

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Railway applications - Fixed installations - Protection principles for AC and DC electric traction power supply systems

Applications ferroviaires - Installations fixes - Principes de protection pour les réseaux d'alimentation de traction électrique à courant alternatif et à courant continu



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**RAILWAY APPLICATIONS – FIXED INSTALLATIONS –
PROTECTION PRINCIPLES FOR AC AND DC ELECTRIC
TRACTION POWER SUPPLY SYSTEMS**

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EN 50633 (2016) has served as a basis for the elaboration of this document.

The text of this International Standard is based on the following documents:

Draft	Report on voting
9/3114/FDIS	9/3143/RVD

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

The language used for the development of this International Standard is English.

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RAILWAY APPLICATIONS – FIXED INSTALLATIONS – PROTECTION PRINCIPLES FOR AC AND DC ELECTRIC TRACTION POWER SUPPLY SYSTEMS

1 Scope

This International Standard applies to the electrical protection system, provided for AC and DC electric traction power supply systems. It:

- establishes railway specific protection principles;
- describes the railway specific protection system functionality;
- specifies minimum functional requirements and informative examples of their application;
- establishes limitations of the protection system and the acceptability of residual risks;
- specifies principles for design verification.

This document is applicable to:

- railways;
- guided mass transport systems, such as tramways, elevated and underground railways, mountain railways, trolleybus systems, and magnetically levitated systems which use a contact line system.

This document can also be applied to electrified road traffic with a contact line, such as truck-trolley systems.

This document applies to new electric traction power supply systems and can be applied to changes of existing systems.

This document does not apply to:

- underground mine traction systems;
- 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;
- suspended cable cars;
- funicular railways;
- magnetic levitated systems (without a contact line system);
- railways with an inductive power supply without contact system;
- railways with a buried contact system that is required to be energized only below the train to ensure safety.

This document does not cover:

- technical requirements for products, e.g. protection devices;
- rules for maintenance of protection systems.

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.

IEC 61991:2019, *Railway applications – Rolling stock – Protective provisions against electrical hazards*

IEC 61992-1:2006, *Railway applications – Fixed installations – DC switchgear – Part 1: General*
IEC 61992-1:2006/AMD1:2014

IEC 61992-7-1:2006, *Railway applications – Fixed installations – DC switchgear – Part 7-1: Measurement, control and protection devices for specific use in d.c. traction systems – Application guide*

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

IEC 62128-3:2013, *Railway applications – Fixed installations – Electrical safety, earthing and the return circuit – Part 3: Mutual interaction of a.c. and d.c. traction systems*

IEC 62590:2019, *Railway applications – Fixed installations – Electronic power converters for substations*

IEC 62313:2009, *Railway applications – Power supply and rolling stock – Technical criteria for the coordination between power supply (substation) and rolling stock*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

3.1

contact line system

support system and contact line supplying electric energy to vehicles through current-collecting equipment

Note 1 to entry: The contact line system can comprise

- the contact line;
- masts and foundations;
- supports and any components registering the conductors,
- cross-spans or cables,
- tensioners,
- other along track conductors such as feeders, earth wires and return conductors when supported from the same masts as the contact line,
- conductors connected permanently to the contact line for supplying other electrical equipment such as lighting, signal operation, point control and point heating.

[SOURCE: IEC 60050-811:2017, 811-33-59]

3.2 electric traction power supply system

railway electrical distribution network used to provide energy for rolling stock

Note 1 to entry: The system includes:

- contact line systems;
- return circuit of electric traction power supply systems;
- electrical installations in power plants and substations, which are utilized solely for distribution of power directly to the contact line;
- electrical installations of switching stations.

[SOURCE: IEC 60050-811: 2017, 811-36-21, modified – "power supply" added in the term for enhancing clarity since electric traction is typically used for onboard power supply. Also, running rails of non-electrified lines in the vicinity of, and conductively connected to the running rails of an electric traction power supply system, and electrical installations which are supplied from contact lines either directly or via a transformer have been excluded from Note 1 to entry.]

