



BSI Standards Publication

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

Part 1: Protective provisions against electric shock

National foreword

This British Standard is the UK implementation of EN 50122-1:2022+A1:2025. It supersedes BS EN 50122-1:2022, which is withdrawn.

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

The UK participation in its preparation was entrusted to Technical Committee GEL/9/3, Railway Electrotechnical Applications - Fixed Equipment.

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

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English Version

[A1] Fixed installations for railway application - Electrical safety, earthing and the return circuit - Part 1: Protective provisions against electric shock **[A1]**

Applications ferroviaires - Installations fixes - Sécurité électrique, mise à la terre et circuit de retour - Partie 1: Mesures de protection contre les chocs électriques

Bahnanwendungen - Ortsfeste Anlagen - Elektrische Sicherheit, Erdung und Rückleitung - Teil 1: Schutzmaßnahmen gegen elektrischen Schlag

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European foreword

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The following dates are fixed:

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conflicting with this document have to be
withdrawn

This document supersedes EN 50122-1:2011 and all of its amendments and corrigenda (if any).

EN 50122-1:2022 includes the following significant technical changes with respect to EN 50122-1:2011:

- some definitions were modified;
- the dimensions for protection by clearance were modified, and there are now voltage dependent differences for high voltage electric traction power supply systems;
- methods for the use of protective obstacles were significantly changed.

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.

This document has been prepared under a Standardization Request given to CENELEC by the European Commission and the European Free Trade Association.

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European foreword to Amendment 1

This document (EN 50122-1:2022/A1:2025) has been 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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1 Scope

This document specifies requirements for the protective provisions relating to electrical safety in fixed installations associated with AC and/or DC traction systems and to any installations that can be endangered by the electric traction power supply system. This also includes requirements applicable to vehicles on electrified lines.

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

This document applies to new electric traction power supply systems and major revisions to electric traction power supply systems for:

- a) railways;
- b) guided mass transport systems such as
 - 1) tramways,
 - 2) elevated and underground railways,
 - 3) mountain railways,
 - 4) trolleybus systems,
 - 5) electric traction power supply systems for road vehicles, which use an overhead contact line system, and
 - 6) magnetically levitated systems, which use a contact line system;
- 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 or via transformers from the contact line system and are not endangered by the electric traction power supply system,
- c) suspended cable cars,
- d) funicular railways,
- e) existing vehicles.

This document does not specify working rules for maintenance.

The requirements within this document related to protection against electric shock are applicable to persons only.

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 50119:2020, *Railway applications - Fixed installations - Electric traction overhead contact lines*

EN 50122-2:2022, *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*

EN 50124-1:2017, *Railway applications - Insulation coordination - Part 1: Basic requirements - Clearances and creepage distances for all electrical and electronic equipment*

EN 50153:2014,¹ *Railway applications - Rolling stock - Protective provisions relating to electrical hazards*

EN 50163:2004,² *Railway applications - Supply voltages of traction systems*

EN 50341 (series), *Overhead electrical lines exceeding AC 1 kV*

EN 50522:2010, *Earthing of power installations exceeding 1 kV a.c.*

EN 60529:1991,³ *Degrees of protection provided by enclosures (IP Code) (IEC 60529:1989)*

EN 60898-1:2019, *Electrical accessories - Circuit-breakers for overcurrent protection for household and similar installations - Part 1: Circuit-breakers for a.c. operation (IEC 60898-1:2016)*

EN 61140:2016, *Protection against electric shock - Common aspects for installation and equipment (IEC 61140:2016)*

EN 61936-1:2010,⁴ *Power installations exceeding 1 kV a.c. - Part 1: Common rules (IEC 61936-1:2010)*

EN 62305 (series), *Protection against lightning (IEC 62305 series)*

HD 60364-4-41:2017,⁵ *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock (IEC 60364-4-41:2005, modified)*

IEC 60755:2017, *General safety requirements for residual current operated protective devices*

ISO 3864-1:2011, *Graphical symbols — Safety colours and safety signs — Part 1: Design principles for safety signs and safety markings*

ISO 7010:2019, *Graphical symbols — Safety colours and safety signs — Registered safety signs*

¹ As impacted by EN 50153:2014/A1:2017 and EN 50153:2014/A2:2020.

² As impacted by EN 50163:2004/AC:2013 and EN 50163:2004/A2:2020.

³ As impacted by EN 60529:1991/A1:2000 and EN 60529:1991/A2:2013.

⁴ As impacted by EN 61936-1:2010/AC:2011, EN 61936-1:2010:2013 and EN 61936-1:2010/A1:2014.

⁵ As impacted by HD 60364-4-41:2017/A11:2017 and HD 60364-4-41:2017/A12:2019.

3 Terms and definitions

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

These definitions apply to all standards in this series.

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/>

3.1 Electrical safety and hazards

3.1.1

electrical safety

freedom from unacceptable risk of harm caused by electrical systems

3.1.2

electric shock

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

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

3.1.3

(effective) touch voltage

U_{te}

voltage between conductive parts when touched simultaneously by a human being

Note 1 to entry: The value of the effective touch voltage can be appreciably influenced by the impedance of the human being in electric contact with these conductive parts.

Note 2 to entry: The conductive path through the body of a human being is conventionally from hand to both feet (horizontal distance of 1 m) or from hand to hand.

[SOURCE: IEC 60050-195:2021, 195-05-11, modified – in the headline “touch voltage, <effective>” was replaced by “(effective) touch voltage”; “or livestock” in the end of the paragraph and in Note 1 have been deleted, the symbol and the Note 2 to entry have been added]

3.1.4

prospective touch voltage

U_{tp}

voltage between simultaneously accessible conductive parts when those conductive parts are not being touched by a human being

[SOURCE: IEC 60050-195:2021, 195-05-09, modified – The symbol has been added, “or livestock” has been deleted.]

3.1.5

body voltage

U_b

product of the current through the body and the body impedance

3.1.6

standing surface

any point on a surface where persons have an intentional access

3.1.7**protective boarding**

non-conducting barrier to protect persons from coming into direct contact with a live conductor rail

3.1.8**electrically protective obstacle**

part preventing unintentional direct contact, but not preventing such contact by deliberate action

Note 1 to entry: Electrically protective obstacles are intentionally applied in this document also for the protection of ordinary persons.

