SLOVENSKI STANDARD
SIST EN 50329:2003

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Nadomeģļ a:

SIST HD 591 S1:1998

Ģelezniģke naprave ï Stabilne naprave elektriļ ne vleke ï Transformatorji vleļ nih tokokrogov

Railway applications - Fixed installations - Traction transformers

Bahnanwendungen - Ortsfeste Anlagen - Bahn-Transformatoren

Applications ferroviaires - Installations fixes - Transformateurs de traction

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ICS:

29.180	Transformatorji. Dušilke	Transformers. Reactors
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Supersedes HD 591 S1:1993 and EN 60146-1-3:1993 (partly)

English version

Railway applications – Fixed installations – Traction transformers

Applications ferroviaires – Installations fixes – Transformateurs de traction

Bahnanwendungen – Ortsfeste Anlagen – Bahn-Transformatoren

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CENELEC

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Foreword

This European Standard was prepared by SC 9XC, Electric supply and earthing systems for public transport equipment and ancillary apparatus (fixed installations), of Technical Committee CENELEC TC 9X, Electrical and electronic applications for railways.

The text of the draft was submitted to the formal vote and was approved by CENELEC as EN 50329 on 2002-05-01.

This European Standard supersedes HD 591 S1:1993 and, for the transformers mentioned in the scope of this EN 50329, EN 60146-1-3:1993.

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) 2003-09-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2005-05-01

Annexes designated "normative" are part of the body of the standard.
Annexes designated "informative" are given for information only.
In this standard, Annexes B and C are normative and Annexes A, D, E and F are informative.

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Introduction

HD 591 S1 was prepared jointly by SC 9XC and TC 14 to face specific aspects of the transformers used in fixed installations of traction systems, which differ from other transformers. In effect transformer standards are mainly dealing 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, EN 61378-1 deals with converter transformers for industrial use which have loading characteristics different from traction transformers for converters.

Therefore HD 591 S1 and this document were set up to clarify such particular aspects.

HD 591 S1 was studied in early '90 and published in 1993 and experienced during the period 1993 to 1997. Then, having decided to convert the HD into an EN, the opportunity was taken to revise the document to introduce the improvements that have been found suitable during this trial period.

1 General

1.1 Scope

This European Standard covers specific characteristics of traction transformers as defined in 1.3.1, used in traction substation 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,
- single-, three- or poly-phase rectifier-transformers or converter/inverter-transformers for d.c. or a.c. contact line,
- single phase auto-transformers for traction power supply,
- single- or three-phase auxiliary transformers at traction supply voltage.

Transformers feeding a.c. contact lines are covered by EN 60076. Dry-type transformers are covered by HD 464. These standards are valid with the additional requirements given in this document.

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

NOTE Transformers mounted on-board traction vehicles are covered by EN 60310 and are excluded from the scope of this document.

Electromagnetic compatibility is ruled by EN 60076-1 which states that a transformer may be considered a passive element in this respect.

Some accessories however are subject to EMC requirements and shall comply with EN 50121-5.

1.2 Normative references

This European Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 50121-5	2000	Railway applications - Electromagnetic compatibility Part 5: Emission and immunity of fixed power supply installations and apparatus
EN 50122-1	1997	Railway applications - Fixed installations Part 1: Protective provisions relating to electrical safety and earthing
EN 50124-1	2001	Railway applications - Insulation coordination Part 1: Basic requirements - Clearances and creepage distances for all electrical and electronic equipment
EN 50125-2	2002	Railway applications - Environmental conditions for equipment Part 2: Fixed electrical installations
EN 50152-1	1997	Railway applications - Fixed installations - Particular requirements for a.c. switchgear Part 1: Single-phase circuit-breakers with Um above 1 kV
EN 50163	1995	Railway applications - Supply voltages of traction systems
EN 50327	2003	Railway applications - Fixed installations - Harmonisation of the rated values for converter groups and tests on converter groups
EN 50328	2003	Railway applications - Fixed installations - Electronic power converters for substations
EN 60076-1 + A11	1997 1997	Power transformers - Part 1: General (IEC 60076-1:1993, mod.)
EN 60076-2	1997	Power transformers - Part 2: Temperature rise (IEC 60076-2:1993, mod.)

EN 60076-3	2001	Power transformers - Part 3: Insulation levels, dielectric tests and external clearances in air (IEC 60076-3:2000 + corrigendum December 2000)
EN 60076-5	2000	Power transformers - Part 5: Ability to withstand short circuit (IEC 60076-5:2000)
EN 61000-2-12	- [1)]	Electromagnetic Compatibility (EMC) Part 2-12: Environment - Compatibility levels for low-frequency conducted disturbances and signalling in public medium-voltage power supply systems
EN 61378-1	1998	Convertor transformers - Part 1: Transformers for industrial applications (IEC 61378-1:1997)
HD 428.4 S1	1994	Three phase oil-immersed distribution transformers 50 Hz, from 50 to 2 500 kVA with highest voltage for equipment not exceeding 36 kV Part 4: Determination of the power rating of a transformer loaded with non-sinusoidal currents
HD 464 S1 + A2 + A3 + A4	1988 1991 1992 1995	Dry-type power transformers (IEC 60726:1982 + A1:1986, mod.)
HD 538.3 S1	1997	Three-phase dry-type distribution transformers 50 Hz, from 100 to 2 500 kVA, with highest voltage for equipment not exceeding 36 kV Part 3: Determination of the power rating of a transformer loaded with non-sinusoidal current
IEC 60354	1991	Loading guide for oil-immersed power transformers
IEC 60905	1987	Loading guide for dry-type power transformers

1.3 Definitions

For the purpose of this European Standard, the terms and definitions given in EN 60076-1 and EN 50328 and the following apply.

