SLOVENSKI STANDARD
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Železniške naprave - Fiksni postroji in vozna sredstva - Tehnični kriteriji za uskladitev med napajalnimi viri in voznimi sredstvi za doseganje interoperabilnosti - 1. del: Splošno

Railway Applications - Fixed installations and rolling stock - Technical criteria for the coordination between electric traction power supply systems and rolling stock to achieve interoperability - Part 1: General

Applications ferroviaires - Installations fixes et matériel roulant - Critères techniques pour la coordination entre les installations fixes de traction électrique et le matériel roulant pour réaliser l'interopérabilité

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ICS:

29.280	Električna vlečna oprema	Electric traction equipment
45.060.01	Železniška vozila na splošno	Railway rolling stock in general

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EUROPEAN STANDARD

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July 2022

ICS 29.280; 45.060.01

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English Version

Railway Applications - Fixed installations and rolling stock - Technical criteria for the coordination between electric traction power supply systems and rolling stock to achieve interoperability - Part 1: General

Applications ferroviaires - Installations fixes et matériel roulant - Critères techniques pour la coordination entre les installations fixes de traction électrique et le matériel roulant pour réaliser l'interopérabilité - Partie 1: généralités

Bahnanwendungen - Ortsfeste Anlagen und Fahrzeuge - Technische Kriterien für die Koordination zwischen elektrische Bahnenergieversorgungssysteme und Fahrzeugen zum Erreichen der Interoperabilität - Teil 1: Allgemeines

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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European foreword

This document (EN 50388-1:2022) has been prepared by CLC/SC 9XC, “Electric supply and earthing systems for public transport equipment and ancillary apparatus (Fixed installations)”, of Technical Committee CLC/TC 9X, “Electrical and electronic applications for railways”. It also concerns the expertise of CLC/SC 9XB, “Electromechanical material on board of rolling stock”.

The following dates are fixed:

• latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2023-07-04
• latest date by which the national standards conflicting with this document have to be withdrawn	(dow)	2025-07-04

This document supersedes EN 50388:2012 and all of its amendments and corrigenda (if any).

EN 50388−1:2022 includes the following significant technical changes with respect to EN 50388:2012:

- Clause 1: clarification of scope,
- Clause 2: set dated normative references, simplification,
- Clause 3: clarification of definition, renumbering, coherence among terms, addition of abbreviations, withdrawal of terms not used anymore,
- Clause 4: clarification of applicability,
- Clause 5: new structure,
- Clause 6: new drafting taking into account the latest development of traction unit drives,
- Clause 7: new structure taking into account the latest development of traction unit and needs from infrastructure traction power supply system. Addition of power limitation due to frequency variation,
- Clause 8: complete change, giving new parameters to evaluate the capability of the traction power supply system to supply the trains, definition of new indices,
- Previous text of Clause 8 in new Annex B,
- Clause 9: distinction between the table on traction power supply systems and their characterization,
- Clause 10: new structure and text, reference to future EN 50388-2, description of compatibility study process moved to Annex I,
- Clause 11: clarification on the use of this chapter, new information on the sequence of tripping among the circuit breakers, new figure on reclosing sequences, new chapter on maximum inrush current of AC traction unit,
- Clause 12: clarification and improvement, ex Table 8 in new Annex G, new condition for DC systems
- Clause 15: adaptation of the subclauses due to changes in Clauses 5 to 12
- Clause 15.4.1: new text, former Table 10 in Annex B,
- Annex A: improvement on values,
- Annex B, includes part of the previous Clause 8,
- Former Annex C will be located in part 2 of the EN 50388,

- New Annex C on sign convention, includes ex Annex E,
- New Annex D including ex Annex F, on maximum allowable train set current,
- New Annex E on power limitation as a function of line frequency,
- New Annex F on maximum traction and power of a train set against voltage, includes parts of ex Clause 7,
- New Annex G includes ex Table 8 on the use of regenerative braking,
- New Annex H includes former Annex D as long as part 2 of the EN 50388 is not issued,
- New Annex I includes former text from 10.3 on compatibility study
- New Annex J includes former Annex G

This version includes technical changes, clarifications without technical changes and best practises coming from the use of the last version of the document.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a Standardization Request given to CENELEC by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s) / Regulation(s).

For relationship with EU Directive(s) / Regulation(s), see informative Annex ZZ, which is an integral part of this document.

An additional part 2 is in preparation. In relation to assessment of harmonics and dynamic effects, this document (Part 1) sets out the generic process in Clause 10, and a future part 2 of this standard will give details and acceptance criteria related to known stability, harmonic phenomena and technologies.