[SOURCE: IEC 60050-195:2021, 195-06-16, modified – in the headline replaced “protective obstacle, <electrically>” by “electrically protective obstacle”, replaced “contact by a human being or livestock with hazardous-live-parts” by “direct contact”, Note 1 to entry has been added]

3.1.9**anti-trespassing guard**

equipment provided to deter entry to a restricted area, structure or building by an unauthorized person

3.1.10**conductive part**

part that can carry electric current

[SOURCE: IEC 60050-195:2021, 195-01-06]

3.1.11**exposed-conductive-part**

[A1] conductive part of equipment that can be touched and that is not live under normal conditions, but that can become energized when basic insulation fails

Note 1 to entry: A conductive part of electrical equipment, which can become energized only through contact with an exposed-conductive-part which has become energized, is not considered to be an exposed-conductive-part itself.

[SOURCE: IEC 60050-195:2021, 195-06-10, modified – “become live” was replaced with “become energized”, Note 1 to entry has been added.] **[A1]**

3.1.12**live part**

conductor or conductive part intended to be energized in normal use

Note 1 to entry: This concept does not necessarily imply a risk of electric shock.

Note 2 to entry: By convention, this does not include the running rails and parts connected to them.

[SOURCE: IEC 60050-811:2017, 811-36-23]

3.1.13**hazardous-live-part**

live part that, under certain conditions, can give a harmful electric shock

Note 1 to entry: A hazardous voltage can be present on the accessible surface of solid insulation. In such a case, this surface is considered to be a hazardous-live-part.

[SOURCE: IEC 60050-195:2021, 195-06-05]

3.1.14

direct contact

electric contact of human beings or livestock with live parts

[SOURCE: IEC 60050-195:2021, 195-06-03]

3.1.15

indirect contact

electric contact of human beings or livestock with exposed-conductive-parts that have become live under fault conditions

[SOURCE: IEC 60050-195:2021, 195-06-04]

3.1.16

neutral conductor

conductor electrically connected to the neutral point and capable of contributing to the distribution of electric energy

[SOURCE: IEC 60050-826:2004, 826-14-07]

3.1.17

A1 protective conductor

conductor provided for purposes of electrical safety

[SOURCE: IEC 60050-195:2021, 195-02-09] A1

A1 3.1.18

protective earthing conductor

PE conductor

protective conductor provided for protective earthing

[SOURCE: IEC 60050-195:2021, 195-02-11, modified, “protective grounding conductor, US” was deleted] A1

A1 3.1.19 A1

PEN conductor

conductor combining the functions of both a protective earthing conductor and a neutral conductor

[SOURCE: IEC 60050-826:2004, 826-13-25]

A1 3.1.20 A1

solid-wall design

any kind of construction made of concrete, steel or other material without any holes or gaps

A1 3.1.21 A1

voltage-limiting device

VLD

protective device whose function is to prevent existence of an impermissible high touch voltage

[SOURCE: IEC 60050-811:2017, 811-29-41, modified – abbreviation “VLD” added]

3.2 Earthing and equipotential bonding

3.2.1

earth

conductive mass of the earth, whose electric potential at any point is conventionally taken as equal to zero

3.2.2

earthing

connection of conductive parts to an appropriate earth electrode

3.2.3**earth electrode**

conductive part, which may be embedded in a specific conductive medium, e.g. concrete or coke, in electric contact with earth

[SOURCE: IEC 60050-826:2004, 826-13-05, modified – “in the soil or” has been removed. “the Earth” has been replaced with “earth”.]

3.2.4**structure earth**

construction made of metallic parts or construction including interconnected metallic structural parts, which can be used as an earth electrode

Note 1 to entry: Examples are reinforced railway structures such as bridges, viaducts, tunnels, mast foundations and reinforced track bed.

3.2.5**rail to earth resistance**

electrical resistance between the running rails and the earth

3.2.6**equipotential bonding**

provision of electric connections between conductive parts, intended to achieve equipotentiality

3.2.7**main equipotential busbar****MEB**

busbar where the equipotential conductors terminate

3.2.8**earthing conductor**

conductor which provides a conductive path, or part of the conductive path, between a given point in a system or in an installation or in equipment and an earth electrode

3.2.9**cross bond**

any electrical connection intended to connect two or more conductors of the return circuit in parallel

3.2.10**rail-to-rail cross bond**

electrical bond that interconnects the running rails of the same track

3.2.11**track-to-track cross bond**

electrical bond that interconnects tracks

3.2.12**rail joint bond**

conductor ensuring the electrical continuity of rails at a joint

[SOURCE: IEC 60050-811:2017, 811-35-07]

3.2.13**open connection**

connection of conductive parts to the return circuit by a voltage-limiting device which makes a conductive connection either temporary or permanent if the limited value of the voltage is exceeded

3.2.14

common building

building or structure which contains or supports an AC railway and a DC railway; furthermore where some conductive parts of the structure are within the contact line zone or the current collector zone of the AC railway and some conductive parts of the structure are within the contact line zone or the current collector zone of the DC railway

Note 1 to entry: Even the unintended connection of conductive parts of different structures can form a common building, e.g. via reinforcement, wiring, pipes, etc.

3.3 Return circuit

3.3.1

extended return circuit

[A1] part of the electric traction power supply system, which leads the current from loads such as vehicles or other equipment to the source

EXAMPLE

- running rails,
- return conductor rails,
- return conductors,
- substation return conductors,
- booster transformer return conductors.

Note 1 to entry: The auto transformer system negative feeder is part of the feeding circuit. **[A1]**

3.3.2

return circuit

subset of the extended return circuit where the direct contact is permissible during both operational and fault conditions

Note 1 to entry: The earthed line conductor of a three-phase electric traction power supply system can be considered as a return circuit.

3.3.3

track return system

system in which the running rails of the track form a part of the return circuit for the traction current

[SOURCE: IEC 60050-811:2017, 811-35-02]

3.3.4

return conductor

conductor paralleling the track return system and connected to the running rails at periodic intervals

[SOURCE: IEC 60050-811:2017, 811-35-13]

3.3.5

return conductor rail

return current rail

conductor rail used instead of the running rails for the traction return currents

[SOURCE: IEC 60050-811:2017, 811-34-10]

3.3.6**booster transformer return conductor****BT return conductor**

insulated set of return conductors which is necessary for the functionality of a booster transformer system

3.3.7**substation return conductor**

conductor connecting the running rails or other parts of the return circuit to the substation

3.3.8**traction return current**

current returning to the supply source, the substation or regenerative braking vehicles

Note 1 to entry: This can also include load fed from the electric traction power supply systems for example point heating, auxiliary supplies.

