEC 60076-15:2008, *Power transformers – Part 15: Gas-filled power transformers*

IEC TR 60146-1-2:2011*, Semiconductor converters – General requirements and line commutated converters – Part 1-2: Application guide*

IEC 60850:2007, *Railway applications – Supply voltages of traction systems*

IEC 61000-2-12:2003, *Electromagnetic Compatibility (EMC) – Part 2-12: Environment – Compatibility levels for low-frequency conducted disturbances and signalling in public medium-voltage power supply systems*

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 62498-2:2010, *Railway applications – Environmental conditions for equipment – Part 2: Fixed electrical installations*

IEC 62505-1:2009, *Railway applications – Fixed installations – Particular requirements for a.c. switchgear – Part 1: Single-phase circuit-breakers with* U_m *above 1 kV*

IEC 62589:2010, *Railway applications – Fixed installations – Harmonisation of the rated values for converter groups and tests on converter groups*

IEC 62590:2010, *Railway applications – Fixed installations – Electronic power converters for substations*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60076-1 and IEC 62590, as well as the following apply.

3.1.1
traction transformer
transformer (with separate or auto-connected windings) connected to an a.c. or d.c. contact line, directly or through a converter, used in fixed installations of railway applications

Note 1 to entry: The above definition relates to the contents of this standard and is introduced to simplify the following definitions, which, in most cases, are not valid for all transformers and autotransformers.

3.1.2
traction converter transformer
traction transformer on the supply side of a converter group and supplying contact line(s) through static converter(s)

3.1.3
traction inverter transformer
traction transformer on the traction (contact) line side of a converter group and supplied by a static converter(s) (inverter)

3.1.4
directly-coupled traction transformer
traction transformer supplying contact line(s) without the interposition of static converter(s)

3.1.5
rated value
numerical value for the electrical, thermal, mechanical and environmental rating assigned to the quantities which define the operation of a traction transformer in the conditions specified in accordance with this International Standard and on which the manufacturer's guarantees and tests are based

3.1.6
rated frequency
f_{N}
frequency at which the traction transformer is designed to operate

3.1.7
rated voltage on the supply side of a traction transformer
U_{NL}
r.m.s. value of the sinusoidal no-load voltage assigned to be applied to the supply side terminals of a traction transformer (for traction converter transformers)

3.1.8
rated voltage of a traction autotransformer
U_{OHL}
r.m.s. value of the sinusoidal no-load voltage between the overhead contact line and the line feeder in a traction autotransformer

3.1.9
rated intermediate voltage of a traction autotransformer
U_{rail}
r.m.s. value of the sinusoidal no-load voltage between the overhead contact line and the connection to the rail

3.1.10
rated voltage on the converter side(s) of a traction converter transformer and on the traction side of a directly-coupled traction transformer
U_{NS}
r.m.s. value of the no-load voltage at the line-to-line terminals of the converter side(s) of a traction converter transformer or of the traction side of a directly-coupled traction transformer, at the rated voltage on the supply side of the traction transformer

3.1.11
rated voltage on the inverter side of a traction inverter transformer
U_{NP}
r.m.s. value of the sinusoidal no-load voltage resulting at the inverter side terminals of a traction transformer

3.1.12
rated voltage on the traction side(s) of an inverter transformer
U_{NV}
r.m.s. value of the no-load voltage at the line-to-line terminals of the traction side(s) of an inverter transformer at the rated voltage on its inverter side

3.1.13
rated power of a winding
S_{NL}, S_{NP}, S_{NSn}, S_{NV}
conventional value of apparent power assigned to a winding, which, together with the rated voltage of the winding, determines its rated current. It is based on the fundamental components of voltage and current (see 3.1.7, 3.1.10, 3.1.12 and 3.1.14)

Note 1 to entry: "primary" and "secondary" are referred to the normal flow of energy from the supply side to the traction side.

Note 2 to entry: In the suffix "S_n" for secondary windings "n" is the assigned order number of the secondary winding. In a formula where any winding is separately considered, S_N indicates the rated power of the winding considered.

3.1.14
rated current on the primary side of the traction transformer
I_{NL}, I_{NP}
r.m.s. value of the fundamental component of the current flowing through a line terminal of the primary winding which is derived from the rated power S_N and rated voltage U_N for the winding

Note 1 to entry: The generic r.m.s. of fundamental component of an a.c. current is indicated as I and the generic rated current as I_N.

3.1.15
rated current in the series winding of a traction autotransformer
I_{OHL}
r.m.s. value of the current flowing between the contact line terminal of a traction autotransformer and rail terminal

3.1.16
rated current in the common winding of a traction autotransformer
I_{feed}
r.m.s. value of the current flowing between the line feeder terminal of a traction autotransformer and rail

3.1.17
rated service current on the primary side of the traction converter transformer
I_{NGL}
r.m.s. value of the current flowing through a line terminal of the supply side winding of a traction converter transformer which contains all harmonic components and whose fundamental component is the rated current I_{NL}

Note 1 to entry: In case of traction inverter transformers it is assumed that the service current is not sensibly different from sinusoidal current in all windings.

Note 2 to entry: The generic r.m.s. value of the service current is indicated as I_G.