3.3 traction substation <electric traction> substation <electric traction>

substation, the main function of which is to supply an electric traction power supply system

Note 1 to entry: The synonym substation is used only when the context is clear

[SOURCE: IEC 60050-811:2017, 811-36-02]

3.4 switching station traction switching station

installation from which electrical energy can be distributed to different feeding sections or from which different feeding sections can be switched on and off or can be interconnected

[SOURCE: IEC 60050-811:2017, 811-36-22]

3.5 feeding section

electrical section of the route fed by individual track feeder circuit-breakers within the area supplied by one or more substations

[SOURCE: IEC 60050-811:2017, 811-36-25]

3.6 electrical safety

freedom from risk that is not tolerable and which is caused by electricity

[SOURCE: IEC 60050-195:2021, 195-01-20]

3.7 electric shock

physiological effect resulting from an electric current passing through a human body or livestock

[SOURCE: IEC 60050-195:2021, 195-01-04]

3.8 return circuit

all conductors which form the intended path for the traction return current and the current under fault conditions

Note 1 to entry: The conductors can be for example:

- running rails;
- return conductor rails;
- return conductors;
- return cables.

[SOURCE: IEC 60050-811:2017, 811-35-01]

3.9 switchgear

switching devices and their combination with associated control, measuring, protective and regulating equipment, also assemblies of such devices and equipment with associated interconnections, accessories, enclosures and supporting structures, intended in principle for use in connection with generation, transmission, distribution and conversion of electric energy

[SOURCE: IEC 60050-441:1984, 441-11-02]

3.10 protection operating time

interval of time between the fault inception and the instant of initiation of the opening operation of a switching device, e.g. circuit-breaker

Note 1 to entry: This time includes measurement, communication and protection device operation.

3.11 opening time <of a mechanical switching device>

interval of time between the specified instant of initiation of the opening operation and the instant when the arcing contacts have separated in all poles

Note 1 to entry: The instant of initiation of the opening operation, i.e. the application of the opening command (e.g. energizing the release, etc.), is given in the relevant specifications.

[SOURCE: IEC 60050-441:1984, 441-17-36]

3.12 break-time

interval of time between the beginning of the opening time of a mechanical switching device (or the pre-arcing time of a fuse) and the end of the arcing time

[SOURCE: IEC 60050-441:1984, 441-17-39]

3.13 fault clearance time

time interval between the fault inception and the fault clearance

Note 1 to entry: This time is the longest fault current interruption time of the associated circuit-breaker(s) for elimination of fault current on the faulty item of plant.

Note 2 to entry: Fault clearance time is the total of the protection operating time, the (mechanical) opening time and the arc extinction time. The latter two are included in break-time, IEC 60050-441-17-39.

[SOURCE: IEC 60050-448:1995, 448-13-15, modified – Note 2 to entry has been added.]

3.14**touch voltage** <effective>

voltage between conductive parts when touched simultaneously by a human being or livestock

Note 1 to entry: The value of the touch voltage is influenced by the impedance of the human being or the livestock in electric contact with these conductive parts.

[SOURCE: IEC 60050-195:2021, 195-05-11]

3.15**fault condition**

non intended condition caused by short-circuit, whilst the time duration is terminated by the correct function of the protection devices and circuit-breakers

Note 1 to entry: For the relevant fault duration the correct operation of protection devices and circuit-breakers is taken into account.

[SOURCE: IEC 62128-1:2013, 3.4.5, modified – "Whilst" added so as to link the sentence "The time duration ..." with the rest of the definition.]

3.16**low resistance fault**

fault condition where the resistance of the fault is sufficiently low that the fault current has a similar magnitude to that which would flow if the fault resistance were zero

Note 1 to entry: The resistance of the fault is typically dominated by the resistance of the power arc.

Note 2 to entry: In this definition, resistance will be understood as also being impedance for AC fault currents.