NOTE Figure 1 and Figure 2 of EN 50327 give a graphic orientation among various quantities.

1.3.1
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 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.

1.3.1.1
traction converter transformer
traction transformer on the supply side of a converter group and supplying contact line(s) through static converter(s)

1.3.1.2
traction inverter transformer
traction transformer on the traction (contact) line side of a converter group and supplied by a static converter(s) (inverter)

1.3.1.3
directly-coupled traction transformer
traction transformer supplying contact line(s) without the interposition of static converter(s)

[1)] To be published.

1.3.2
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 European Standard and on which the manufacturer's guarantees and tests are based

1.3.3
rated frequency (f_N)
frequency at which the traction transformer is designed to operate

1.3.4
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)

1.3.4.1
rated voltage of a traction autotransformer (U_{OHL})
r.m.s. value of the sinusoidal voltage between the overhead contact line and the line feeder (see 3.3.10 of EN 50122-1) in a traction autotransformer

1.3.4.2
rated intermediate voltage of a traction autotransformer (U_{rail})
r.m.s. value of the sinusoidal voltage between the overhead contact line and the connection to the rail

1.3.5
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

1.3.6
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

1.3.7
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

1.3.8
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 1.3.4, 1.3.5, 1.3.7 and 1.3.9)

NOTE 1 "Primary" and "secondary" are referred to the normal flow of energy from the supply side to the traction side.

NOTE 2 In the suffix "Sn" 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.

1.3.9
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 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.

1.3.9.1
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

1.3.9.2
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

1.3.10
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 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 The generic r.m.s. value of the service current is indicated as I_G.

NOTE 3 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 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.

1.3.11
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 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 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 EN 50327).

1.3.12
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 I_{NGS} differs from I_{NS}. The latest 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 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 EN 50327).

NOTE 3 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.

1.3.13
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 1.3.18), 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. By consequence are defined

1.3.13.1
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

1.3.13.2
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})

1.3.13.3
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

1.3.13.4
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})

1.3.14
leakage reactance related to the primary winding (for three winding transformer) (X_p)
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

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

1.3.15
leakage reactance related to each of the secondary windings (for three winding transformer) (X_{S1}, X_{S2})
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

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

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

1.3.16
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 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 $X_{S1} = X_{S2} = X_S$ and

$$K = X_p / (X_S + X_p)$$

1.3.17
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

1.3.17.1
load diagram
true demand of current by the traction circuit in the worse expected condition

1.3.18
load cycle
conventional representation of the current demand to a traction transformer expressed in per unit of the rated currents. It shows the repetitive variation of the loads with the time and, hence, the overloads

and underloads the traction transformer is expected to carry, as well as the duration and intervals assumed

NOTE Load cycles and duty classes are intended to allow testing of the traction transformers.

1.3.19
duty class
conventional classification of the current capability of a traction transformer expressed in per unit of the basic currents (I_B). The duty classes, associated with other rated values, define the characteristics of a traction transformer. Annex A indicates preferred duty classes and the corresponding basic and rated values

NOTE The indication of a duty class is not compulsory.

1.3.20
long time overload
peak load in the load cycle lasting from 480 s up to 7 200 s

1.3.21
short time overload
peak load in the load cycle lasting up to and including 480 s

1.3.22
additional winding
winding required for connection of auxiliary devices such as harmonic filters

1.4 List of symbols

See also Figure 1 of EN 50327.

f_N	rated frequency
I_{BL}	basic current on the supply side of a traction converter transformer
I_{BP}	basic current on the supply side of a traction inverter transformer
I_{BS}	basic current on the secondary side of a traction converter transformer
I_{BGL}	basic service current on the primary side of a traction converter transformer
I_{BGS}	basic service current on the converter (valve) side of a traction converter transformer
I_{BGSn}	basic service current on the converter (valve) side of a traction converter transformer
I_{BV}	basic current on the secondary side of a traction inverter transformer
I_{feed}	rated current in the common winding of a traction autotransformer
I_{NGL}	rated service current on the primary side of a traction converter transformer
I_{NGSn}	rated service current on the converter (valve) side of a traction converter transformer
I_{NL}	rated current on the supply side of a traction converter transformer
I_{NP}	rated current on the supply side of a traction inverter transformer
I_{NS}	rated current on the secondary side of a traction converter transformer
I_{NV}	rated current on the secondary side of a traction inverter transformer
I_{OHL}	rated current in the series winding of a traction autotransformer
K	coupling factor
S_{NL}	rated power of the supply side winding of a traction transformer
S_{NP}	rated power on the inverter side winding of a traction inverter transformer
S_{NSn}	rated power of the converter side winding(s) of a traction converter transformer and on the traction side winding of a directly-coupled traction transformer
S_{NV}	rated power on the traction side winding(s) of an inverter transformer
U_{NL}	rated voltage on the supply side of a traction transformer