Note 3 to entry: The generic r.m.s. value of the harmonic current of order h of an a.c. current is indicated as I_h.

Note 4 to entry: In formulas where any winding is separately considered, I_N indicates the rated current of the winding considered and I_{NG} its rated service current.

3.1.18
rated current on the secondary side of a traction transformer
I_{NS}, I_{NV}
r.m.s value of the fundamental component of the current flowing at the terminals of the secondary winding(s) of a traction transformer, which is derived from the rated power S_N and rated voltage U_N for the winding

Note 1 to entry: When the secondary windings of a converter transformer are more than one, even if the secondaries are intended to feed a single conversion bridge, the rated secondary current of each winding may differ from that of other winding(s) by small quantities. The tolerances in any case should be observed.

Note 2 to entry: In some cases, the secondary current(s) of a traction converter transformer are not equal to the input current of the converter due to the presence of an auxiliary transformer (see Clause 3 of IEC 62589:2010).

3.1.19
rated service current on the converter (valve) side of a traction converter transformer
I_{NGSn}
r.m.s value of the current flowing at the terminals of the secondary winding(s) of a traction converter transformer which contains all harmonic components and whose fundamental component is the rated current I_{NS}

Note 1 to entry: I_{NGS} differs from I_{NS}. The latter is taken into account to determine loadability of given accessories such as bushing insulators. Loss and temperature rise calculations are based on the rated service current, considering also the additional eddy losses in the windings and structural parts produced by the harmonics.

Note 2 to entry: In some cases, the secondary current(s) of a traction converter transformer are not equal to the input current of the converter due to the presence of an auxiliary transformer (see Clause 3 of IEC 62589:2010).

Note 3 to entry: In a formula where any winding is separately considered, I_N indicates the rated current of the winding considered and I_{NG} its rated service current.

3.1.20
basic current

I_{BL}, I_{BP}, I_{BS}, I_{BV}, I_{BGL}, I_{BGS}
current value in a winding which, according to a given duty class (see 3.1.31), is assumed to last for longer periods and represents the load carried out continuously by the traction transformer and on which the overloads are imposed.

3.1.21
basic current on the primary side of a traction transformer
I_{BL}, I_{BP}
r.m.s. value of the fundamental component of the current flowing through a line terminal of the primary winding which is derived from the basic power S_B and rated voltage U_N for the winding

3.1.22
basic service current on the primary side of the traction converter transformer
I_{BGL}
r.m.s. value of the current flowing through a line terminal of the supply side winding of a traction converter transformer which contains all harmonic components and whose fundamental component is the basic current I_{BL}

3.1.23
basic current on the secondary side of a traction transformer
I_{BS}, I_{BV}
r.m.s. value of the fundamental component of the current flowing at the terminals of the secondary winding(s) of a traction transformer, which is derived from the basic power S_B and rated voltage U_N for the winding

3.1.24

basic service current on the converter (valve) side of a traction converter transformer

I_{BGSn}

r.m.s value of the current flowing at the terminals of the secondary winding(s) of a traction converter transformer which contains all harmonic components and whose fundamental component is the basic current I_{BS}

3.1.25

leakage reactance related to the primary winding

X_{p}

<for three winding transformer> difference between the mean of the short circuit reactance values measured between the primary winding and each secondary winding and one half of the short circuit reactance measured between the two secondary windings

$$X_{\mathrm{p}} = \frac{X_{\mathrm{ccP/S1}} + X_{\mathrm{ccP/S2}}}{2} - \frac{X_{\mathrm{ccS1/S2}}}{2}$$

3.1.26

leakage reactance related to each of the secondary windings

X_{S1}, X_{S2}

<for three winding transformer> sum of the half difference of the short circuit reactance values measured between the primary winding and each secondary winding and one half of the short circuit reactance measured between the two secondary windings

$$X_{\mathrm{S1}} = \frac{X_{\mathrm{ccP/S1}} - X_{\mathrm{ccP/S2}}}{2} + \frac{X_{\mathrm{ccS1/S2}}}{2}$$

$$X_{\mathrm{S2}} = \frac{X_{\mathrm{ccP/S2}} - X_{\mathrm{ccP/S1}}}{2} + \frac{X_{\mathrm{ccS1/S2}}}{2}$$

3.1.27

reactance ratio

coupling factor

K

ratio between the leakage reactance from primary side and the sum of the leakage reactance from primary and secondary side

Note 1 to entry: In case of a traction transformer with two secondary windings, used for a twelve-pulse reaction converter, the reactance ratio is designed to have the same no-load secondary voltages and the same impedance between the primary and each secondary winding, in order to obtain an even sharing of the current on both bridges in case the d.c. outputs are paralleled. Then $X_{\mathrm{S1}} = X_{\mathrm{S2}} = X_{\mathrm{S}}$ and

$$K = X_{\mathrm{p}} / (X_{\mathrm{S}} + X_{\mathrm{p}})$$

3.1.28

current demand

actual or expected load variation of the current absorbed by a traction line, whose root mean square value is the rated current. It is expressed by a load diagram

3.1.29

load diagram

true demand of current by the traction circuit in the worse expected condition