3.17**high resistance fault** <for electric traction power supply system>

shunt fault with high resistance at the fault location, where the resistance of the fault is sufficiently high that the fault current has a substantially different magnitude to that which would flow with a low resistance fault

Note 1 to entry: In this definition, resistance will be understood as also being impedance for AC fault currents.

[SOURCE: IEC 60050-448:1995, 448-13-08, modified – Definition amended to enhance clarity for the application in electric traction power supply systems. Note 1 added.]

3.18**abnormal operating condition** <for electric traction power supply system>

condition where the system operates beyond its intended capabilities such that damage or reduced life expectancy can be anticipated

3.19**short-circuit**

accidental or intentional conductive path between two or more conductive parts forcing the electric potential differences between these conductive parts to be equal to or close to zero

[SOURCE: IEC 60050-151:2001, 151-12-04]

3.20**current collector**

equipment fitted to a vehicle and intended to collect current from a contact wire or conductor rail

[SOURCE: IEC 60050-811:2017, 811-32-01]

3.21 protection

provisions for detecting faults or other abnormal operating conditions in a power system, for enabling fault clearance, for terminating abnormal operating conditions, and for initiating signals or indications

Note 1 to entry: The term "protection" is a generic term for protection equipment or protection systems.

Note 2 to entry: The term "protection" may be used to describe the protection of a complete power system or the protection of individual plant items in a power system e.g. transformer protection, line protection, generator protection.

Note 3 to entry: Protection does not include items of power system plant provided, for example, to limit overvoltages on the power system. However, it includes items provided to control the power system voltage or frequency deviations such as automatic reactor switching, load-shedding, etc.

[SOURCE: IEC 60050-448:1995, 448-11-01, modified – "abnormal condition" becomes "abnormal operating conditions".]

3.22 protection system

arrangement of one or more protection equipments, and other devices intended to perform one or more specified protection functions

Note 1 to entry: A protection system includes one or more protection equipment, intelligent electronic devices (IED), instrument transformer(s), wiring, tripping circuit(s), auxiliary supply(s) and, where provided, communication system(s). Depending upon the principle(s) of the protection system, it may include one end or all ends of the protected section and, possibly, automatic reclosing equipment.

Note 2 to entry: The circuit-breaker(s) are excluded.

Note 3 to entry: The circuit-breaker protection functions are included, e.g. direct overcurrent or falling voltage release of dc-circuit-breaker(s).

[SOURCE: IEC 60050-448:1995, 448-11-04, modified – Note 3 to entry added.]

3.23 protection equipment

equipment incorporating one or more protection relays and, if necessary, logic elements intended to perform one or more specified protection functions

Note 1 to entry: A protection equipment is part of a protection system.

[SOURCE: IEC 60050-448:1995, 448-11-03, modified – Example omitted.]

3.24 protection relay

measuring relay which, either solely or in combination with other relays, is a constituent of a protection equipment

[SOURCE IEC 60050-448:1995, 448-11-02]

3.25 protected section

part of a power system network, or circuit within a network, to which specified protection has been applied

Note 1 to entry: The protected section normally originates from a point of automatic disconnection to at least the next point of automatic disconnection or the end of the circuit.

Note 2 to entry: An electric traction power supply system is a form of power system network.

[SOURCE: IEC 60050-448:1995, 448-11-05, modified – Notes to entry added.]

3.26**selectivity of protection**

ability of a protection to identify the faulty section and/or phase(s) of a power system

Note 1 to entry: The synonym selectivity is used only when the context is clear.

[SOURCE: IEC 60050-448:1995, 448-11-06, modified – Note 1 to entry added.]

3.27**reliability of protection**

probability that a protection can perform a required function under given conditions for a given time interval

Note 1 to entry: The required function for protection is to operate when required to do so and not to operate when not required to do so.

