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

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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

This European Standard was approved by CENELEC on 2005-03-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

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

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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 the Technical Committee CENELEC TC 9X, Electrical and electronic applications for railways. It also concerns the expertise of SC 9XB, Electromechanical material on board of rolling stock.

The text of the draft was submitted to the formal vote and was approved by CENELEC as EN 50388 on 2005-03-01.

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)	2006-03-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2008-03-01

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

This European Standard has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association and covers essential requirements of EC Directive 96/48/EC. See Annex ZZ.

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1 Scope

This European Standard is intended to be used to set up the requirements for the acceptance of rolling stock on infrastructure in the field of:

- 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 power demand of the trains;
- co-ordination of traction unit regenerative braking and power supply receptivity;
- co-ordination of harmonic behaviour.

This standard deals with the definition and quality requirements of the power supply at the interface between traction unit and fixed installations.

The standard specifies the interface between rolling stock and electrical fixed installations for traction, in the frame "supply system“. The interaction between pantograph and overhead line is dealt with in EN 50367. The interaction with subsystem “control-command” (especially signalling) is not dealt with in the standard.

Requirements are given for the following categories of line:

- TSI lines (high speed and conventional),
- classical lines.

For classical lines, values, if any, are given for the existing European networks. A set of values is also specified for the future network, which is named "target“ network.

The following electric traction systems are concerned:

- railways;
- guided mass transport systems that are integrated with the railways;
- material transport systems that are integrated with the railways.

This standard does not apply retrospectively to rolling stock already accepted by infrastructure managers. However, on new infrastructure, existing rolling stock may be accepted by the infrastructure manager, provided there is an agreement.

Information is given to the train operating companies on electrification parameters to enable them 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 referenced documents are indispensable for the application 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.

96/48/EC, *EU council directive on the interoperability of the trans-European high speed rail system TSI sub-system Energy, Official Journal L 235 , 17/09/1996 P. 0006 – 0024*

2001/16/EC, *Directive of the European Parliament and of the Council on the interoperability of the trans-European conventional rail system*

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

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

EN 50367[1], *Railway application — Current collection systems — Technical criteria for the interaction between pantograph and overhead line (to achieve free access)*

IEC 60050-811, *International Electrotechnical vocabulary (IEV) — Chapter 811: Electric traction*

EN ISO 3166-1:1997, *Codes for the representation of the names of countries and their subdivisions – Part 1: Country codes* (ISO 3166-1:1997)

3 Terms and definitions

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

3.1
TSI line
line defined as part of the Trans European High-Speed rail network for the High Speed Technical Specification for Interoperability, TSI HS, (see 96/48/EC) or line defined as conventional as part of TEN Trans European Network in the conventional TSI (see2001/16/EC).

It includes for the HS TSI:

— category I: specially built high-speed lines equipped for speeds generally equal to or greater than 250 km/h, named as "high speed" in this standard;

— category II: specially upgraded high-speed lines equipped for speeds of the order of 200 km/h, named as "upgraded" in this standard;

— 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, named as "connecting" in this standard

3.2
classical line
line which does not belong to the TSI lines.

It includes:

— information on European networks named with their national country code (see EN ISO 3166-1);

— future target network named as "target", see 3.25

3.3
type of line
classification of lines as a function of the parameters described in 3.4 to 3.6

3.4
train power at the pantograph
active power of the train taking into account power for traction, regeneration and auxiliary

3.5
minimum possible headway
interval at which trains can run as allowed by the signalling system

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

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[1] In preparation.

3.7
contact line
conductor system for supplying electric energy to vehicles through current-collecting equipment

[IEC 60050-811-33-01]

3.8
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

[IEC 60050-811-33-02]

3.9
(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

3.10
total power factor λ

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

3.11
deformation factor υ

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

3.12
power factor of the fundamental wave

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

NOTE This is also the displacement factor cos φ.

3.13
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

[IEC 60050-811-36-16]

3.14
vehicle
general term denoting any single item of rolling stock, e.g. a locomotive, a coach or a wagon

[IEC 60050-811-02-02]

3.15
traction unit
general term covering a locomotive, motor coach or train unit

[IEC 60050-811-02-04]

3.16
rolling stock
general term covering all vehicles with or without motors

[IEC 60050-811-02-01]

3.17
train
any combination of rolling stock coupled together. It includes banking locomotives

3.18
normal operating conditions
traffic operating to the design timetable and train formation used for power supply fixed installation design

Power supply equipment is operated according to standard design-rules.

NOTE Standard rules may vary depending on the infrastructure manager's policy.

3.19
abnormal operating conditions
either higher traffic loads or outage of power supply equipment outside the design standard

NOTE Under these conditions, traffic may not operate to the design timetable.

