# SLOVENSKI STANDARD
# SIST EN 50388:2012

**01-maj-2012**

**Nadomešča:**
**SIST EN 50388:2006**

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**Železniške naprave - Preskrba z električno energijo in vozna sredstva - Tehnična merila za uskladitev med elektronapajalnimi postajami in elektrovlečnimi vozili za doseganje medobratovalnosti**

Railway Applications - Power supply and rolling stock - Technical criteria for the coordination between power supply (substation) and rolling stock to achieve interoperability



Bahnanwendungen - Bahnenergieversorgung und Fahrzeuge - Technische Kriterien für die Koordination zwischen Anlagen der Bahnenergieversorgung und Fahrzeugen zum Erreichen der Interoperabilität



Applications ferroviaires - Alimentation électrique et matériel roulant - Critères techniques pour la coordination entre le système d'alimentation (sous-station) et le matériel roulant pour réaliser l'interopérabilité

**Ta slovenski standard je istoveten z:** **EN 50388:2012**

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EUROPEAN STANDARD

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# EN 50388

March 2012

ICS 29.280; 45.060.01

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English version

# Railway Applications - Power supply and rolling stock - Technical criteria for the coordination between power supply (substation) and rolling stock to achieve interoperability

Applications ferroviaires -
Alimentation électrique
et matériel roulant -
Critères techniques pour la coordination
entre le système d'alimentation (sous-station) et le matériel roulant pour réaliser
l'interopérabilité

Bahnanwendungen -
Bahnenergieversorgung und Fahrzeuge -
Technische Kriterien für die Koordination
zwischen Anlagen der
Bahnenergieversorgung und Fahrzeugen
zum Erreichen der Interoperabilität



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CENELEC

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

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## Foreword

This document (EN 50388:2012) 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) | 2013-02-13 |
| • latest date by which the national standards conflicting with this document have to be withdrawn | (dow) | 2015-02-13 |

This document supersedes EN 50388:2005 + corrigendum May 2010.

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



For the relationship with EU Directive 2008/57/EC, see informative Annex ZZ, which is an integral part of this document.

For TSI lines, modification and amendments shall be made within a procedure which is related to the legal status of the HS and CR TSIs.

# 1 Scope

This European Standard establishes requirements for the compatibility of rolling stock with infrastructure particularly in relation to:

– co-ordination of protection principles between power supply and traction units, especially fault discrimination for short-circuits;

– co-ordination of installed power on the line and the power demand of trains;

– co-ordination of traction unit regenerative braking and power supply receptivity;

– co-ordination of harmonic behaviour.

This European Standard deals with the definition and quality requirements of the power supply at the interface between traction units and fixed installations.

This European Standard specifies the interface between rolling stock and electrical fixed installations for traction, in respect of the power supply system. The interaction between pantograph and overhead contact line is dealt with in EN 50367. The interaction with the "control-command" subsystem (especially signalling) is not dealt with in this standard.

Requirements are given for TSI lines (both high speed and conventional) and classical lines.

For classical lines, values, where given, are for the existing European networks. Furthermore the maximum values that are specified are applicable to the foreseen developments of the infrastructure of the Trans European rail networks.



The following electric traction systems are within scope:



– railways;

– guided mass transport systems that are integrated with railways;

– material transport systems that are integrated with railways.

This European Standard does not apply retrospectively to rolling stock already in service.

Information is given on electrification parameters such as to enable train operating companies to confirm, after consultation with the rolling stock manufacturers, that there will be no consequential disturbance on the electrification system.

# 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.

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 50122-3:2010, *Railway applications — Fixed installations — Electrical safety, earthing and the return circuit — Part 3: Mutual Interaction of a.c. and d.c. traction systems*

EN 50123-1:2003, *Railway applications — Fixed installations — D.C. switchgear — Part 1: General*

EN 50163:2004 + A1:2007, *Railway applications — Supply voltages of traction systems*

EN 50367, *Railway applications — Current collection systems — Technical criteria for the interaction between pantograph and overhead line (to achieve free access)*

IEC 60050-811, *International Electrotechnical Vocabulary — Chapter 811: Electric traction*

## 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

**3.1**
**abnormal operating conditions**
either higher traffic loads or outage of power supply equipment outside the design standard

Note 1 to entry: Under these conditions, traffic may not operate to the design timetable.