EN 50388 “Railway applications – Fixed installations and rolling stock - Technical criteria for the coordination between traction power supply and rolling stock to achieve interoperability” will consist of the following parts:

- EN 50388-1, General
- Future EN 50388-2, Stability and harmonics

Any feedback and questions on this document should be directed to the users’ national committee. A complete listing of these bodies can be found on the CENELEC website.

1 Scope

This document establishes requirements for the electrical aspects to achieve technical compatibility between rolling stock and electric traction systems, limited to:

— co-ordination of protection principles between power supply and traction units, i.e. separation sections, train set current or power limitation, short circuit current discrimination, breaker coordination and use of regenerative braking.

— co-ordination of installed power on the line and the power demand of trains, i.e. traction unit power factor, train set current or power limitation, electric system performance, type and characterization.

— compatibility assessment relating to harmonics and dynamic effects.

Informative values are given for some parts of the existing European railway networks, in annexes.

NOTE For those railways within the scope of EU Interoperability Directive, definitive values are set out in the register of infrastructure published in accordance with Article 49 of Directive (EU) 2016/797, and the list of items included in the register is described in the commission decision (EU) 2019/777.

The following electric traction systems are within the scope of this document:

— railways;

— guided mass transport systems that are integrated with railways;

— material transport systems that are integrated with railways.

Information is given on electrification parameters to enable train operating companies to confirm, after consultation with the rolling stock manufacturers, that risks of non-compatibility are minimized and that there will be no consequential disturbance on the electrification system.

The interaction between pantograph and overhead contact line is dealt with in EN 50367:2020.

The interaction with the control-command and signalling subsystem is not dealt with in this document.

Basic considerations have been included concerning the use of accumulator trains.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

EN 50122-2:2010, *Railway applications - Fixed installations - Electrical safety, earthing and the return circuit - Part 2: Provisions against the effects of stray currents caused by d.c. traction systems*

EN 50124-1:2017, *Railway applications - Insulation coordination - Part 1: Basic requirements - Clearances and creepage distances for all electrical and electronic equipment*

EN 50163:2004,[1] *Railway applications - Supply voltages of traction systems (with Corrigenda in May 2010 and January 2013)*

IEC 60050-811:2017, *International Electrotechnical Vocabulary (IEV) - Part 811: Electric traction*

[1] As impacted by EN 50163:2004/A1:2007, EN 50163:2004/AC:2013 and EN 50163:2004/Corrigendum May 2010.

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-811:2017 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at http://www.iso.org/obp
- IEC Electropedia: available at http://www.electropedia.org/

3.1.1
contact line
conductor system for supplying electric energy to vehicles through current-collecting equipment

[SOURCE: IEC 60050-811:2017, 811-33-01, modified - The Note 1 to entry has been removed.]

3.1.2
overhead contact line
contact line placed above the upper limit of the vehicle gauge and supplying vehicles with electric energy through pantographs

[SOURCE: IEC 60050-811:2017, 811-33-02, modified - “Catenary” has been removed as synonym, “or beside” has been removed, “roof mounted current collection equipment” has been replaced by “pantographs“.]

3.1.3
infrastructure manager
any body or undertaking that is responsible in particular for establishing and maintaining railway infrastructure

Note 1 to entry: This may also include the management of infrastructure control and safety systems. The functions of the infrastructure manager on a network or part of a network may be allocated to different bodies or undertakings.

[SOURCE: Directive 2012/34/EU Article 3 (2) modified - only referring to part of the infrastructure.]

3.1.4
new element
new, rebuilt or modified traction-unit or power supply component (hardware or software) having a possible influence on the harmonic or dynamic behaviour of the power supply system

Note 1 to entry: This new element can be integrated in an existing power supply network with traction units e.g. for fixed installation:

- Transformer;
- HV cable;
- Filters;
- Converter.

Note 2 to entry: Depot areas are a combination of equipment listed in note 1 to entry associated with a large number of traction units and therefore very prone to harmonic and dynamic effects.

Note 3 to entry: New means also introduction of an existing element on another infrastructure system: “new to this infrastructure”.

Note 4 to entry: This concept will be addressed further in the future part 2 of this document.

3.1.5
normal operating conditions
conditions pertaining when traffic is operating to the design timetable and train formation used for power supply fixed installation design

Note 1 to entry: Power supply equipment is operated in accordance with the system specification which is defined by the infrastructure manager's policy,

[SOURCE: EN 50163:2004, 3.16, modified – "traffic operating" has been replaced by "Conditions pertaining when traffic is operating ", last sentence has been removed and the Note 1 to entry has been modified.]

