



BSI Standards Publication

Fixed installations for railway applications — Electrical safety, earthing and the return circuit

Part 2: Provisions against the effects of stray
currents caused by DC traction systems

National foreword

This British Standard is the UK implementation of EN 50122-2:2022+A1:2025. It supersedes BS EN 50122-2:2022, which will be withdrawn on 31 August 2028.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to CENELEC text carry the number of the CENELEC amendment. For example, text altered by CENELEC amendment A1 is indicated by A1 A1.

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

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

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European foreword

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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) 2023-07-25
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This document supersedes EN 50122-2:2010 and all of its amendments and corrigenda (if any).

EN 50122-2:2022 includes the following significant technical changes with respect to EN 50122-2:2010:

- harmonization with EN 50122-1:2022;
- improvement of measurement specification in Annex A;
- new Annex D “Laboratory testing of materials for the insulation of rails”.

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.

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.

European foreword to Amendment 1

This document (EN 50122-2:2022/A1:2025) was prepared by SC 9XC, “Electric supply and earthing systems for public transport equipment and ancillary apparatus (fixed installations)”, of CLC/TC 9X, “Electrical and electronic applications for railways”.

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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 specifies requirements for protective provisions against the effects of stray currents, which result from the operation of DC electric traction power supply systems.

As several decades' experience has not shown evident corrosion effects from AC electric traction power supply systems, this document only deals with stray currents flowing from a DC electric traction power supply system.

This document 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 document applies to all new DC lines and to all major revisions to existing DC lines. The principles can also be applied to existing electrified transportation systems where it is necessary to consider the effects of stray currents.

This document does not specify working rules for maintenance but 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) magnetically levitated systems, which use a contact line system, and
 - 5) trolleybus systems,
- c) material transportation systems.

This document does not apply to

- a) electric traction power supply systems in underground mines,
- b) 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 electric traction power supply system,
- c) suspended cable cars,
- d) funicular railways.

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 50122-1:2022, *Railway applications - Fixed installations - Electrical safety, earthing and the return circuit - Part 1: Protective provisions against electric shock*

EN 50122-3:2022, *Railway applications - Fixed installations - Electrical safety, earthing and the return circuit - Part 3: Mutual Interaction of AC and DC traction systems*

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

EN ISO 21857:2021, *Petroleum, petrochemical and natural gas industries - Prevention of corrosion on pipeline systems influenced by stray currents (ISO 21857:2021)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 50122-1:2022 apply.

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

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

4 Identification of hazards and risks

[A1] DC electric traction power supply systems can cause stray currents, which can adversely affect railway infrastructure as well as third party structures, if the feed and return circuits are not sufficiently insulated from earth.

Where current leaves the structure through an electrolytic path such as concrete or soil the major effects of such stray currents can be corrosion. **[A1]** There is also the risk of overheating, arcing and fire and subsequent danger to persons and equipment both inside and outside the DC electric traction power supply system.

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

- DC railways using running rails carrying the traction return current including track sections of other traction systems bonded to the tracks of DC railways;
- DC trolleybus systems which share the same power supply with a system using the running rails carrying the traction return current;
- DC railways not using running rails carrying the traction return current, where DC 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,
- earthing installations,
- steel reinforced concrete structures and elements (e.g. bearers and slab track components),
- buried metallic structures,
- signalling and telecommunication installations,
- non-traction AC and DC 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 document.

[A1] The railway system design shall be completed before key parameters for stray current effects are decided. This includes parameters such as substation locations, track formations, bonding, insulated rail joint positions and civil structure designs (e.g. overhead contact line system, including foundations, bridges, viaducts, tunnels). See also 5.4 and Clause 6. **[A1]**

The entity responsible for the design and construction 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 mitigation adversely affects electrical safety with regards to electric shock, then the electrical safety provisions described in EN 50122-1:2022 shall take precedence.

5 Criteria for stray current assessment and acceptance

5.1 General

A1 The magnitude and extent of stray currents depends on the overall system design of the electric traction power supply system. Stray currents leaving the return circuit through an electrolytic path can affect the return circuit itself and neighbouring installations, see Clause 4. **A1**

As well as the operating currents, the most important parameters for the magnitude of stray current are:

- the conductance per length of the tracks and the other parts of the return circuit;
- the distance between traction substations;
- the longitudinal resistance of the running rails, when used for traction return current;
- spacing of cross bonds.

There shall be no permanent direct electrical connection of the return circuit, either accidental or intended, to earthing installations and earth.

NOTE 1 Depots, workshops and similar locations are an exception as described in Clause 9.

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

NOTE 2 **A1** Stray currents from DC railway systems are, by their nature, dynamic, and adherence to the guidelines in Clause 5 does not always ensure that the corrosion risk to third party infrastructure does not exist. **A1**

The most important influencing variable for stray currents leaving the tracks is the combination of the conductance per length between track and earth and the rail potential. **A1** The corrosion risk to the railway system can be assessed using the guidelines in this document.

NOTE 3 The responsibility for the assessment of the corrosion risk to third-party structures lies with the owners of those structures. EN ISO 21857 provides guidance for pipelines and can be used for other structures as well. EN ISO 21857 recommends joint committees to assess the stray current corrosion risks, e.g. railway infrastructure managers and other involved parties. **A1**

5.2 Criteria for the protection of the tracks

A1 Experience over more than three decades has proven that the corrosion damage to the tracks including their fixings over this period is acceptable, if the average stray current per length does not exceed the following value: **A1**

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

A1 The given value of $I'_{\max}$ indicates a time averaged stray current leakage per length of one track. **A1**

For a double track line, the value for the maximum average stray current leakage is to be multiplied by two. For more than two tracks or tracks with more than two running rails the factor increases accordingly.