**3.2**
**classical line**
existing line that is not subject to a renewal or upgrading project to bring it into compliance with a TSI

**3.3**
**contact line**
conductor system for supplying electric energy to vehicles through current-collecting equipment

[SOURCE: IEC 60050-811-33-01]

**3.4**
**dimensioning train**
train with the lowest mean useful voltage



**3.5**
**infrastructure manager**
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.

Note 2 to entry: In TSI Energy, this body is referred to as the contracting or adjudicating entity.

**3.6**
**maximum line speed**
speed for which the line was approved for operation

**3.7**
**mean useful voltage at the pantograph ($U_{\text{mean useful}}$)**

**3.7.1**
**$U_{\text{mean useful}}$ (zone)**
voltage giving an indication of the quality of the power supply in a geographic zone during the peak traffic period in the timetable

**3.7.2**
**$U_{\text{mean useful}}$ (train)**
voltage identifying the dimensioning train and which enables the effect on its performance to be quantified

**3.8**
**minimum possible headway**
minimum interval at which trains can run as allowed by the signalling system

**3.9**
**new element**
new, rebuilt or modified traction-unit or power supply component (hardware or software) having a possible influence on the harmonic behaviour of the power supply system

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

- transformer;
- HV cable;
- filters;
- converter.

**3.10**
**normal operating conditions**
traffic operating to the design timetable and train formation used for power supply fixed installation design

Note 1 to entry: Power supply equipment is operated according to standard design rules. Rules can vary depending on the infrastructure manager's policy.

**3.11**
**overhead contact line**
contact line placed above (or beside) the upper limit of the vehicle gauge and supplying vehicles with electric energy through roof–mounted current collection equipment

[SOURCE: IEC 60050-811-33-02]

**3.12**
**power factor**

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

Note 1 to entry: In this standard, only the fundamental wave is considered.



Note 2 to entry: This is also the displacement factor cos $\varphi$.



**3.13**
**register of infrastructure**
for TSI, a single document which compiles, for each section of line, the characteristics of the lines concerned in respect of all subsystems including fixed equipment

Note 1 to entry: The list of items included in the register is described in annexes of the TSI Energy.

**3.14**
**rolling stock**
general term covering all vehicles with or without motors

[SOURCE: IEC 60050-811-02-01]

**3.15**
**separation or neutral section**
section of a contact line provided with a sectioning point at each end to prevent successive electrical sections, differing in voltage, phase or frequency being connected together by the passage of current collectors

**3.16**
**(traction) substation**
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

**3.17**
**total power factor $\lambda$**

$$\lambda = \frac{\textit{active power}}{\textit{apparent power}}$$

Note 1 to entry: Deformation factor $\upsilon$:

$$\upsilon = \frac{\lambda}{\cos \varphi}$$

**3.18**
**traction unit**
general term covering a locomotive, motor coach or train unit

[SOURCE: IEC 60050-811-02-04]

**3.19**
**train**
combination of rolling stock coupled together. It includes banking locomotives

**3.20**
**train power at the pantograph**
active power of the train taking into account power for traction, regeneration and auxiliaries

**3.21**
**TSI line**
high speed or conventional rail line being part of the Trans-European Rail Network (TEN) and complying with the requirements of the relevant Technical Specifications for Interoperability (TSI)

Note 1 to entry: It includes for the High Speed rail network:

– category I: specially built high-speed lines equipped for speeds generally equal to or greater than 250 km/h;
– category II: specially upgraded high-speed lines equipped for speeds of the order of 200 km/h;
– category III: specially upgraded high-speed lines which have special features as a result of topographical, relief or town planning constraints on which the speed must be adapted to each case.