3.3.9**rail potential** **U_{RE}**

voltage occurring between running rails and earth

3.3.10**closed formation**

area where the top of the running rails is at the same level as the surrounding surface

3.3.11**open formation**

area where the running rails are laid above the surrounding surface

3.3.12**(rail to earth) conductance per length** **G'_{RE}**

electrical conductance between the running rails and earth, $\frac{S}{km}$ per length (S/km) $\frac{A_1}{A_1}$

3.3.13**insulated rail joint**

mechanical rail joint which longitudinally separates the rail electrically

[SOURCE IEC 60050-811:2017, 811-35-11, modified – “longitudinally” been added]

3.3.14**track circuit**

electric circuit of which the rails of a track section form a part, with usually a source of current connected at one end and a detection device at the other end for detecting whether this track section is clear or occupied by a vehicle

Note 1 to entry: In a continuous signalling system, the track circuit can be used to transmit information between the ground and the train.

[SOURCE: IEC 60050-821:2017, 821-03-01]

3.3.15**top of rail level****TOR**

common rail level tangent

3.4 Electric traction power supply system

3.4.1

electric traction power supply system

railway electrical distribution network used to provide energy for rolling stock

Note 1 to entry: The system can comprise:

- contact line systems;
- extended return circuit;
- running rails of non-electrified tracks, which are in the vicinity of, and conductively connected to the running rails of an electric traction system;
- electrical installations, which are supplied from contact lines either directly or via a transformer;
- electrical installations in power plants in substations, which are utilized solely for distribution of power directly to the contact line;
- electrical installations of switching stations.

3.4.2

traction substation substation

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.

Note 2 to entry: It includes equipment for protection and switching-off.

[SOURCE: IEC 60050-811:2017, 811-36-02, modified – the specific use “<in electric traction>” in the headline has been removed; the term “electric traction system” has been replaced by “electric traction power supply system”. The Note 2 to entry has been added.]

3.4.3

switching station traction switching station

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

Note 1 to entry: In this document a feeder station as defined in IEC 60050-811:2017, 811-36-07 is regarded as a switching station.

3.4.4

feeding section

electric 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]

3.4.5

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 60050-195:2021, 195-04-11]

3.4.6**short-circuit duration**

duration of a short-circuit determined by the correct function of the protection devices and circuit breakers

3.4.7**cut-off current**

maximum instantaneous value of current attained during the breaking operation of a switching device or a fuse

Note 1 to entry: This concept of particular importance when the switching device or the fuse operates in such a manner that the prospective peak current of the circuit is not reached.

[SOURCE: ^[A1] IEC 60050-441:1984 ^[A1], 441-17-12, modified – the alternative term “let-through current” has been deleted]

3.4.8**high voltage****HV**

any nominal voltage exceeding AC 1 000 V or DC 1 500 V

Note 1 to entry: The definition is derived from ^[A1] IEC 60050-601:1985 ^[A1], 601-01-25 and 601-01-27.

3.4.9**low voltage****LV**

any nominal voltage up to and including AC 1 000 V or DC 1 500 V

Note 1 to entry: The definition is derived from ^[A1] IEC 60050-601:1985 ^[A1], 601-01-25 and 601-01-26.

3.4.10**zone of mutual interaction**

zone for which a mutual interference between AC railway and DC railway is considered

3.5 Contact line**3.5.1****contact line system**

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

Note 1 to entry: The mechanical system can be comprised of:

- the contact line;
- structures and foundations;
- supports and any components supporting or registering the conductors;
- head and cross spans;
- along-track feeders, negative feeders, and other lines like earth wires and return conductors, including boosters, as far as they are supported from contact line system structures;
- cross-track feeders;
- disconnectors;
- over-voltage protection devices;
- conductors connected permanently to the contact line for supply of other electrical equipment such as lights, signal operation, point control and point heating;

— any other equipment necessary for operating the contact line.

[SOURCE: IEC 60050-811:2017, 811-33-59, modified – Note 1 to entry has been modified.]

3.5.2

contact line

 conductor system for supplying electric energy to vehicles through current-collecting equipment 

Note 1 to entry: This includes all current-collecting conductors and conducting rails or bars, including the following:

- reinforcing feeders;
- cross-track feeders;
- disconnectors;
- section insulators;
- over-voltage protection devices;
- supports that are not insulated from the conductors;
- insulators connected to live parts;

but excluding other conductors, such as the following:

- along-track feeders;
- earth wires and return conductors.

[SOURCE: IEC 60050-811:2017, 811-33-01, modified – The Note 1 to entry has been modified.]

3.5.3

overhead contact line system

contact line system using an overhead contact line to supply current for use by traction units

[SOURCE: EN 50119:2020, 3.1.1.3]

3.5.4

overhead contact line

contact line placed above or beside the upper limit of the vehicle gauge and supplying vehicles with electric energy through roof-mounted current collection equipment

[SOURCE: IEC 60050-811:2017, 811-33-02, modified – alternative term “catenary” has been deleted]

3.5.5

out of running overhead contact line

part of overhead contact line, not intended to be directly used for current collection, e.g. in order to reach a termination point on a mast or a structure

3.5.6

conductor rail system

contact line system using a conductor rail for current collection

3.5.7

conductor rail

rigid metallic conductor mounted on insulators intended to interface with a vehicle mounted current collector

Note 1 to entry: The conductor rail can be mounted in a variety of positions including at ground level or overhead.

Note 2 to entry: The conductor rail can be of composite construction.

[SOURCE: IEC 60050-811:2017, 811-34-01]

3.5.8

overhead conductor rail

conductor rail mounted above the upper limit of the vehicle gauge

3.5.9

ground level conductor rail

conductor rail mounted close to the running rails

3.5.10

overhead contact line zone

OCLZ

zone the limits of which are in general not exceeded by a $\overline{A_1}$ broken contact wire $\overline{A_1}$ or catenary wire

3.5.11

current collector zone

CCZ

zone the limits of which are in general not exceeded by an energized collector no longer in contact with the contact line or broken collector and its fragments

3.5.12

contact wire

electric conductor of an overhead contact line with which the current collectors make contact

[SOURCE: IEC 60050-811:2017, 811-33-15]

3.5.13

catenary wire

longitudinal cable supporting the contact wire or wires either directly or indirectly

[SOURCE: IEC 60050-811:2017, 811-33-06]

3.5.14

stagger

lateral displacement of the contact wire to opposite sides of the track centre at successive supports

Note 1 to entry: Stagger avoids localized wear of the pantograph contact strips.