3.1.6
displacement power factor cos φ
ratio of the active power of the fundamental component P_1 to the apparent power of the fundamental component S_1 under periodic conditions

$$cos\varphi = \frac{active\ power\ of\ the\ fundamental}{apparent\ power\ of\ the\ fundamental}$$

Note 1 to entry: In this document, only the fundamental component is considered

3.1.7
register of infrastructure
for those railways within the scope of EU Interoperability Directive, register stating the values of the network parameters of each subsystem or part of subsystem concerned, as set out in the relevant TSI

Note 1 to entry: The parameters are given for each section of line and those relevant to the electric traction system are set out in the Energy subsystem entry.

Note 2 to entry: The register of infrastructure is published in accordance with Article 49 of Directive (EU) 2016/797, and the list of items included in the register is described in the commission decision (EU) 2019/777.

[SOURCE: derived from Article 49 of Directive (EU) 2016/797]

3.1.8
rolling stock
all vehicles with or without motors

Note 1 to entry: Examples of vehicles include a locomotive, a coach and a wagon.

Note 2 to entry: Preferred German translation "Bahnfahrzeuge", French translation "Matériel roulant", other translations given in IEV.

[SOURCE: IEC 60050-811:2017, 811-02-01, modified – The Note 2 to entry has been added.]

3.1.9
separation section
section of a contact line provided with a sectioning point at each end to prevent successive electrical sections, differing in voltage amplitude, phase or frequency being connected together by the passage of current collectors

Note 1 to entry: In other standards, IEV, EN 50367, the term "neutral" replaces "separation".

3.1.10
substation, <traction>
installation, the main function of which is to supply a contact line system, at which the voltage of a primary supply system, and in certain cases the frequency, is converted to the voltage and frequency of the contact line

[SOURCE: IEC 60050-811:2017, 811-36-02, modified – The specific use "in electric traction" and the synonym "substation" have been removed.] The definition has been modified and the Note 1 to entry has been removed.]

3.1.11
traction unit (TU)
locomotive, motor coach or train-unit

Note 1 to entry: German translation "Triebfahrzeugeinheit", French translation "Unité motrice", other translations given in IEV.

[SOURCE: IEC 60050-811:2017, 811-02-04, modified – The Note 1 to entry has been added.]

3.1.12
train set
combination of vehicles coupled together, including banking locomotives

Note 1 to entry: German translation “Zugverband”, French translation “Train (composition)”.

3.1.13
maximum power at wheel
highest power derived from tractive effort vs speed diagram calculated for any type of train set

3.1.14
electric traction power supply system
railway electric distribution network used to provide energy for rolling stock

Note 1 to entry: The system includes

- contact line systems,
- return circuit of electric traction systems,
- running rails of non-electric traction systems, which are in the vicinity of, and conductively connected to the running rails of an electric traction system,
- electric installations, which are supplied from contact lines either directly or via a transformer,
- electric installations in power plants and substations, which are utilized solely for generation and distribution of power directly to the contact line,
- electric installations of switching stations.

[SOURCE: IEC 60050-811:2017, 811-36-21], modified – “power supply” has been added in the term

3.1.15
vehicle
any single item of rolling stock, e.g. a locomotive, a coach or a wagon

Note 1 to entry: German translation “Fahrzeug”, French translation “Véhicule”.

3.1.16
short-circuit current (I_{ss})
prospective sustained current resulting from a short circuit due to a fault or an incorrect connection in an electric circuit

Note 1 to entry: The term I_{ss} relates to the short circuit performance characteristics for DC switchgear.

[SOURCE: EN 50123-1:2003, 3.2.12], modified – Note 1 to entry has been added

3.1.17
cut-off current ($I_{cut\text{-}off}$)
maximum instantaneous value of current attained during the breaking operation of a switching device

[SOURCE: EN 50123-1:2003, 3.2.14], modified – “($I_{cut\text{-}off}$)” has been added in the term

3.1.18
inrush current
transient current associated with energizing of transformers, cables, reactors, etc

