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Železniške naprave - Fiksni postroji - Električna varnost, ozemljitev in povratni tokokrog - 2. del: Zaščitni ukrepi proti učinkom blodečih tokov, ki jih povzročajo enosmerni sistemi vleke

Railway applications - Fixed installations - Electrical safety, earthing and the return circuit - Part 2: Provisions against the effects of stray currents caused by DC traction systems

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

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

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ICS:

29.120.50	Varovalke in druga nadtokovna zaščita	Fuses and other overcurrent protection devices
29.280	Električna vlečna oprema	Electric traction equipment

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European Committee for Electrotechnical Standardization
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Ref. No. EN 50122-2:2022 E

Contents

Page

Figures

European foreword

This document (EN 50122-2:2022) has been prepared by CLC/SC 9XC “Electric supply and earthing systems for public transport equipment and ancillary apparatus (Fixed installations)”.

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
• latest date by which the national standards conflicting with this document have to be withdrawn	(dow)	2025-07-25

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.

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*

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

DC traction systems can cause stray currents which could adversely affect the railway concerned and/or outside installations, when the feed and return circuits are not sufficiently insulated from 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 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.

The 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 line equipment mast bases). See also 5.4 and Clause 6.

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

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

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 Third party installations in proximity to the railway system could require additional measures.

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. The corrosion rate is the main aspect for the assessment of risk.

5.2 Criteria for the protection of the tracks

Experience over more than three decades has proven that there is no damage in the tracks over this period, if the average stray current per length does not exceed the following value:

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

(Time averaged stray current leakage per length of a single track line).

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 life-time, further investigations according to 5.4 do not need to be performed.

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

— $G'_{RE} \leq$ 2,5 S/km per track and $\Delta U_{RE} \leq$ + 1 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).

$$G'_{RE} \leq \frac{I'}{\Delta U_{RE}} \qquad (3)$$

where

- I' is 2,5 mA/m per track or the value coming from the investigation in 5.4;
- G'_{RE} is the conductance per length between rails and earth, in siemens per kilometre (S/km, whereby 1 S/km = 1/Ω ·km);
- ΔU_{RE} is the average positive rail potential shift, in volts (V).

Because of changing moisture, a conductance per length of G'_{RE} < 0,5 S/km is not practical for tracks in closed formation and hence not recommended. If the average conductance per length does not allow to fulfil the criteria of I' = 2,5 mA/m, the electric traction power supply system should be optimized.

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 EN 50162:2004. 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. For both requirements refer to EN 50162:2004.

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. As an example for calculation see C.2. This is a conservative procedure which ensures that the actual values for the structure potential with respect to 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 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.

The longitudinal resistance can be reduced by using rails with a greater cross section or, if signalling considerations allow, cross bonding of the running rails.

6.2.3 Track system

When the running rails are used as a part of the return circuit, the insulation between the running rails and the earth shall ensure that the requirements of 5.2 are fulfilled.

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

The values of conductance per length, specified in 5.2, apply to a track consisting of two running rails, as well as any attached system parts (e.g. tie bars or cross bonds) under dry conditions.

NOTE 1 In this context, dry conditions means at least 24 h without, for example, precipitation or washing water.

NOTE 2 After concreting, it is preferable to wait until the concrete has set and has dried out sufficiently. This takes usually at least one month. The setting of concrete is strongly dependent on the environmental conditions.

EXAMPLE 1 The following provisions can be made to achieve the required values of the conductance G'_{RE} for rails laid in an open formation:

— clean ballast;

— wooden sleepers or steel reinforced concrete sleepers with insulating fastening;

— provide the required distance between running rails and ballast.

EXAMPLE 2 The following provisions can be made to achieve the required values of the conductance G'_{RE} for rails laid in a closed formation:

— fitting of the running rails in an insulating resin bed; Annex D and Annex E provide guidelines to test encapsulation and fastening systems respectively;

— provision of insulating intermediate layers between the tracks and the bearing systems;

— effective water drainage.

6.2.4 Return conductors

Return conductors, if required, are laid in parallel to the running rails and shall be connected to them at regular intervals so that the rail potentials and stray current criteria are met. The return conductors shall be insulated from earth.

6.2.5 Return cables

Return cables connect the running rails with the substation. They shall have an insulating outer sheath, so that no stray currents can leave or enter.

Where mechanical damage is likely, return cables should have an additional protection.

Requirements of EN 50122-1:2022, 10.3 remain.

6.2.6 Electrical separation between the return circuit and system parts with earth-electrode effect

In order to reduce stray currents, no part of the return circuit shall have a direct conductive connection to installations, components or metallic structures which are not insulated from earth.

If a connection to the return circuit is unavoidable for reasons of protection against electric shock, provisions shall be taken to reduce the stray current effects. These can be for example:

— open connection to the return circuit, protected by a voltage limiting device, which shall be in accordance with EN 50122-1:2022, Annex G;