[SOURCE: IEC 60050-811:2017, 811-33-21]

3.5.15

feeder

feeder cable

<in electric traction> electrical connection between the contact line and a substation or a switching station

Note 1 to entry: Feeder can be uninsulated or insulated.

Note 2 to entry: The feeder is fed by a circuit breaker.

[SOURCE: IEC 60050-811:2017, 811-36-08, modified – “cable” in Note 1 to entry has been deleted, Note 2 to entry has been added]

3.5.16

reinforcing feeder

overhead conductor mounted adjacent to the overhead contact line, and directly connected to it at frequent intervals

Note 1 to entry: The reinforcing feeder increases the effective cross-sectional area of the overhead contact line.

[SOURCE: IEC 60050-811:2017, 811-33-60]

3.5.17

section insulator

sectioning point formed by insulators inserted in a continuous run of a contact line, with skids or similar devices to maintain continuous electrical contact with the current collector

[SOURCE: IEC 60050-811:2017, 811-36-15]

3.6 Corrosion and corrosion protection

3.6.1

corrosion

electrochemical reaction of a metal with its environment, resulting in its progressive degradation or destruction

Note 1 to entry: This document deals with corrosion caused by stray currents.

A1 Text deleted. **A1**

A1 3.6.2

stray current

unintended current in earth and/or in conductive structures

Note 1 to entry: In AC electric traction power supply systems, currents in earth are intended. **A1**

A1 3.6.3 **A1**

cathodic protection

electrochemical immunity produced by an appropriate cathodic polarization

[SOURCE: IEC 60050-114:2014, 114-04-05]

3.7 Current collection

3.7.1

current collection

current transmission between the contact line and a vehicle

3.7.2

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]

3.7.3**pantograph**

apparatus for collecting current from one or more contact wires, formed of a hinged device designed to allow vertical movement of the pantograph head

[SOURCE: IEC 60050-811:2017, 811-32-02]

3.7.4**shoegear**

assembly of parts for collecting current from a conductor rail mounted in the vicinity of the running rails

[SOURCE: IEC 60050-811:2017, 811-32-19]

3.7.5**trolley**

apparatus for collecting current from a contact wire by means of a grooved wheel or contact slipper mounted on a pole which is movable in any direction

[SOURCE: IEC 60050-811:2017, 811-32-08]

3.8 Residual current devices**3.8.1****residual current device****RCD**

mechanical switching device designed to make, carry and break currents under normal service conditions and to cause the opening of the contacts when the residual current attains a given value under specified conditions

Note 1 to entry: A residual current device can be a combination of various separate elements designed to detect and evaluate the residual current and to make and break current.

[SOURCE: IEC 60050-442:2019, 442-05-02, modified – “or association of devices” has been removed. The Note 1 to entry has been added.]

3.8.2**residual current operated circuit-breaker without integral overcurrent protection****RCCB**

residual current operated switching device not designed to perform the functions of protection against overloads and/or short-circuits

[SOURCE: IEC 60050-442:2019, 442-05-03, modified – “circuit-breaker” has been replaced by “switching device”]

3.8.3**residual current operated circuit-breaker with integral overcurrent protection****RCBO**

residual current operated switching device designed to perform the functions of protection against overloads and/or short-circuits

[SOURCE: IEC 60050-442:2019, 442-05-04, modified – “circuit-breaker” has been replaced by “switching device”]

3.9 General terms**3.9.1****authorized trackside walking route**

safe path alongside the track for use only by authorized persons

3.9.2

monitoring

activity, performed either manually or automatically, intended to observe the state of an item

Note 1 to entry: Automatic supervision may be performed internally or externally to the item.

3.9.3

electrical clearance

minimum distance between conductive parts with different electric potentials to avoid disruptive discharge

3.9.4

protection clearance

electrical clearance plus a safety margin

3.9.5

danger zone

in the case of high voltage, area limited by the electrical clearance around hazardous-live-parts without complete protection

Note 1 to entry: Entering the danger zone is considered the same as touching hazardous-live-parts.

[SOURCE: IEC 61140:2016, 3.35; modified – “minimum” has been replaced by “electrical”]

3.9.6

proximity zone

space outside the danger zone limited by the protection clearance where specific precautions are taken to avoid encroaching into the danger zone

Note 1 to entry: Encroaching into the danger zone will create an electrical hazard.

3.9.7

basic protection

protection against electric shock under A_1 normal A_1 conditions

[SOURCE: IEC 60050-195:2021, 195-06-01]

3.9.8

fault protection

protection against electric shock under single-fault conditions

[SOURCE: IEC 60050-195:2021 195-06-02]

3.9.9

basic insulation

insulation that provides basic protection

Note 1 to entry: This concept does not apply to insulation used exclusively for functional purposes.

[SOURCE: IEC 60050-195:2021, 195-06-06]

3.9.10

supplementary insulation

independent insulation applied in addition to basic insulation, that provides fault protection

[SOURCE: IEC 60050-195:2021, 195-06-07]

3.9.11**double insulation**

insulation comprising both basic insulation and supplementary insulation

[SOURCE: IEC 60050-195:2021, 195-06-08]

3.9.12**reinforced insulation**

insulation that provides a degree of protection against electric shock equivalent to double insulation

Note 1 to entry: Reinforced insulation can comprise several layers that cannot be tested singly as basic insulation or supplementary insulation.

[SOURCE: IEC 60050-195:2021, 195-06-09]

3.9.13**public area**

standing surface to which the public has intentional access

EXAMPLE: platforms, level crossings, pedestrian bridges, pedestrian areas with tram overhead contact lines

3.9.14**restricted area**

standing surface for which the appropriate railway infrastructure manager has the responsibility and to which access is only permitted for authorized persons

EXAMPLE open lines, tunnels, viaducts

Note 1 to entry: If an operator manages infrastructure, an operator can act as infrastructure manager.

3.9.15**traffic area**

public area for pedestrians and/or a public area for vehicular traffic

Note 1 to entry: Cyclists and horse riders (e.g. police) are included.