[SOURCE: IEC 60050-448:1995, 448-12-05]

3.28**redundancy**

in an item, existence of more than one means for performing a required function

[SOURCE: IEC 60050-448:1995, 448-12-08]

3.29**sensitivity** <of protection>

minimum operating level (e.g. current, voltage, frequency, temperature) in a process that can be detected for the purpose of protection

EXAMPLE Sensitivity of a protection system can be expressed by minimum fault current or maximum fault impedance coverage.

3.30**main protection**

protection expected to have priority in initiating fault clearance or an action to terminate an abnormal condition in a power system

Note 1 to entry: For a given item of plant, two or more main protections may be provided.

[SOURCE: IEC 60050-448:1995, 448-11-13]

3.31**backup protection**

protection which is intended to operate when a system fault is not cleared, or abnormal condition not detected, in the required time because of failure or inability of other protection to operate or failure of the appropriate circuit-breaker(s) to trip

[SOURCE: IEC 60050-448:1995, 448-11-14, modified – Note to entry omitted.]

3.32**circuit local backup protection**

backup protection where the input is either from those transducers which are used by the main protection or from transducers associated with the same primary circuit as the main protection

[SOURCE: IEC 60050-448:1995, 448-11-15 modified – "which is energised either from those instrument transformers which energize" replaced with "where the input is either from those transducers which are used by". "instrument transformers" replaced with "a transducer" to make it more generic. Note to entry omitted.]

3.33**substation local backup protection**

backup protection where the input is taken from a transducer located within the same substation as the corresponding main protection and not associated with the same primary circuit

Note 1 to entry: Substation local backup also extends to switching station local backup where appropriate.

[SOURCE: IEC 60050-448:1995, 448-11-16 modified – 'which is energized' replaced with 'where the input is taken'. 'instrument transformers' replaced with 'a transducer' to make it more generic. Note 1 to entry added.]

3.34**remote backup protection**

backup protection located in a substation remote from that substation in which the corresponding main protection is located

[SOURCE: IEC 60050-448:1995, 448-11-17]

3.35**circuit-breaker failure protection**

protection which is designed to clear a system fault by initiating tripping of other circuit-breaker(s) in the case of failure to trip of the appropriate circuit-breaker

[SOURCE: IEC 60050-448:1995, 448-11-18]

3.36**tripping**

opening of a circuit-breaker by either manual or automatic control or by protective devices

[SOURCE: IEC 60050-448:1995, 448-11-31]

3.37**direct overcurrent release**

overcurrent release directly energized by the current in the main circuit of a mechanical switching device

[SOURCE: IEC 60050-441:1984, 441-16-36]

3.38**indirect overcurrent release**

overcurrent release energized by the current in the main circuit of a mechanical switching device through a current transformer or a shunt

[SOURCE: IEC 60050-441:1984, 441-16-37]

4 System to be protected

4.1 Description

The system to be protected within the scope of this document is the electric traction power supply system, within the limits set out in Figure 1. The electric traction power supply system comprises:

- infeed to traction power conversion;
- traction power conversion (e.g. converter, transformer);
- infeed to secondary distribution busbar (including bus coupler);
- infeed to power absorbing equipment (e.g. energy storage system or braking resistor unit);
- line feeder, traction power distribution to the contact line system;
- interconnecting feeders between secondary distribution busbars, e.g. between two substations or switching stations;
- switching station (including switching station feeder and bus coupler);
- autotransformers;
- contact line;
- return circuit.

Not every electric traction power supply system necessarily has all of the above mentioned parts.

NOTE 1 The operational responsibility of the above mentioned components can be split among different operators (owners). However, the protection principles described hereafter are valid for all installations.

The electric traction power supply system has interfaces to other parts of the railway system. These interfaces can include:

- infeed to the primary distribution busbar;
- rolling stock;
- electrical installations fed by the contact line system or busbar (e.g. auxiliary transformers).

Other subsystems or equipment, e.g. signalling and communication can be influenced by the electric traction power supply system but their protection is not within the scope of this document.

Transmission and distribution power lines which are in parallel to or in the railway boundary are not considered to be part of the electric traction power supply system. These are considered to be covered by the protection principles for general transmission and distribution systems.