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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

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National foreword

This British Standard is the UK implementation of EN 50122-2:2010. It supersedes BS EN 50122-2:1999 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee GEL/9/3, Railway Electrotechnical Applications - Fixed Equipment.

A list of organizations represented on this committee can be obtained on request to its secretary.

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31 March 2011	Correction February's Corrigendum

English version

**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**

Applications ferroviaires -
Installations fixes -
Sécurité électrique, mise à la terre et
circuit de retour -
Partie 2: Mesures de protection contre les
effets des courants vagabonds issus de la
traction électrique à courant continu

Bahnanwendungen -
Ortsfeste Anlagen -
Elektrische Sicherheit, Erdung und
Rückleitung -
Teil 2: Schutzmaßnahmen gegen
Streustromwirkungen durch Gleichstrom-
Zugförderungssysteme

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CENELEC

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

Management Centre: Avenue Marnix 17, B - 1000 Brussels

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. It was submitted to the formal vote and was approved by CENELEC as EN 50122-2 on 2010-10-01.

This document supersedes EN 50122-2:1998 + A1:2002.

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

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) 2011-10-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2013-10-01

This draft 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 Directives 96/48/EC (HSR), 2001/16/EC (CONRAIL) and 2008/57/EC (RAIL). See Annex ZZ.

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1 Scope

This European Standard specifies requirements for protective provisions against the effects of stray currents, which result from the operation of d.c. traction systems.

As experience for several decades has not shown evident corrosion effects from a.c. traction systems and actual investigations are not completed, this European Standard only deals with stray currents flowing from a d.c. traction system.

This European Standard applies to all metallic fixed installations which form part of the traction system, and also to any other metallic components located in any position in the earth, which can carry stray currents resulting from the operation of the railway system.

This European Standard applies to all new d.c. lines and to all major revisions to existing d.c. lines. The principles may also be applied to existing electrified transportation systems where it is necessary to consider the effects of stray currents.

It provides design requirements to allow maintenance.

The range of application includes:

- a) railways,
- b) guided mass transport systems such as:
 - 1) tramways,
 - 2) elevated and underground railways,
 - 3) mountain railways,
 - 4) trolleybus systems, and
 - 5) magnetically levitated systems, which use a contact line system,
- c) material transportation systems.

This European Standard does not apply to:

- d) mine traction systems in underground mines,
- e) cranes, transportable platforms and similar transportation equipment on rails, temporary structures (e.g. exhibition structures) in so far as these are not supplied directly from the contact line system and are not endangered by the traction power supply system,
- f) suspended cable cars,
- g) funicular railways.

This European Standard does not specify working rules for maintenance.

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.

EN 50122-1:2010, *Railway applications – Fixed installations – Electrical safety, earthing and the return circuit – Part 1: Protective provisions against electric shock*

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 50162:2004, *Protection against corrosion by stray current from direct current systems*

EN 50163, *Railway applications – Supply voltages of traction systems*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 50122-1:2010 apply.

4 Identification of hazards and risks

D.C. traction systems can cause stray currents which could adversely affect both the railway concerned and/or outside installations, when the return circuit is not sufficiently insulated versus earth.

The major effects of stray currents can be corrosion and subsequent damage of metallic structures, where stray currents leave the metallic structures. There is also the risk of overheating, arcing and fire and subsequent danger to persons and equipment both inside and outside the railway or trolley bus system.

The following systems, which can produce stray currents, shall be considered:

- d.c. railways using running rails carrying the traction return current including track sections of other traction systems bonded to the tracks of d.c. railways;
- d.c. trolleybus systems which share the same power supply with a system using the running rails carrying the traction return current;
- d.c. railways not using running rails carrying the traction return current, where d.c. currents can flow to earth or earthing installations.

All components and systems which can be affected by stray currents shall be considered such as:

- running rails,
- metallic pipe work,
- cables with metal armour and/or metal shield,
- metallic tanks and vessels,
- earthing installations,
- reinforced concrete structures,
- buried metallic structures,
- signalling and telecommunication installations,
- non-traction a.c. and d.c. power supply systems,
- cathodic protection installations.

Any provisions employed to control the effects of stray currents shall be checked, verified and validated according to this European Standard.

The system design shall be completed sufficiently early that the results can be taken into account in the essential system parameters, which influence the stray current effects, like the spacing of the substations and in the design of the civil structures, see also 5.4.

The entity responsible for the design and erection of the railway infrastructure shall make sure that electrical requirements for railway related civil structures are met.

In case of major revisions of existing lines the effects on the stray current situation shall be assessed by calculation and/or by measurements.

If stray current provisions affect electrical safety, protective provisions against electric shock according to EN 50122-1 shall take precedence over provisions against the effects of stray currents.

5 Criteria for stray current assessment and acceptance

5.1 General

The amount of stray currents and their effects depend on the overall system design of the traction power supply. Stray currents leaving the return circuit can affect the return circuit itself and neighbouring installations, see Clause 4.

Beside to the operating currents, the most important parameters for the amount of stray current are:

- the conductance per length of the tracks and the other parts of the return circuit,
- the distance of the substations,
- the longitudinal resistance of the running rails,
- spacing of cross bonds.

If the railway system meets the requirements and measures of this European Standard, the system is assumed to be acceptable from the stray current point of view.

5.2 Criteria for the protection of the tracks

The most important influencing variable for stray currents leaving the tracks is the conductance per unit length between track and earth. The corrosion rate is the main aspect for the assessment of risk.

