IEC 62128-2

Edition 2.0 2013-09

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

IEC 62128-2:2013

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International Standard IEC 62128-2 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

This second edition cancels and replaces the first edition issued in 2003. It constitutes a technical revision.

The main technical changes with regard to the previous edition are a consequence of the revision of the related European Standard, EN 50122-2. Main changes are the restructuring of all clauses.

The text of this standard is based on the following documents:

FDIS	Report on voting
9/1804/FDIS	9/1833/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62128 series, published under the general title *Railway applications – Fixed installations – Electrical safety, earthing and the return circuit*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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

1 Scope

This part of IEC 62128 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 standard only deals with stray currents flowing from a d.c. traction system.

This 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 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 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 standard does not specify working rules for maintenance.

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.

NOTE Normative references are made to IEC standards. For some references the IEC standards do not exist. In these cases, references are made to European Standards which are normative for Europe. For non-European countries these references are only informative and therefore listed in the bibliography.

IEC 60850, *Railway applications – Supply voltages of traction systems*

IEC 62128-1, *Railway applications – Fixed installations – Electrical safety, earthing and the return circuit – Part 1: Protective provisions against electric shock*

IEC 62128-3, *Railway applications – Fixed installations – Electrical safety, earthing and the return circuit – Part 3: Mutual interaction of a.c. and d.c. traction systems*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62128-1 apply.

4 Identification of hazards and risks

DC 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 standard.

The system design shall be completed sufficiently early so that the results can be taken into account in the essential system parameters, which influence the stray current effects, such as the spacing of the substations and in the design of the civil structures, see also 5.4 and Clause 6.

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 IEC 62128-1 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.

In addition 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 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 criteria for the protection of the tracks shall comply with this subclause, except there are . national regulations providing an equivalent level of protection.

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).

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.

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

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

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

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

$$G'_{RE} = \frac{I'}{U_{RE}} \tag{3}$$

where

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

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.

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 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 Formulas (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 Formulas (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, such as:

– 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.

The criteria for the protection of structures shall comply with this subclause, except there are national regulations providing an equivalent level of protection. Experience has shown, that for non-cathodically protected structures 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 structures the values depend on soil resistivity and the material.

NOTE 1 For European countries EN 50162:2004 gives appropriate values.

NOTE 2 Experience has shown that in case the requirements given in this Standard are fulfilled, impacts on non-railway installations caused by stray currents are acceptable.

In order to avoid inadmissible stray current effects at the civil structures the longitudinal voltage between any two points of the through connected metal reinforced tunnel structure should be calculated. The maximum longitudinal voltage shall be smaller than the permissible potential shift. As an example for calculation see Clause 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 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 standard.

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 IEC 62128-1, 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 %. This does not include the insulated rail joints of signalling system.

In case of impedance bonds at insulated rail joints the total resistance may be 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 Formulas (1), (2) and (3) of 5.2 the water drainage of the substructure of the running rails is essential.

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.

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 reinforced-concrete sleepers with insulating fastening;

– 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;

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

– effective 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. They 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.

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.

In case of direct conductive connection to installations, components or metallic structures which are not insulated from earth, the values given in Formulas (1), (2) and (3) of 5.2 should be fulfilled for the return circuit and parts connected to it.

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 with the return circuit, in this case the voltage-limiting device shall satisfy the requirements given in IEC 62128-1, Annex F;
– insulation of the equipment or components that are connected to the running rails, from foundations or components that are earthed;
– insulation of the metal reinforcement of the structure from earth.

For exceptions regarding workshops and similar locations see Clause 9.

A conductor rail insulated from earth, the so-called "fourth rail", can be used for the traction return current. If this is a live part and not connected to the running rails, usually no stray currents occur. In the case of conductor rail systems with third and fourth rails, each conductor rail shall be insulated from earth depending on the nominal voltage of the system according to IEC 60850.

6.2.7 Rail-to-rail and track-to-track cross-bonds

Rail-to-rail cross-bonds, tie bars, track-to-track cross-bonds and other bonds which can come in contact with earth shall be insulated.

6.3 Non-traction related electrical equipment

Non-traction related electrical equipment shall be installed according to IEC 62128-1, Clause 7.

6.4 Tracks of other traction systems

Generally, the tracks of other traction systems shall not have any direct conductive connection to tracks of d.c. traction systems.

Tracks without contact line may be connected to the return circuit in special cases if they fulfil the requirements given in 6.2.3.

If running rails are used by d.c. and a.c. traction systems, additional provisions shall be made against the stray current hazard and against impermissible touch voltages, see IEC 62128-3.

Any additional provisions shall not affect other safety criteria, particularly those that are made to minimise the touch voltage as well as those that are made to operate the power supply, track circuits and communication systems.

6.5 Return busbar in the substation

The substation shall be arranged so that direct current does not flow in the substation structure earth. Risks from stray current relating to the earthing of equipment due to maintenance work shall be taken into account. The return busbars in substations and similar

installations shall be operated so that they are insulated from earth. Where required for safety reasons a voltage-limiting device (minimum type O) to connect between the return busbar and earth shall be provided in accordance with IEC 62128-1, Annex F. For substations in depots and workshops see Clause 9.

6.6 Level crossings

At level crossings, where the running rails are laid in a closed formation, care shall be taken that the value of the conductance per length does not exceed the value of the neighbouring tracks.

6.7 Common power supply for tram and trolleybus

If trolleybuses and tramways receive their traction power from the same substation, one of the trolley contact wires may be connected with the track return system according to IEC 62128-1. In this case it shall be checked whether the protective provisions for both systems to minimise stray current effects are still sufficient.

The insulation of the running rails shall be coordinated with other provisions ensuring that acceptable touch voltages according to IEC 62128-1 are not exceeded during operation, in case of a short-circuit and in case of an earth fault.

6.8 Changeover from the mainline to depot and workshop areas

See Clause 9.

7 Provisions for influenced metallic structures

7.1 General

The resistance between conductive structures which are not insulated from earth and the track return system shall be high. Except in the case of depots and workshops (see Clause 9) earth and track return systems shall not be connected directly. A direct connection to earth may also be allowed in certain industrial systems with d.c. traction taking into consideration the particular surrounding conditions, e.g. open cast coal mines.

7.2 Tunnels, bridges, viaducts and reinforced concrete slab track

7.2.1 Basic proceeding

In a structure which incorporates conductive components it can be necessary to make provisions to limit possible effects of stray currents. The requirements for protection against electric shock shall be taken into account. This is applicable to tunnels, viaducts, bridges and reinforced concrete slab tracks.

EXAMPLE The provisions to reduce the stray current effects in tunnel structures with conductive components can depend on:

– whether the predominant source of the stray current is internal or external to the tunnel,

– whether the main priority is to protect the tunnel metallic structures, or to protect other metallic structures external to the tunnel and the railway.

7.2.2 Longitudinal interconnection

In the case of tunnels, viaducts, bridges or slab tracks with metal reinforced concrete structures it is possible that stray currents can flow into such structures and from there influence other outside non-railway conductive structures. In this case the effect of such influence shall be reduced by means of equipotential bonding in the lower part of the individual tunnel sections or other conductive structures to achieve the voltage requirements according to 5.3. This equipotential bonding shall be achieved by: