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INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

Applications ferroviaires – Installations fixes – Sécurité électrique, mise à la terre et circuit de retour – Partie 3: Interactions mutuelles entre systèmes de traction en courant alternatif et en courant continu

IEC 62128-3:2013

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International Standard IEC 62128-3 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

This standard is based on EN 50122-3.

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

FDIS	Report on voting
9/1805/FDIS	9/1838/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- withdrawn,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 3: Mutual interaction of a.c. and d.c. traction systems

1 Scope

This part of IEC 62128 specifies requirements for the protective provisions relating to electrical safety in fixed installations, when it is reasonably likely that hazardous voltages or currents will arise for people or equipment, as a result of the mutual interaction of a.c. and d.c. electric traction systems.

It also applies to all aspects of fixed installations that are necessary to ensure electrical safety during maintenance work within electric traction systems.

The mutual interaction can be of any of the following kinds:

– parallel running of a.c. and d.c. electric traction systems;
– crossing of a.c. and d.c. electric traction systems;
– shared use of tracks, buildings or other structures;
– system separation sections between a.c. and d.c. electric traction systems.

Scope is limited to basic frequency voltages and currents and their superposition. This standard does not cover radiated interferences.

This standard applies to all new lines, extensions and to all major revisions to existing lines for the following electric traction systems:

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.

The 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 or via transformers from the contact line system and are not endangered by the traction power supply system for railways;
f) suspended cable cars;
g) funicular railways;
h) procedures or rules for maintenance.

The rules given in this standard can also be applied to mutual interaction with non-electrified tracks, if hazardous voltages or currents can arise from a.c. or d.c. electric traction systems.

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.

IEC 62128-1:2013, *Railway applications – Fixed installations – Electrical safety, earthing and the return circuit – Part 1: Protective provisions against electric shock*

IEC 62128-2:2013, *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*

3 Terms and definitions

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

4 Hazards and adverse effects

4.1 General

The different requirements specified in IEC 62128-1 and IEC 62128-2, concerning connections to the return circuit of the a.c. railway, and connections to the return circuit of the d.c. railway, shall be harmonized in order to avoid risks of hazardous voltages and stray currents.

Such hazards and risks shall be considered from the start of the planning of any installation which includes both a.c. and d.c. railways. Suitable measures shall be specified for limiting the voltages to the levels given in this standard, while limiting the damaging effects of stray currents in accordance with IEC 62128-2.

Additional adverse effects are possible, for example:

– thermal overload of conductors, screens and sheaths;
– thermal overload of transformers due to magnetic saturation of the cores;
– restriction of operation because of possible effects on the safety and correct functioning of signalling systems;
– restriction of operation because of malfunction of the communication system.

These effects should be considered in accordance with the appropriate standards.

4.2 Electrical safety of persons

Where a.c. and d.c. voltages are present together the limits for touch voltage given in Clause 7 apply in addition to the limits given in IEC 62128-1:2013, Clause 9.

5 Types of mutual interaction to be considered

5.1 General

Coupling describes the physical process of transmission of energy from a source to a susceptible device.

The following types of coupling shall be considered:

a) galvanic (conductive) coupling;

b) non-galvanic coupling;

   1) inductive coupling;

   2) capacitive coupling.

Galvanic coupling dominates at low frequencies, when circuit impedances are low. The effects of galvanic coupling are conductive voltages and currents.

The effects of inductive coupling are induced voltages and hence currents. These voltages and currents depend *inter alia* on the distances, length, inducing current conductor arrangement and frequency.

The effects of capacitive coupling are influenced voltages into galvanically separated parts or conductors. The influenced voltages depend *inter alia* on the voltage of the influencing system and the distance. Currents resulting from capacitive coupling also depend on the frequency.

NOTE As far as the capacitive and inductive coupling is concerned, general experience is that only the influence of the a.c. railway to the d.c. railway is significant.

5.2 Galvanic coupling

5.2.1 AC and d.c. return circuits not directly connected

A mutual interaction between the return circuits is possible by currents through earth caused by the rail potential of both a.c. and d.c. railways, for example return currents flowing through the return conductors, earthing installations of traction power supply substations and cable screens.

In case a conductive parallel path to the return circuit exists in the influenced system, various effects are possible. In case a vehicle forms part of the parallel path, return current of the influencing railway system can flow through the propulsion system of the traction unit. The same effects are possible when the return current of the influencing system flows, for example, through the auto-transformer and substation transformer of an auto-transformer system or through booster transformers or other devices.

An electric shock with combined voltages can occur when parts of the return circuits or conductive parts which are connected to the return circuits by voltage limiting devices are located in the overhead contact line zone of the other railway system, see 8.2.2.

5.2.2 AC and d.c. return circuits directly connected or common

In addition to the effects described in 5.2.1 current exchange will be increased where a.c. and d.c. return circuits are directly connected or common.

EXAMPLE Direct connections can be railway level crossings, common tracks, system separation sections, etc.

Currents flowing between the a.c. railway and the d.c. railway can create mutual interaction between the return circuits.

Both return circuits are at the same potential at the location of the connection. A short-circuit within the a.c. system can cause a peak voltage on conductive structures connected to the return circuit of the d.c. railway. The same effects apply for conductive structures connected to it directly or via a voltage limiting device (VLD). The voltage across the voltage limiting device can trip the device without a fault on the d.c. side.

The connection of the return circuit of the d.c. railway to the earthed return circuit of the a.c. railway increases the danger of stray current corrosion.

For requirements for fixed installations see 8.3.

5.3 Non-galvanic coupling

5.3.1 Inductive coupling

An a.c. voltage can be induced on a d.c. contact line system and on the d.c. system's return circuit. This effect needs to be considered in case the d.c. railway is within the zone of mutual interaction.

Consequently an a.c. voltage can occur within the d.c. substation at the busbars versus earth (i.e. at the rectifier or in the feeder cubicles).

Interaction can occur in terms of impermissible touch voltages. See Clause 7.

Perpendicular crossings do not result in inductive effects in the d.c. system.

5.3.2 Capacitive coupling

Within small distances an a.c. voltage can be influenced on a d.c. contact line system when it is isolated with a disconnector or circuit-breaker open. The possibility shall be considered that the flash-over voltage of the insulators or of the surge arrestors can be reached.

Distance depends *inter alia* on geometry and voltage.

An a.c. voltage can occur within the d.c. substation at the d.c. busbars versus earth, i.e. in the feeder cubicles.

Interaction can occur in terms of impermissible touch voltages. See Clause 7.

6 Zone of mutual interaction

6.1 General

The a.c. railway affects the d.c. railway and vice-versa by galvanic, inductive and/or capacitive coupling (see Clause 5). The zone of mutual interaction indicates a distance and a length of parallelism between an a.c. railway and a d.c. railway (see Annex A). The limits of zone of mutual interaction are based on the limits of the touch voltage given in Clause 7.

If a zone of mutual interaction exists the requirements given in this standard shall be fulfilled.

When the distance between both a.c. and d.c. railways is less than 50 m a zone of mutual interaction is assumed. Distances in excess of 50 m are dealt with in 6.2 and 6.3.

When the distance between a.c. and d.c. railways becomes less than 50 m effects as described in 5.2.1 or even 5.2.2 can be expected.

Distances between a.c. railway and the d.c. railway cannot be given in a generic way and should be addressed separately depending on the local conditions.

NOTE For information on analysis and assessment of zone of mutual interaction see Annex C.

6.2 AC

In case of an a.c. railway influencing a d.c. railway the zone of mutual interaction is based on voltages coupled into the affected system.

For planning purposes the zone of mutual interaction has to be investigated either by calculation or by the following procedure.

Where the following preconditions apply the limit of the distance between a.c. and d.c. railway is 1 000 m:

– double track line, where only the four running rails of the a.c. railway are used for the return circuit;
– the inducing current is 500 A per overhead contact line (1 000 A in total);
– the length of parallelism between a.c. and d.c. railway is 4 km;
– the soil resistivity is 100 Ωm;
– the rated frequency is 50 Hz;
– the affected system is insulated versus earth along its entire length and connected to earth at one end only;
– screening effects of other parallel metallic objects have not been taken into account.

Where other preconditions apply the dimension of the zone of mutual interaction shall be calculated.

A method for the calculation is given in Annex A.

NOTE The example above is based on a 35 V limit for a.c. with a time duration longer than 300 s.

In case a d.c. railway is within the zone of mutual interaction of an a.c. railway, the level of voltages or currents coupled into the d.c. system is not necessarily too high; in this case further analysis of the situation shall be carried out.

6.3 DC

For the effects of d.c. railway systems on a.c. railway systems the dimension of the zone of mutual interaction can be neglected due to the steep voltage gradient in the soil, caused by the insulated rails.

However if the possibility of a voltage transfer exists, either permanently or temporary, due to a galvanic connection towards conductive or partly conductive parts, the zone of mutual interaction is given by the dimensions of those parts. In this case the level of voltages or currents coupled into the a.c. system is not necessarily too high; further analysis of the situation shall be carried out.

7 Touch voltage limits for the combination of alternating and direct voltages

7.1 General

The limits given in 7.2 to 7.6 are based on touch voltage only and shall not be exceeded. Other effects with respect to electrical installations are not taken into account.

Limits for electrical installations cannot be given in a generic way and should be addressed separately if necessary, depending on the sensitivity of the affected installations.

Where either an alternating or a direct voltage is present the touch voltage limits given in IEC 62128-1 apply.

The direct and the alternating components of a combined voltage $u(t)$ for time duration in excess of 1 s are calculated as follows:

$$U_{\text{dc}} = \frac{1}{T} \cdot \int_{a}^{a+T} u(t) \cdot \text{d}t \qquad (1)$$

$$U_{ac} = \sqrt{\frac{1}{T} \cdot \int_{a}^{a+T} \left(u(t) - U_{dc}\right)^2 \cdot dt} \qquad (2)$$

where

T = 1 s;

t is the time;

$u(t)$ is the combined voltage;

U_{dc} is the direct component of combined voltage;

U_{ac} is the alternating component of combined voltage.

NOTE 1 Formula (1) gives the moving average value of the direct component, Formula (2) gives the moving r.m.s. value of the alternating component.

Only for short-duration phenomena $t \leq 1$ s the following definitions for alternating voltage and direct voltage are used:

– U_{dc} is defined as that part of the combined voltage that is caused by the d.c. system;

– U_{ac} is defined as that part of the combined voltage that is caused by the a.c. system.

NOTE 2 Further information on combined voltages is given in Annex B.

NOTE 3 Long-term conditions are associated with operation conditions and short-term conditions are associated with fault conditions or for example switching operations.

7.2 Touch voltage limits for long-term conditions

The following approach shall be used to check whether the combined voltage is permissible:

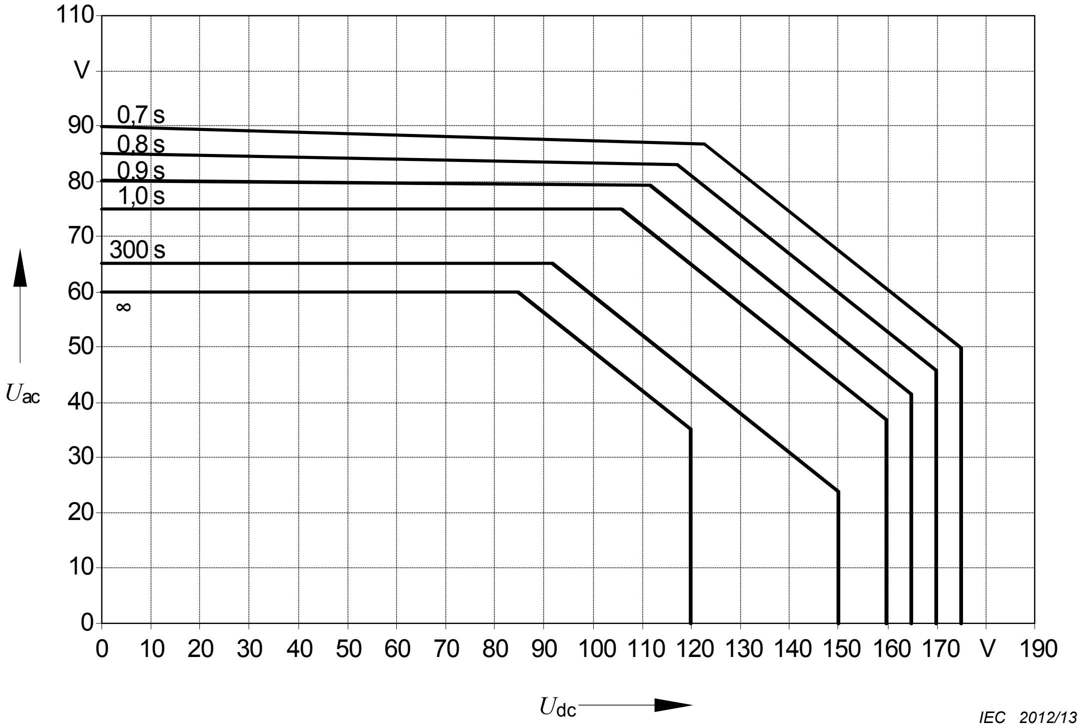
a) the alternating part of the combined voltage shall not exceed the maximum permissible alternating body voltage as given in IEC 62128-1, Table 3 for the applicable duration;

b) the direct part of the combined voltage shall not exceed the maximum permissible direct body voltage as given in IEC 62128-1, Table 5 for the applicable duration;

c) the combined voltage is permissible if it is within the envelope as given for the applicable duration in Figure 1;

d) for time durations in excess of 1 s the combined peak value (see explanation in Annex B) shall be less than $2 \times \sqrt{2}$ times the maximum permissible alternating body voltage as given in IEC 62128-1, Table 3 for the applicable duration irrespective of frequency content.