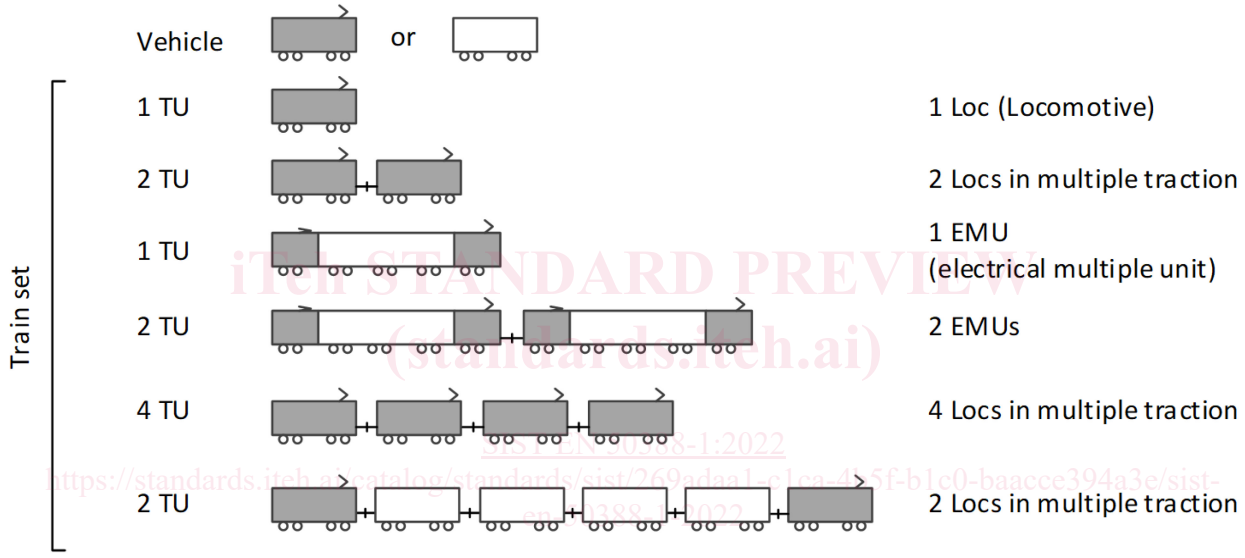
[SOURCE: IEC 60050-448:1995, 448-11-30]

3.2 Term clarification, coherence and translation

Due to inconsistency of definitions in the bibliography, the following statement in the Table 1, Figure 1, Figure 2 and following text should be considered.

Table 1 — Term coherence and translation

Subclause	English term	German term	French term
3.1.15	Vehicle	Fahrzeug	Véhicule
3.1.8	Rolling stock	Bahnfahrzeuge	Matériel roulant
3.1.12	Train set	Zugverband	Train (composition)
3.1.11	Traction unit (TU)	Triebfahrzeugeinheit	Unité motrice
For information	Train (train path)	Zug (Zugfahrt)	Train (circulation)
For information	(motor) Train-unit	Triebzug	Automotrice



Key

Motor vehicles shown in solid grey.

Unpowered vehicles are shown in white.

Note: in the case of an EMU, motored axles are typically distributed throughout vehicles.

Figure 1 — Term clarification for Traction unit (TU) and Train set

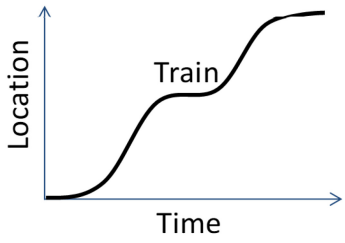


Figure 2 — Term clarification for Train (train path)

NOTE A unit is a piece of rolling stock which is subject to the application of a TSI, and subject to 'EC' verification. It can be composed of several vehicles, as defined in Directive (EU) 2016/797, Article 2(3); considering the scope of a TSI, the use of the term "vehicle" in a TSI is limited to the rolling stock subsystem.

3.3 Abbreviations and symbols

For the purposes of this document, the following abbreviations apply.

EC	European Commission
EU	European Union
ETCS	European Train Control System
HV	High Voltage
LRAS	Load Reference-Arrow System
RMS.	root mean square
RINF	register of infrastructure
TSI	Technical specification for interoperability
U_{max2}	highest non-permanent voltage defined in EN 50163:2004, 3.5
U_{max1}	highest permanent voltage defined in EN 50163:2004, 3.4
U_n	nominal voltage defined in EN 50163:2004, 3.3
U_{min1}	lowest permanent voltage defined in EN 50163:2004, 3.7
U_{min2}	lowest non-permanent voltage defined in EN 50163:2004, 3.8
v	velocity

Other terms in the document are defined at the point of use within this document.

4 Periods over which parameters should be averaged or integrated - reference time

Where train operators or infrastructure managers use various parameters for their dimensioning computations, protection measures and planning, these are effective only if they are averaged over precisely defined time spans. Guidance and recommendations on these time spans are given in Annex A (informative).

5 Separation sections

5.1 General

Separation sections shall allow train sets to move from one overhead contact line section to another without bridging them by the pantograph(s). Train sets shall be designed to accommodate this.

NOTE 1: EN 50367:2020 describes the mechanical design of separation sections with allowed section lengths and pantograph distances and connections.