The rail potential provides the main information about the relevant parameters, which represent the stray currents. These parameters are the traction currents, the longitudinal resistance of the running rails, the resistance to earth and the length of the feeding sections. The precondition for this proceeding is that there is no direct electrical connection either accidental or intended to earthing installations.

Experience proves that there is no damage in the tracks over a period of 25 years, if the average stray current per unit length does not exceed the following value:

$$I'_{\max} = 2,5 \text{ mA/m}$$

(average stray current per length of a single track line).

NOTE 1 For a double track line the value for the maximum average stray current should be multiplied by two. For more than two tracks the value increases accordingly. For the averaging process, only the total positive parts of the stray current over 24 h or multiples are considered.

If the following values for the conductance per length G'_{RE} and average rail potential U_{RE} are not exceeded during the system life-time, further investigations according to 5.4 need not be performed.

$$- \quad G'_{\text{RE}} \leq 0,5 \text{ S/km per track and } U_{\text{RE}} \leq + 5 \text{ V} \quad \text{for open formation} \quad (1)$$

$$- \quad G'_{\text{RE}} \leq 2,5 \text{ S/km per track and } U_{\text{RE}} \leq + 1 \text{ V} \quad \text{for closed formation} \quad (2)$$

For the average rail potential shift U_{RE} only positive values of the rail potential are considered. The averaging period shall be 24 h or multiples.

NOTE 2 A guide value for the sampling rate is 2 per second.

If the requirements in Equations (1) and (2) are not met, an alternative value for G'_{RE} shall be calculated and used for the design, applying Equation (3).

$$G'_{RE} = \frac{I}{U_{RE}} \quad (3)$$

where

$$I' = 2,5 \text{ mA/m per track or the value coming from the investigation in 5.4.}$$

NOTE 3 For a double track line the value for the maximum conductance per length should be multiplied by two. For more than two tracks the values increase accordingly.

NOTE 4 As it is not easy to measure the stray currents directly, the measurement of the rail potential is a convenient method. According to Equation (3), the acceptable conductance per length can be calculated for a single track line.

NOTE 5 Simulation of the traction power supply for scheduled train operation can provide values for the stray current per length for design purposes. A method of calculating dead-end tracks is given in Clause C.1. This is a conservative method, because the actual values are lower.

When the construction phase has been completed, it shall be proven that the permissible conductance per length according to Equations (1), (2) or (3) is fulfilled. Annex A indicates proven methods for the measurement.

During operation, compliance with the limits of conductance per length according to Equations (1), (2) or (3) shall be maintained.

5.3 Criteria for systems with metal reinforced concrete or metallic structures

In systems with metal reinforced concrete or metallic structures, like:

- reinforced track bed,
- tunnels, or
- viaducts,

the impact on the structures shall be considered.

The voltage shift of the structure versus earth is an additional criterion for assessment.

Experience has shown, that there is no cause for concern, if the average value of the potential shift between the structure and earth in the hour of highest traffic does not exceed + 200 mV for steel in concrete structures. For buried metal constructions the values depend on soil resistivity and the material. For both requirements refer to EN 50162:2004, Table 1.

In order to avoid inadmissible stray current effects at the tunnel structure and at structures outside of the tunnel, the longitudinal voltage between any two points of the through connected metal reinforced tunnel structure should be calculated. The maximal longitudinal voltage shall be smaller than the permissible potential shift. As an example for calculation see C.2. This is a conservative procedure which ensures that the actual values for the tunnel potential against earth will be lower.

5.4 Specific investigations and measures

If the requirements stated in 5.2 and 5.3 are not achieved, or if other methods of construction are planned, a study shall be carried out at an early planning stage. The study becomes also necessary in case of major revisions of existing lines, when the stray current situation is likely to become worse.

The possible impact of stray current corrosion shall be investigated, where the following aspects are included, such as:

- insulation from earth of the rails and connected metallic structures,
- humidity of the track bed,
- longitudinal resistance of the running rails,
- number of and distance between the substations,
- effects of inequalities in the no load voltages of substations,
- substation no-load voltage and source impedance,
- timetable and vehicles,
- neighbouring metallic structures.

Clause 6 and Clause 7 show suitable corrective provisions.

6 Design provisions

6.1 General

Any provisions employed to control the effects of stray currents shall be checked, verified and validated according to this European Standard.

The system design shall be completed sufficiently early that the results can be taken into account in the essential system parameters which influence the stray current effects, like the spacing of the substations and the design of the civil structures.

6.2 Return circuit

6.2.1 General

In order to minimise stray current caused by a d.c. traction system, the traction return current shall be confined to the intended return circuit as far as possible.

As the return circuit in case of d.c. traction systems usually is not connected to earth, safety requirements for the rail potential according to EN 50122-1:2010, 6.2.2 and Clause 9, shall be fulfilled.

6.2.2 Resistance of running rails

The longitudinal resistance of the running rails shall be low. Therefore, rail joints shall be welded or connected by rail joint bonds of low resistance such that the longitudinal resistance of the rails is not increased by more than 5 %.

The longitudinal resistance can be reduced by the use of rails with greater cross section and/or cross bonding of the running rails and/or the tracks where signalling considerations allow.

6.2.3 Track system

A high level of insulation from earth of the running rails and of the whole return circuit is required, when the running rails are used as part of the return circuit.

The track shall be so designed that the insulation quality of the rails toward earth will not be diminished substantially by water. In order to fulfil the values given in Equations (1), (2) and (3) of 5.2 the water drainage of the substructure of the running rails is essential.

NOTE 1 The values given for the conductance per length apply to a track consisting of two running rails with tie bars as well as the attached system parts.