3.20
mean useful voltage at the pantograph ($U_{\text{mean useful}}$)

3.20.1
$U_{\text{mean useful}}$ (zone)
voltage giving an indication of the quality of the power supply in a geographic zone during the peak traffic period in the timetable

3.20.2
$U_{\text{mean useful}}$ (train)
voltage identifying the dimensioning train and enables the effect on its performance to be quantified

3.21
dimensioning train
train with the lowest mean useful voltage

3.22
register of infrastructure
for HS TSI: a single document which compiles, for each section of line of the trans-European high speed rail system, the characteristics of the lines concerned for all subsystems that include fixed equipment.

This "register of infrastructure" should be drawn up by the infrastructure manager or its authorised representative.

For other lines: a single document which compiles, for each section of line, the characteristics of the lines concerned for all subsystems that include fixed equipment

3.23
infrastructure manager
any body or undertaking that is responsible in particular for establishing and maintaining railway infrastructure. 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 In HS TSI Energy, this body is referred to as the contracting or adjudicating entity.

3.24
new element
generally, any new, rebuilt or modified (hardware or software) traction-unit or power supply component having a possible influence on the harmonic behaviour of the power supply system

This new element will be integrated in an existing power supply network with traction units

e.g. for fixed installation side:

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

3.25
target network
network whose design allows the requirements of European interoperability and should avoid later costly investments

4 Periods over which parameters can be averaged or integrated

This clause is informative and refers to Annex A.

The train operators or infrastructure managers use parameters for:

- their dimensioning computations;
- protection measures;
- planning;
- etc.

These are effective only if they are averaged over precisely defined time spans.

Annex A gives, for information, the periods over which those parameters should be averaged.

5 Neutral sections

5.1 A.C. phase separation sections

The train shall be able to move from one section to an adjacent one without bridging the two phases.

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

For HS TSI lines, this shall be done automatically.

For Conventional TSI lines and for classical lines, automatic operation is preferred, however manual on board operation is also permitted.

Lowering of the pantographs is not necessary.

The infrastructure manager shall provide adequate means to allow a train that is gapped underneath the phase separation to be restarted.

NOTE In case of "active automatic switched" neutral sections, for which no provisions are necessary on board when passing through, some requirements of this clause may not apply.

EN 50367 describes the design of phase separation sections.

5.2 System separation sections

The 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 systems. The necessary actions (opening of the main circuit breaker, lowering of the pantographs) 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 the train to run through system separation sections:

1) with pantograph raised and touching the contact wire;

2) with pantograph lowered and not touching the contact wire.

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:

1) Pantograph raised

If the system separation sections are negotiated with pantographs raised to the contact wire, provisions shall be taken in the infrastructure to avoid bridging of both adjacent power supply systems when the opening of the on-board circuit breaker(s) fails.

— For HS TSI lines, on rolling stock, devices shall open automatically the circuit breaker before reaching the separation section and recognise automatically the voltage of the new power supply system at the pantograph in order to switch the corresponding circuits.

— For conventional TSI lines and for classical lines, these requirements for HS TSI lines may be applied.

2) Pantograph lowered

If the system separation sections are negotiated 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 of two power supply systems is avoided and switching off both supply sections is triggered immediately. Triggering of a short-circuit ensures operation of insulated sections.

— For HS TSI 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 Conventional TSI lines and for classical lines, these requirements for HS TSI lines may be applied.

EN 50367 describes the design of the system separation sections as well as some other functional requirements of the overhead-line and pantographs.

5.3 Acceptance criteria

Infrastructure, traction units and control command designers shall comply with the requirements of 5.1 and 5.2.

6 Power factor of a train

6.1 General

The higher the power factor of a train, the better is the power supply performance, therefore the rules below apply.

Capacitive or inductive power from a train can be utilised to change the overhead 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_{min1} to U_{max1} defined in EN 50163.

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

Table 1 — Total inductive power factor λ of a train

Instantaneous train power P at the pantograph	**HS TSI lines**		**HS TSI lines connecting Conventional TSI lines Classical lines**
MW	**High-speed**	**Upgraded** [c]	**Target** [d]
P > 6	≥ 0,95 [e]	≥ 0,95 [e]	≥0,95 [a] [e]
2 < P ≤ 6	≥ 0,93 [e]	≥ 0,93 [e]	≥0,93 [a] [e]
0 ≤ P ≤ 2	[b]	[b]	[b]

For yards or depot, when a train is stationary, with traction power off, and the active power taken from the overhead contact line is greater than 10 kW per vehicle, the total power factor resulting from the train load shall not be less than 0,8, but with a target value of 0,9.

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.

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

[a] These values are recommended.

[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.

[c] applicable to trains in conformity with the HS TSI "rolling stock".

[d] The infrastructure manager may impose conditions e.g.: economic, operating, power limitation for acceptance of interoperable trains having power factors below the target value.

[e] It is expected that these values may be improved, respectively 0,98 and 0,95

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