Train sets shall pass a separation section by use of one of the following operational principles of train set action:

1. No action required, i.e. pantograph(s) may remain raised and on-board circuit breaker may remain closed.

   NOTE 2: No train set action can be used for sectioning points.

2. With pantograph(s) raised and touching the contact wire(s), but with traction power exchange to the contact line brought to zero before entering the separation section.

   NOTE 3: This solution to bring traction power exchange to zero is faster than opening the on-board circuit breaker and is in many cases sufficient as auxiliary and no-load current from components can be negligible to create an arc. The on-board circuit breaker can however be opened depending on train set design e.g., in order not to exceed permissible voltage limits.

3. With pantograph(s) raised and touching the contact wire(s) and on-board circuit breaker opened before entering the separation section.

4. With pantograph(s) lowered before entering the separation section and not touching the contact wire(s). Power exchange to the contact line shall be brought to zero before lowering the pantograph(s).

For lines with speed

- v ≥ 250 [km/h] train set action shall be done automatically.
- v < 250 [km/h] train set action should be done automatically, otherwise it shall be done manually by intervention of the driver.

The choice of principle of train set action for each separation section shall be made by the infrastructure manager(s) and shall be set out in register of infrastructure. The train set's driver shall be informed about necessary manual action by adequate means (e.g. visual signs along the track) sufficiently before entering the separation section.

NOTE 4 There might be other types of overhead contact line sections requiring train set actions, e.g. de-energised sections due to insufficient insulation distance or sections where overhead contact line is not installed for use of train sets with on-board energy storage. Such solutions are not yet standardized, but the requirements as for separation sections may be applied as far as reasonable to facilitate interoperability.

5.2 System separation sections

System separation sections separate different types of electric traction power supply systems.

Train set action (automatic or manual, for train sets designed for several power supply systems) additionally include choosing correct pantograph and electric circuits for the actual type of electric traction power supply system.

System separation section shall have provisions to avoid bridging of the adjacent systems if the train set action fails, e.g. a neutral zone connected to rail.

5.3 Phase separation sections

Phase separation sections separate feeding sections with different voltage amplitude or phase within the same type of electric traction power supply system.

If train set action is required, the principle of passing with raised pantographs are preferred. It depends mainly on the distribution of pantographs on the train set. Principle of lowering pantograph may be used under particular circumstances.

Other designs of phase separation sections that allow train sets to pass a sectioning point whilst taking power from the contact line (e.g. automatically switched sections or “change over sections”), are subject to future development. In this case, reliability and compatibility parameters shall be agreed between the parties involved.

6 Power factor of a traction unit

6.1 General requirements

The total power factor of a traction unit influences the power supply system performance, i.e. voltage profile, power feeding (active and reactive) and transfer capacity, energy losses, system stability and reliability of protection relays.

Where a train set comprises multiple traction units, if the requirements of each single traction unit are fulfilled, then they are considered to be fulfilled for the train set.

The displacement factor is measured at the pantograph.

The total power factor is composed of the following two elements:

- The displacement power factor and
- The total harmonic distortion caused by load current or source current harmonics.

No requirement on total harmonic distortion is given in this document.

NOTE 1 Requirements on overvoltages caused by harmonics are given in Clause 10 and in the future EN 50388-2.

More specifically the requirements below do not apply to traction units in AC systems in short term conditions (e.g. < 2 s) and transformer inrush.

NOTE 2 Infrastructure managers can impose economic conditions and/or operational restrictions or power limiting conditions to existing traction units not fulfilling the requirements of Clause 6.

The requirements apply only to traction units and therefore do not apply to separate loads such as carriages and wagons which are supplied by traction units.

NOTE 3 For carriages/wagons, see CEN/TS 50535:2010, 6.1.

NOTE 4 Informative Annex C gives only sign convention on active and reactive power.

In the ideal situation the displacement power factor of a traction unit is 1. In practice, the following applies to each traction unit, except as set out in 6.2:

- The displacement power factor shall be 0,95 or greater, e.g. taking into account control accuracy at high power.
- A reactive power (inductive or capacitive) of 3 % of the maximum power at wheel at nominal voltage U_n shall be allowed e.g. taking into account control accuracy at low power and all passive components within the traction unit (e.g. filters, cables) whatever the operating mode (traction, regenerative, standstill).
- For line voltages exceeding U_{max1} the capacitive reactive power per traction unit shall not exceed the following limits in all operation modes:
  - 60 kVAr at U_{max1} for 15 kV, 16,7 Hz system;
  - 190 kVAr at U_{max1} for 25 kV, 50 Hz system