For stray current considerations the local positive rail potential shift ΔU_{RE} is relevant. This is the difference between the rail potential U_{RE} occurring during operation and no-operation.

NOTE 1 During non-operational periods a voltage U_{RE} can be present.

If the following values for the conductance per length G'_{RE} and time averaged rail potential shift ΔU_{RE} are not exceeded during the system **A1** lifetime **A1**, further investigations according to 5.4 do not need to be performed.

- $G'_{\text{RE}} \leq 0,5 \text{ S/km per track}$ and $\Delta U_{\text{RE}} \leq + 5 \text{ V}$ for open formation (1)
- $G'_{\text{RE}} \leq 2,5 \text{ S/km per track}$ and $\Delta U_{\text{RE}} \leq + 1 \text{ V}$ for closed formation (2)

For the averaging process, only the parts of the rail potential shift, ΔU_{RE} , that are more positive than the potential U_{RE} (measured during the non-operational periods) are taken into account. The averaging period shall normally be 24 h, or multiples of 24 h. For some systems, shorter measuring periods can be used. The ΔU_{RE} values are then divided by the total number of measurements over the recording time. A guide value for the sampling rate is two per second.

Due to the degradation of the track system over time, more conservative values are required at commissioning. Maintenance interventions will help ensure the stray currents do not cause degradation of vulnerable assets.

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

$$\boxed{A1} \quad G'_{RE} \leq \frac{I'_{\max}}{\Delta U_{RE}} \quad (3)$$

where

- $I'_{\max}$ is 2,5 mA/m per track or the value coming from the investigation in 5.4;
- G'_{RE} is the conductance per length, in siemens per kilometre (S/km, whereby 1 S/km = 1/Ωkm);
- ΔU_{RE} is the average positive rail potential shift, in volts (V). $\boxed{A1}$

Because of changing moisture, a conductance per length of $\boxed{A1} \quad G'_{RE} < 0,5 \text{ S/km per track } \boxed{A1}$ is not practical for tracks in closed formation and hence not recommended. $\boxed{A1}$ If the average positive rail potential shift combined with the conductance per length does not meet the criteria of $I'_{\max} = 2,5 \text{ mA/m per track}$, the electric traction power supply system should be optimized. $\boxed{A1}$

For a double track line, the value for the maximum conductance per length is to be multiplied by two. For more than two tracks the factor increases accordingly.

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

NOTE 2 Simulation of the electric traction power supply system 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 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 Formulae (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 Formulae (1), (2) or (3) shall be maintained, see 10.2.1.

NOTE 3 Experience has shown that if the requirements given in 5.2 regarding stray current leakage and conductance are fulfilled, impacts on non-railway installations caused by stray currents are generally acceptable.

5.3 Criteria for systems with steel reinforced concrete or metallic structures

In systems with steel reinforced concrete or metallic structures, like

- reinforced track bed,
- tunnels or
- viaducts,

the impact of stray currents on the structures shall be considered.

The positive voltage shift of the structure with respect to earth is one criterion for acceptance. Measurement of the corrosion rate can be achieved using an electrical resistance probe, and the measured corrosion rate can be compared to the design corrosion rate value.

If the average value of the positive potential shift between the structure and earth does not exceed + 200 mV for steel in concrete structures the risk of corrosion can be considered as low, see $\boxed{A1}$ EN ISO 21857:2021. $\boxed{A1}$ A margin may be added according to the expected possible traffic extension in the future. For buried metal

constructions without cathodic protection the values depend on soil resistivity and the material. ^{A1} Both requirements shall comply with EN ISO 21857:2021.

NOTE An applicable assessment method is described in EN ISO 21857:2021, Annex J. For railway structures case a) is applicable. ^{A1}

In order to avoid inadmissible stray current effects on steel reinforced concrete or metallic structures, the longitudinal voltage between any two points of these (longitudinally) interconnected structures should be calculated. The maximum longitudinal voltage shall be smaller than the permissible positive potential shift, e.g. +200 mV. ^{A1} Clause C.2 shows an example calculation. ^{A1} ^{A1} *Text deleted.* ^{A1}

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 is also necessary when major revisions of existing lines are carried out, when the stray current situation is likely to become worse.

The following aspects should be included in the study:

- insulation from earth of the rails and connected metallic structures,
- humidity of the track bed,
- longitudinal resistance of the running rails, when used for traction return circuit,
- 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

Clause 4 identifies the hazards and risks that shall be considered in the design for stray current mitigation.

6.2 Return circuit

6.2.1 General

In order to minimize stray current caused by a DC electric traction power supply system, the traction return current shall be confined to the intended return circuit as far as possible.

As the return circuit in case of DC electric traction power supply systems usually is not connected to earth, safety requirements for the rail potential according to EN 50122-1:2022, 6.2.2 and Clause 9, shall be fulfilled.

6.2.2 Resistance of running rails

In order to achieve the requirements set out in Clause 5, the longitudinal resistance of the running rails when used for traction return circuit shall be as low as reasonably practical. 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 % of the initial resistance. This does not include insulated rail joints, where electrical separation is required.

Impedance bonds, used for track circuit separation, will also carry the full rail current and can result in an increase of rail resistance greater than the required 5 %. Signalling requirements shall take precedence over stray current mitigation. In such a case, alternative methods to reduce the overall rail circuit resistance, or the effects of the increased stray currents, shall be applied.