It includes for the Conventional Rail network:

a) category IV: New Core Trans European Network (TEN) Line:
   1) passenger and mixed traffic: 200 km/h maximum;
   2) freight traffic: 140 km/h maximum;



b) category V: Upgraded Core TEN Line:
   1) passenger and mixed traffic: 160 km/h maximum;
   2) freight traffic: 100 km/h maximum;
c) category VI: New Other TEN Line:
   1) passenger and mixed traffic: 140 km/h maximum;
   2) freight traffic: 100 km/h maximum;
d) category VII: Upgraded Other TEN Line:
   1) passenger and mixed traffic: 120 km/h maximum;
   2) freight traffic: 100 km/h maximum

**3.22**
**type of line**
classification of lines as a function of the parameters described in 3.6, 3.8 and 3.20

**3.23**
**vehicle**
general term denoting any single item of rolling stock, e.g. a locomotive, a coach or a wagon

[SOURCE: IEC 60050-811-02-02]

## 4 Periods over which parameters can be averaged or integrated

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 Phase separation sections

Trains shall be able to move from one section of an a.c. system to an adjacent section of the same system, through a phase separation section, without bridging the different phases.

Power consumption of the train (traction, auxiliaries and no-load current of the transformer) shall be brought to zero before entering the phase separation section.

For HS TSI lines, this shall be done automatically.

For Conventional Rail TSI lines and for classical lines, where required by the infrastructure manager this shall be done automatically. Otherwise, automatic operation is preferred, but manual on board operation may also be employed.

Where particular circumstances require the lowering of the pantographs this shall be recorded in the register of infrastructure.

For phase separation sections longer than 8 m, the infrastructure manager shall provide adequate means to allow a train that is gapped underneath the phase separation to be restarted.

EN 50367 describes the characteristics of some designs of phase separation sections.

NOTE For other designs of phase separation that allow trains to pass the section with power running (e.g. automatically switched sections or "change over sections"), the requirements of this clause may not apply if reliability and compatibility with all trains can be demonstrated.



## 5.2 System separation sections

### 5.2.1 General



Trains shall be able to move from one energy supply system to an adjacent one which uses a different energy supply without bridging the two contact line systems. The necessary actions (opening of the main circuit breaker, lowering of the pantographs, etc.) depend on the type of both supply systems as well as on the arrangement of pantographs on trains and the running speed.

There are two possibilities for trains to run through system separation sections:

1) with pantograph raised and touching the contact wire(s) as described in 5.2.2;

2) with pantograph lowered and not touching the contact wire(s) as described in 5.2.3.

The choice between 1) and 2) shall be made by the infrastructure manager.

The requirements for the design of the infrastructure and rolling stock are described in following paragraphs.

### 5.2.2 Pantograph raised

Where the system separation sections are traversed by a train with pantographs raised to the contact wire(s), the following conditions apply:

- Provisions shall be made in the infrastructure to avoid bridging the contact lines of both adjacent power supply systems if the opening of the on-board circuit breaker(s) fails.
- For categories I, II and III lines, on board, devices shall automatically open the circuit breaker before reaching the separation section and shall recognise automatically the voltage of the new power supply system at the pantograph in order to switch the corresponding circuits.
- For categories IV to VII lines and for classical lines, the requirements for categories I, II and III lines may be applied.

### 5.2.3 Pantograph lowered

Where the system separation sections are traversed with pantographs lowered the following conditions apply:

- The design of separation section between differing energy supply systems shall ensure that, in case of a pantograph unintentionally applied to the contact line, bridging the contact lines of two power supply systems is avoided and switching off both supply systems is triggered immediately, e.g. by detection of short circuits or unintended voltages.
- For categories I, II and III lines, at supply system separations which require a lowering of the pantograph, the pantograph shall be lowered without the driver’s intervention, triggered by control signals.
- For categories IV to VII lines and for classical lines, the requirements for categories I, II and III lines may be applied.
- EN 50367 describes the design of the system separation sections as well as other functional requirements of the overhead contact line and pantographs.

# 6 Power factor of a train

## 6.1 General

To optimise the power factor of a train, and hence the quality of the power supply performance, the requirements in 6.2 to 6.4 shall apply to the design of the train.



NOTE Capacitive or inductive power from a train can be utilised to change the contact line voltage.

## 6.2 Inductive power factor



This clause deals only with inductive power factor and power consumption over the range of voltage from $U_{\text{min1}}$ to $U_{\text{max1}}$ as defined in EN 50163.

Table 1 gives the requirements for the total inductive power factor $\lambda$ of a train. For the calculation of $\lambda$, only the fundamental of the voltage at the pantograph is taken into account.