Note 2 to entry: A level crossing is a special type of traffic area.

3.9.16**root-mean-square value****RMS value****quadratic mean**

quantity representing the quantities in a finite set or in an interval,

1. for n quantities $x_1, x_2, \dots, x_n$, by the positive square root of the mean value of their squares:

$$X_q = \left(\frac{1}{n} (x_1^2 + x_2^2 + \dots + x_n^2) \right)^{1/2}$$

2. for a quantity x depending on a variable t , by the positive square root of the mean value of the square of the quantity taken over a given interval $(t_0, t_0 + T)$ of the variable:

$$X_q = \left(\frac{1}{T} \int_{t_0}^{t_0+T} (x(t))^2 dt \right)^{1/2}$$

Note 1 to entry: The root-mean-square value of a periodic quantity is usually taken over an integration interval the range of which is the period multiplied by a natural number.

Note 2 to entry: The root-mean-square value of a quantity is denoted by adding the subscript q to the symbol of the quantity.

Note 3 to entry: The abbreviation RMS was formerly denoted as r.m.s. or rms, but these notations are now deprecated.

[SOURCE: IEC 60050-103:2017, 103-02-02]

4 Contact line zone and current collector zone

4.1 Overhead contact line

These zones are defined for protective provisions in accordance with 6.2 and 6.3 and are the zones whose limits are in general not exceeded by a broken $\overline{A_1}$ overhead wire $\overline{A_1}$, catenary wire or an energized dewired or broken current collector and its fragments.

If the contact line zone and/or current collector zone is not specified in national regulations, this shall be specified by the relevant entity (e.g. infrastructure manager, contracting entity etc).

Structures and equipment located entirely or partially in these zones can become energized, if a broken $\overline{A_1}$ overhead wire $\overline{A_1}$, catenary wire or live parts of a broken or dewired current collector come into contact with them. Figure 1 defines the zone inside which such contact is considered to be probable.

NOTE 1 The reason for the broken $\overline{A_1}$ overhead wire $\overline{A_1}$, catenary wire and dewired current collector can for example be a mechanical impact or a mechanical failure due to an electrical cause such as electrical overloading at the current collector contact wire interface.

NOTE 2 A current collector, which has become disconnected from the $\overline{A_1}$ overhead wire $\overline{A_1}$ due to a mishap, can nevertheless be energized.

For the parameters X , Y , Z given in Figure 1, recommended values for normal gauge railways based on experience are $X = 4$ m; $Y = 2$ m; $Z = 2$ m.

The stagger and the track cant have been taken into consideration within the dimension of X .

If the current collector is a pantograph the width of the current collector zone Y is the result of:

- the half width of the pantograph $L_P/2$,
- the lateral movement of the pantograph S_1 ,
- the electrical clearance S_{el} ($= d$ in accordance with 5.1), and
- a safety distance S_2 for the broken or dewired pantograph.

$$Y = L_P/2 + S_1 + S_{el} + S_2$$

The height of the current collector zone Z depends on:

- the maximum height of the fully uplifted current collector H_{max} measured from the TOR (limitation of current collector movement in accordance with EN 50206 series may be considered),
- the electrical clearance S_{el} ($= d$ in accordance with 5.1), and
- a safety distance in height S_3 for the broken pantograph.

$$Z = H_{max} + S_{el} + S_3 - HP$$

The point *HP* is the position of the highest conductor of the catenary wire or contact wire above TOR under all operational conditions considered at the centre line of the track. The limits of the overhead contact line zone below TOR are extended vertically downwards until the earth surface is reached.

These limits need not be extended below the upper surface of the deck when the railway runs over a bridge.

In the case of out of running overhead contact lines the overhead contact line zone shall be extended accordingly to the next insulator.

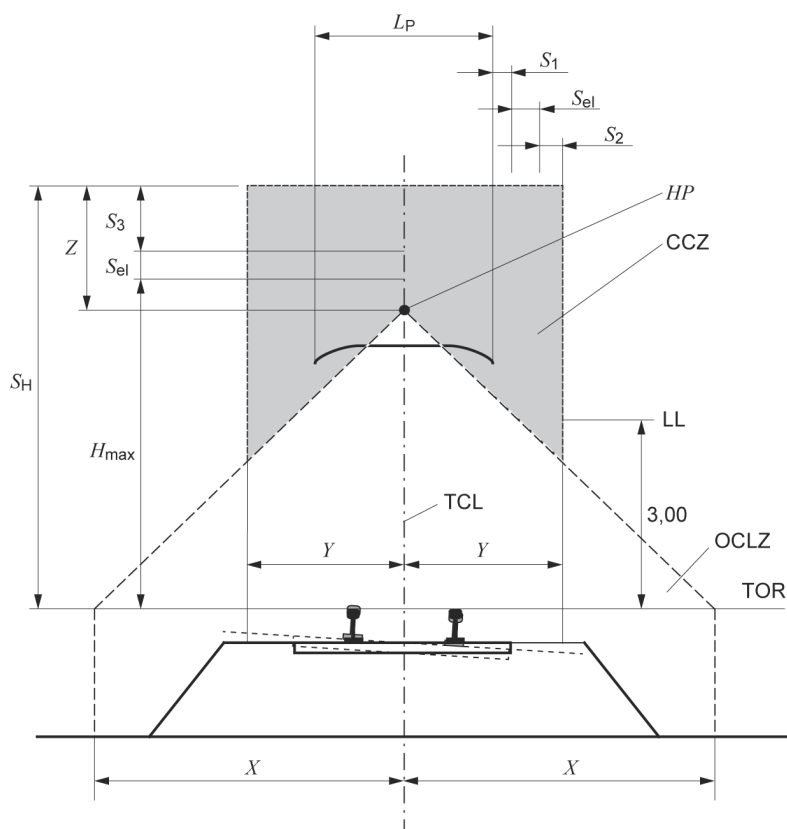
NOTE 3 Attention is drawn to a tunnel lining, at out of running overhead contact lines.

The overhead contact line zone and the current collector zone can be limited by provisions according to 6.3.4 and 6.3.5.

If it is unlikely that an overhead conductor rail will break and/or fall down and endanger the neighbouring structures, an overhead contact line zone in this context is not necessary, but a current collector zone is necessary. The lower limit of this zone shall be 3,00 m above TOR (LL in Figure 1).

If only trolleys are used as current collectors, the limits of the current collector zone shall be stipulated according to each specific case by the infrastructure manager.

NOTE 4 For parameter *Y* see specific requirements given in 4.3.



Key

$\square_{A1}$	TOR	top of rail level (cant to be neglected)
	HP	highest point of the catenary wire or contact wire above TOR
	OCLZ	overhead contact line zone
	CCZ	current collector zone
	TCL	track centre line
	LL	lower limit of CCZ, if OCLZ is not present
	X	maximum unidirectional (half) horizontal width of OCLZ at top of rail level
	Y	maximum unidirectional (half) horizontal width of CCZ
	Z	difference between height of HP and S_H
	S_1	width of lateral movement of the current collector
	S_2	lateral safety distance for the broken or dewired current collector
	S_3	vertical safety distance for the broken or dewired current collector
	S_{el}	electrical clearance (= d in accordance with 5.1)
	S_H	maximum limit of current collector zone above TOR
	L_P	current collector width (shape and height of current collector are only for illustration)
	H_{max}	maximum height of the fully uplifted current collector $\square_{A1}$

Figure 1 — Overhead contact line zone and current collector zone

4.2 Ground level conductor rail

In the case of a ground level conductor rail, a contact line zone is not required because the risk of a broken conductor rail is negligible.

The limits of the current collector zone shall be stipulated according to each specific case by the infrastructure manager.

4.3 Trolleybuses and road vehicles using an overhead contact line

This zone is defined for protective provisions in accordance with 5.6.3 and is the zone whose limits are in general not exceeded by one or both broken $\boxed{A_1}$ overhead wire $\langle A_1 \rangle$ or an energized dewired or broken $\boxed{A_1}$ current collector $\langle A_1 \rangle$ and its fragments.

If the contact line zone and/or current collector zone is not specified in national regulations, this shall be specified by the relevant entity (e.g. infrastructure manager, contracting entity etc).

Structures and equipment located entirely or partially in these zones can accidentally come in contact with a energized broken $\boxed{A_1}$ overhead wire $\langle A_1 \rangle$ or live parts of a broken or dewired current collector and thereby become energized. Figure 2 defines the zone inside which such contact is considered to be probable.

For the parameters X , Y , Z given in Figure 2 recommended values $\boxed{A_1}$ for trolley bus systems and electric road vehicles $\langle A_1 \rangle$ based on experience are $X = 4$ m; $Y = 0,6$ m; $Z = 1$ m.

For road vehicles with a bipolar pantograph the width of the current collector (L_p) and S_1 shall be considered.

The width of the current collector zone Y is the result of:

- the half distance of contact wires of of bifilar contact lines $B/2$,
- the half width of the pantograph $L_p/2$,
- the lateral movement of the pantograph S_1 ,
- the electrical clearance S_{el} ($= d$ in accordance with 5.1), and
- a safety distance S_2 for the broken or dewired trolley.

$$Y = B/2 + L_p/2 + S_1 + S_{el} + S_2$$

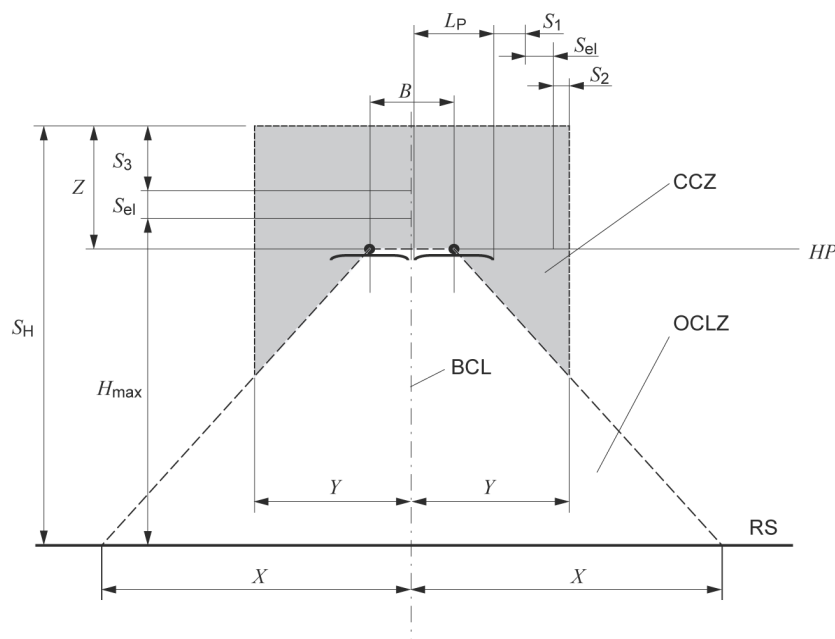
In the case of trolleybuses, the trolley and the current collector head are guided by the contact wire: therefore, the parameters L_p and S_1 are zero.

The height of the current collector zone Z depends on

- the maximum height of the fully uplifted current collector H_{max} measured from the road surface (limitation of trolley movement in accordance with EN 50502 may be considered),
- the electrical clearance S_{el} ($= d$ in accordance with 5.1), and
- a safety distance in height S_3 for the broken current collector.

$$Z = H_{max} + S_{el} + S_3 - HP$$

The point HP is the position of the highest conductor of the catenary wire or contact wire above RS under all operational conditions. The limits of the overhead contact line zone need not be extended beyond the upper surface of the deck when the line runs over a bridge.



Key

	HP	highest point of the catenary wire or contact wire above RS
	RS	road surface
	OCLZ	overhead contact line zone
	CCZ	current collector zone
	BCL	bifilar centre line
	B	distance of contact wires of bifilar contact lines
	L_P	current collector width
	X	maximum unidirectional (half) horizontal width of OCLZ at top of road surface
	Y	maximum unidirectional (half) horizontal width of CCZ
	Z	difference between height of HP and S_H
	S_1	width of lateral movement of the current collectors
	S_2	lateral safety distance for the broken or dewired current collector
	S_3	vertical safety distance for the broken or dewired current collector
	S_{el}	electrical clearance (= d in accordance with 5.1)
	S_H	maximum height of current collector zone
	H_{max}	maximum height of the fully uplifted current collector 

Figure 2 — Overhead contact line zone and current collector zone for trolley bus systems and electric road vehicles using a bipolar contact line

4.4 Limitation of the zones

The size of the overhead contact line zone and the current collector zone can be limited by the use of electrically protective obstacles according to 6.3.4 or bare conductive parts according to 6.3.5.