EXAMPLE Assuming the maximum permissible direct touch voltage of 120 V being present in the d.c. system the alternating voltage limit is 35 V, see Figure 1. Assuming the maximum permissible alternating touch voltage of 60 V being present in the a.c. system the direct voltage limit is 85 V, see Figure 1.



All values are r.m.s.

Figure 1 – Maximum permissible combined effective touch voltages (excluding workshops and similar locations) for long-term conditions

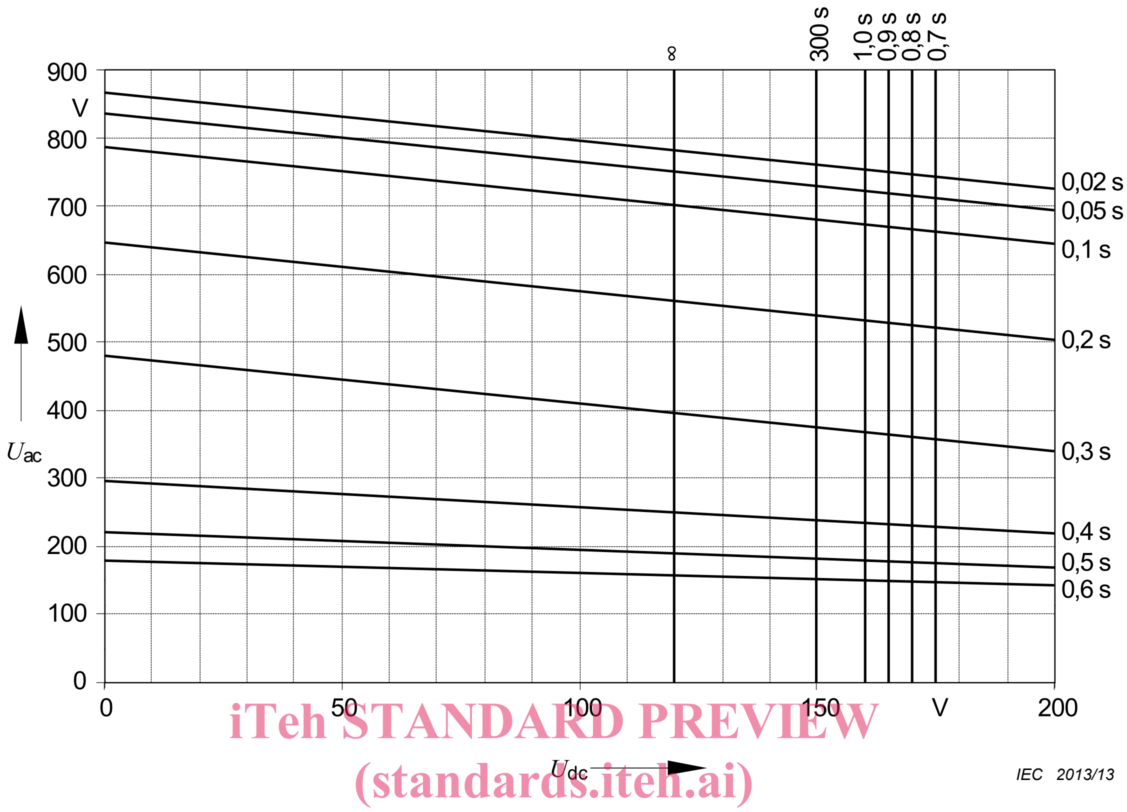
7.3 AC system short-term conditions and d.c. system long-term conditions

The following approach shall be used to check whether the combined voltage is permissible:

a) the short-duration alternating part of the combined voltage shall not exceed the maximum permissible alternating touch voltage as given in IEC 62128-1, Table 4 for the applicable duration;

b) the direct part of the combined voltage shall not exceed the maximum permissible direct touch voltage as given in IEC 62128-1, Table 6 for the applicable duration;

c) the combined voltage is permissible if it is within the envelope as given for the applicable durations in Figure 2.



All values are r.m.s.

Figure 2 – Maximum permissible combined effective touch voltages under a.c. short-term conditions and d.c. long-term conditions

EXAMPLE An example of the use of Figure 2 is given in Annex B.

7.4 AC system long-term conditions and d.c. system short-term conditions

The following approach shall be used to check whether the combined voltage is permissible:

a) the alternating part of the combined voltage shall not exceed the maximum permissible alternating touch voltage as given in IEC 62128-1, Table 4 for the applicable duration;

b) the short-duration direct part of the combined voltage shall not exceed the maximum permissible direct touch voltage as given in IEC 62128-1, Table 6 for the applicable duration;

c) the combined voltage is permissible if it is within the envelope as given for the applicable durations in Figure 3.