**Table 1 — Total inductive power factor $\lambda$ of a train**

| Instantaneous train power P at the pantograph (MW) | Total inductive power factor $\lambda$ of a train | |
|---|---|---|
| | Category I and II of HS TSI lines [a] | TSI line category III; IV; V; VI; VII and Classical lines |
| $P > 2$ | ≥ 0,95 | ≥ 0,95 |
| | | |
| $0 \leq P \leq 2$ | [b] | [b] |

For yards or depots, the power factor of the fundamental wave shall be equal or higher to 0,8 (see Note 2 below) when the train is hotelling with traction power switched off and all auxiliaries running and the active power being drawn is greater than 200 kW.

NOTE 1 The calculation of overall average λ for a train journey, including the stops, is taken from the active energy $W_P$ (MWh) and reactive energy $W_Q$ (Mvarh) given by a computer simulation of a train journey or metered on an actual train:

$$\lambda = \frac{1}{\sqrt{1+\left(\frac{W_Q}{W_P}\right)^2}}$$

NOTE 2 Higher power factors than 0,8 will result in better economic performance due to a reduced requirement for fixed equipment provision.

[a] Applicable to trains in conformity with the HS TSI "rolling stock".



[b] In order to control the total power factor of the auxiliary load of a train during the coasting phases, the overall average λ (traction and auxiliaries) defined by simulation and/or measurement shall be higher than 0,85 over a complete timetable journey (typical journey between two stations including commercial stops).



During regeneration, the inductive power factor may be allowed to decrease freely in order to keep voltage within limits.

NOTE 1 Another representation of Table 1 in a graphic form is given in Annex E.

NOTE 2 On line categories III to VII, for rolling stock existing before publication of this standard, the infrastructure manager may impose conditions e.g. economic, operating, power limitation for acceptance of interoperable trains having power factors below the value specified in Table 1.

## 6.3 Capacitive power factor

During traction mode and standstill, requirements for capacitive power factor in order to keep voltage within limits are:

– within the range of voltage from $U_{min1}$ to $U_{max1}$ as defined in EN 50163, capacitive power factors are not limited;

– within the range of voltage from $U_{max1}$ to $U_{max2}$ as defined in EN 50163, a train shall not behave like a capacitor.

During regenerative mode, capacitive power, if any, shall be limited to 150 kvar within the range of voltage from $U_{min1}$ to $U_{max1}$ as defined in EN 50163.

NOTE 1 Capacitive power factors could lead to overvoltages and/or dynamic effects and should be treated according to Clause 10.

NOTE 2 A representation of capacitive power factor is given in Annex E.

## 6.4 Acceptance criteria

The power factor is acceptable if the values given in Table 1 and requirements given in 6.3 are achieved.

# 7 Train current limitation

## 7.1 Maximum train current

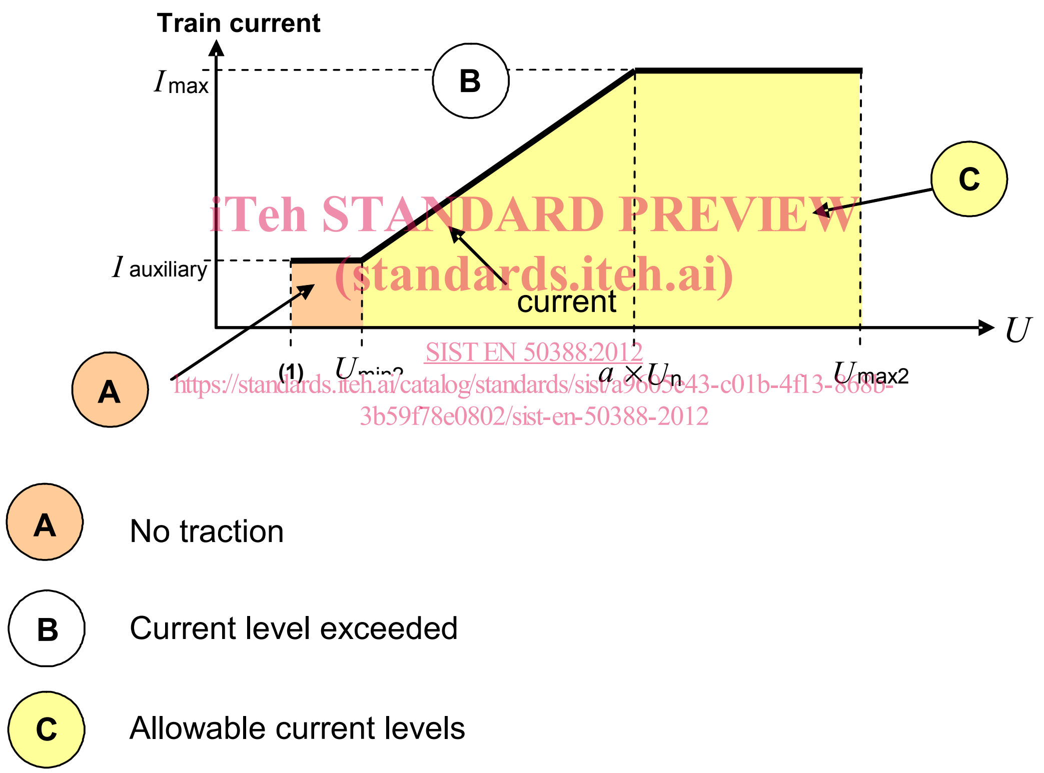
Typical data for the maximum allowable current per train for all European networks are given in informative Annex F.