5 Protective provisions against direct contact

5.1 Preconditions

5.1.1 General

For hazardous-live-parts in electric traction power supply systems, one of the following protective provisions shall be utilized for protection against direct contact or where applicable entering the danger zone:

- protection by clearance,
- protection by electrically protective obstacles

in order to avoid direct contact to:

- live parts of the electric traction power supply system,
- live parts of vehicles, passing or standing adjacent to the standing surface.

EXAMPLE For vehicles, it also includes a stopped train below a pedestrian bridge.

The following situations shall be considered in order to avoid direct contact:

- reach of a person, including where relevant a hand-held object,
- person using a liquid jet.

The following aspects are considered as a minimum for the design of clearances and electrically protective obstacles when mitigating the danger due to direct contact with live parts and where relevant entering the danger zone:

- arc initiation and electric shock due to direct contact of a live part,
- arc initiation and electric shock due to intrusion into the danger zone of a live part,
- arc initiation and electric shock due to short-circuiting of electrical clearance and creepage by liquid jet.

For low voltage systems arc initiation and electric shock are only relevant for direct contact.

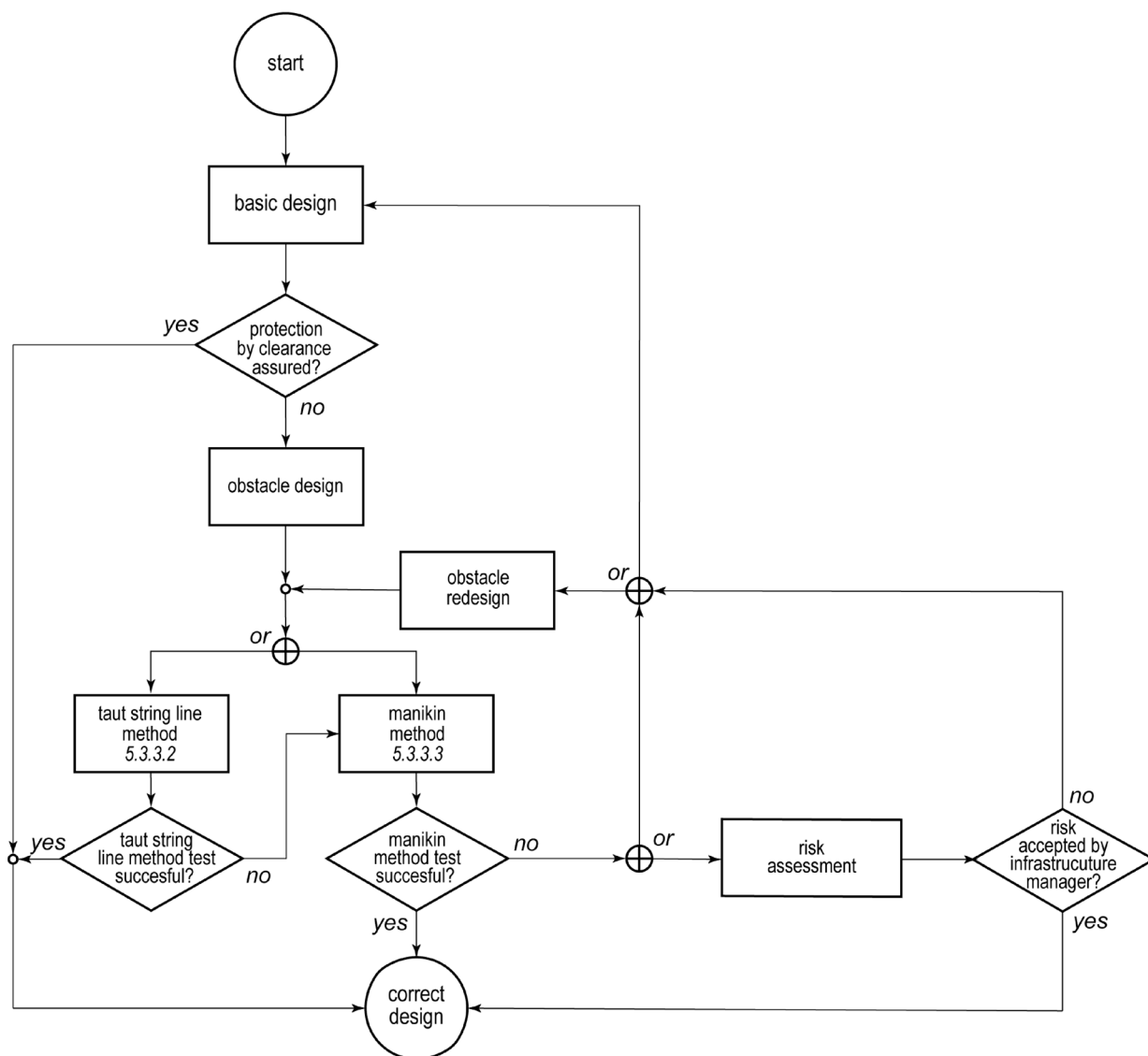
According to HD 60364-4-41:2017⁵ no protection against direct contact is required for circuits with nominal voltages up to and including AC 25 V or DC 60 V. This shall not apply, however, if the circuit concerned is connected to the traction return circuit.

This subclause cannot apply for ground level conductor rail systems. For specific requirements see 5.6.

5.1.2 Design procedure

The design procedure in order to achieve protection against direct contact (with live parts) or where relevant entry into the danger zone is shown in Figure 3.

A1



A1

Figure 3 — Design procedure to achieve protection against direct contact.

If neither protection by clearance nor protection by electrically protective obstacle can be achieved, a risk assessment may be carried out. In this case, any necessary protective measures identified by the risk assessment to control the risk to an acceptable level shall be implemented. The residual risk shall be acceptable to the relevant entity (e.g. infrastructure manager).

NOTE For the process of a risk assessment, see EN 50562.

5.1.3 Electrical clearances

As a basis, the clearances given in Table 1 may be used for the assessment of protection by clearance. These clearances are based on values given in EN 50124-1:2017, Table A.3 for the relevant switching overvoltages and pollution degree PD4B. Alternatively, clearances based on specified overvoltage categories and overvoltage limits set out in EN 50124-1:2017 may be used. The area covered by the envelope of the electrical clearance around a live part is the danger zone.