NOTE There is no obligation to design the infrastructure to these maxima, e.g. allow 800 A in 25 kV (example).

## 7.2 Automatic regulation

In order to facilitate stable operation on weak power supply networks or in abnormal operating conditions, trains shall be equipped with an automatic device which adapts the level of the maximum power consumption depending on contact line voltage in steady state condition. Figure 1 gives the maximum allowable train current as a function of the contact line voltage.

Figure 1 does not apply in regenerative braking mode.






**Key**

$U$ contact line voltage according to EN 50163

$I_{max}$ is the maximum current consumed by the train at nominal voltage.

(1) With regard to the setting values of the under-voltage releases, see EN 50163:2004, 4.1, Note 2.

**Figure 1 — Maximum train current against voltage**

The value of the knee point factor $a$ is given in Table 2.

NOTE The purpose of this diagram is not to design the nominal power of the train.

**Table 2 — Value of factor *a***

| Power supply system | Value of *a* |
|---|---|
| a.c. 25 000 V 50 Hz | 0,9 |
| a.c. 15 000 V 16,7 Hz | 0,95 |
| d.c. 3 000 V | 0,9 |
| d.c. 1 500 V | 0,9 |
| d.c. 750 V | 0,8 |

## 7.3 Power or current limitation device

In order to allow a train to operate on both electrically weak and well supplied lines, on board current or power selection devices shall be installed which will limit the power demand of the train to the electrical capacity of the line. This is applicable on all lines except on category I lines.

The infrastructure manager shall declare the required limitation of each line in a register of infrastructure.

NOTE This setting may be carried out automatically.

## 7.4 Acceptance criteria

The train current limitation systems or devices are acceptable if the requirements of 7.1 to 7.3 are fulfilled.



# 8 Requirements for performance of power supply



## 8.1 General

A dimensioning study shall be performed in order to assess the ability of the power supply system to achieve the specified performance. Its aim, as set out in Annex B, is to define the characteristics of fixed installations.

These fixed installations should allow the most severe conditions, as specified in the design timetable, to be satisfied for:

– the densest operating period in the timetable, corresponding to peak traffic;

– the characteristics of the different types of train involved, taking account of the selected traction units.

The quality index $U_{\text{mean useful}}$ described in 8.2, is calculated by simulation and can be verified by ad hoc measurements on a critical train.

The voltage at the pantographs in EN 50163 and the $U_{\text{mean useful}}$ are relevant to this assessment.

## 8.2 Description

Mean useful voltage is calculated by computer simulation of a geographic zone (zone under study) which takes account of all trains scheduled to pass through the zone in an appropriate period of time corresponding to the peak traffic period in the timetable. This given period of time shall be sufficient to take account of the highest load on each electrical section in the geographic zone.

Account shall be taken of the electrical characteristics of the infrastructure and each different type of train in the simulation.

The fundamental voltage at the pantograph of each train in the geographic zone is analysed at each simulation time step. For a.c. systems, the r.m.s. value of the fundamental voltage is used. For d.c. systems, the mean voltage is used. The time step in the simulation shall be short enough to take into account all events in the timetable.