NOTE 1 The method given in EN 61472 provides similar clearances based on specific conditions.

Table 1 — Electrical clearances

nominal supply voltage of traction system U_n kV	A1 switching overvoltage A1 kV	rounded electrical clearance in air d m
$\leq 1,0$ (AC)/1,5 (DC)	not relevant	$> 0,00$
3	12	0,03
15	75	0,15
25	125	0,24

NOTE 2 For low voltage only a direct contact is considered, see EN 61140:2016, 5.2.5.1.

Additionally, the electrical clearance d may be reduced if surge arresters are used. Then the residual voltage may be used as U_{Ni} for determination of d in accordance with EN 50124-1:2017, Table A.3.

Entering the danger zone shall be prevented under all circumstances. Therefore, a safety distance margin has to be added to the electrical clearance d between live parts and parts of the human body or hand-held objects. The dimension of this safety clearance margin is 0,35 m for high voltage public areas, and 0,05 m for high voltage restricted areas or for low voltage. This leads to the rounded values for the protection clearance given in Table 2. The rounded sum of electrical clearance d and the safety margin is the protection clearance p covering the proximity zone.

Table 2 — Protection clearances

nominal supply voltage of traction system U_n kV	protection clearances for public area p_p m	protection clearances for restricted area p_r m
$\leq 1,0$ (AC)/1,5 (DC)	0,05	0,05
3	0,40	0,10
15	0,50	0,20
25	0,60	0,30

The earthed end of the insulator may be placed within the proximity zone but it shall be outside the danger zone given by the clearances in Table 1. **A1** Text deleted. **A1**

A1 Parts of glass fibre reinforced plastic (GFRP) rods or ropes used in low voltage systems, which are further away from live parts than the minimum creepage length for electrical safety, may be placed within the reach envelope as defined in 5.2.2.

EXAMPLE According to EN 50345 a minimum length of 1 m is applicable for ropes. **A1**

5.1.4 Standing surface

In the context of this document standing surfaces are those locations which are

- places where people are intended to be like station platforms, roads, walkways, traffic areas, tracks, top floor of sightseeing buses etc.
- private properties in the vicinity of electrified railways like gardens or greens, balconies,
- structures such as buildings, viaducts, bridges, walls etc. on public areas which have easy access and access is not prevented, or
- natural areas belonging to the railway property where access is not prevented by height or fence, e.g. rock spur, slope.

There are surfaces where people are either not intended to be or are not authorized to be, even when with sufficient effort such areas could be reached. Surfaces are not standing surfaces in the context of this document

- if they are in a step height of more than 1,20 m,
- if access is restricted by a fence or similar,
- in case of railway structures on restricted areas even when access to the structure is not prevented, e.g. mast on open tracks, or
- in case of natural areas belonging to the railway property where access is prevented by height or fence, e.g. rockspur, slope.

Protective provisions for standing surfaces are not required in areas where persons are not intended or expected to be.

5.2 Protection by clearance

5.2.1 Calculation method for protection by clearance

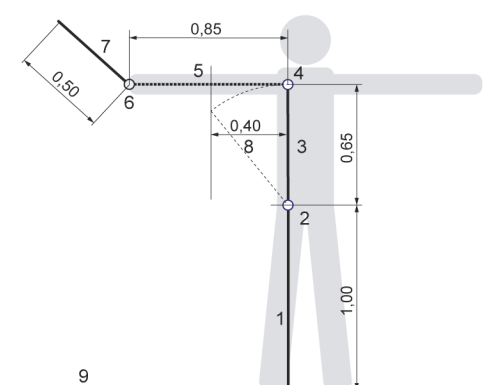
The dimensions for protection by clearance defined in 5.2.2 are based on arm's reach plus a margin which includes a protection clearance and where applicable a hand-held object.

The extent of arm's reach is voltage independent and is derived from the following:

- shoulder height 1,65 m consisting of
 - height of hips 1,00 m,
 - torso length 0,65 m,
- arm length 0,85 m,
- leaning margin 0,40 m.

NOTE The dimensions above have been determined taking into consideration the dimensions given in ISO 13857:2008 and the zone of arm's reach in HD 60364-4-41:2017⁵, Figure B.1.

Dimensions in metres



Key

- | | |
|-------------------------------|-------------------------------------|
| 1 legs | 6 wrist |
| 2 hip joint | 7 hand-held object (where required) |
| 3 torso | 8 leaning margin |
| 4 shoulder joint | 9 standing surface |
| 5 arm (as a taut string line) | |

Figure 4 — Manikin model to be used for the analysis of the arm's reach

A1 In order to consider ergonomic uncertainties and for common use of additional items like walking sticks, umbrellas or so called “selfie sticks” an additional 0,50 m margin has been added to the arm’s reach dimension in public areas. For restricted areas, the 0,50 m margin for hand-held object does not need to be considered. **A1**

5.2.2 Dimensions of clearances

The clearances defined in this subclause are different for public areas and restricted areas. Dimensions for restricted areas and related distances to live parts consider normal and inadvertent behaviour of people in the vicinity of railway installations. The dimensions for public areas include the use of objects in accordance with their normal intended usage and a degree of accidental movement (e.g. inadvertent leaning towards live parts). However, the maximum length of objects used by the public can exceed the lengths considered in this Clause. For such cases an absolute protection against electric shock cannot be ensured.

For standing surfaces accessible to persons, in both public and restricted areas, the clearance of public areas, as shown in Figure 5, shall be provided against contact with live parts. This does not apply to ground level conductor rail systems (refer to 5.6). **A1** In restricted areas the reduced clearances of Figure 5, where the margin for the hand-held object is omitted, may be used if there are construction restrictions which are small in size, and the area is limited. **A1**

The clearances given in Figure 5 are minimum values which shall be maintained at all temperatures and in the full range of electrical and mechanical loads of the live parts.

NOTE National requirements for greater clearances can exist.

For live parts mounted on vehicles, deviating dimensions may be applied as given in 5.4.

In Figure 5, the dimensions are given for a theoretical position of a standing surface which does not offer protection against contact with live parts situated below or to the side thereof. The standing surface can in reality fulfil the function of the electrically protective obstacles as specified in 5.3. In this case the lower clearances applicable to electrically protective obstacles may be applied.