

BS EN 50122-1:2011+A1:2011

Incorporating corrigenda November 2012 and May 2013



BSI Standards Publication

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

**Part 1: Protective provisions against
electric shock**

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National foreword

This British Standard is the UK implementation of EN 50122-1:2011+A1:2011, incorporating corrigendum November 2012. It supersedes BS EN 50122-1:2011 which is withdrawn.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 CENELEC text carry the number of the CENELEC amendment. For example, text altered by CENELEC amendment A1 is indicated by A1 A1.

The start and finish of text introduced or altered by corrigendum is indicated in the text by tags. Text altered by CENELEC corrigendum November 2012 is indicated in the text by AC1 AC1.

In 7.4.1 NOTE 1, reference is made to the TN and TT systems of earth connection for low-voltage distribution systems. Table 2 shows only TT and TN systems, although other systems are allowed by the NOTE 2. For application in the UK, it should be noted that IT systems are not prohibited by this standard.

Attention is drawn to the fact that work is currently in hand to replace the United Kingdom special national condition set out in Annex G (5.2.1). Until this national condition is revised, an appropriate risk assessment is considered essential if public area clearances of less than the minimum set out in Figure 4 (clause 5.2.1) are to be used.

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

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

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31 November 2012	Implementation of CENELEC corrigendum November 2012
31 May 2013	Additional information included in the national foreword

English version

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

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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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

This European Standard was prepared by SC 9XC, Electric supply and earthing systems for public transport equipment and ancillary apparatus (Fixed installations), of Technical Committee CENELEC TC 9X, Electrical and electronic applications for railways. It was submitted to the formal vote and was approved by CENELEC as EN 50122-1 on 2010-11-16.

This document supersedes EN 50122-1:1997.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN and CENELEC shall not be held responsible for identifying any or all such patent rights.

The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
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- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2013-11-16

This European Standard has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association and covers essential requirements of EC Directives 96/48/EC (HSR), 2001/16/EC (CONRAIL) and 2008/57/EC (RAIL). See Annex ZZ.

Foreword to amendment A1

This amendment to the European Standard EN 50122-1:2011 was prepared by SC 9XC, Electric supply and earthing systems for public transport equipment and ancillary apparatus (Fixed installations), of Technical Committee CENELEC TC 9X, Electrical and electronic applications for railways.

The text of the draft was submitted to the Unique Acceptance Procedure and was approved by CENELEC as Amendment A1 to EN 50122-1:2011 on 2011-04-25.

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1 Scope

This European Standard specifies requirements for the protective provisions relating to electrical safety in fixed installations associated with a.c. and/or d.c. traction systems and to any installations that can be endangered by the traction power supply system.

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

This European Standard applies to all new lines 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.

This European 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;
- f) suspended cable cars;
- g) funicular railways.

This European Standard does not specify working rules for maintenance.

2 Normative references

The following referenced documents are indispensable for the application 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 50119:2009, *Railway applications – Fixed installations – Electric traction overhead contact lines*

EN 50122-2, *Railway applications – Fixed installations – Part 2: Protective provisions against the effects of stray currents caused by d.c. traction systems*

EN 50124-1:2001 + A1:2003 + A2:2005, *Railway applications – Insulation coordination – Part 1: Basic requirements – Clearances and creepage distances for all electrical and electronic equipment*

EN 50153:2002, *Railway applications – Rolling stock – Protective provisions relating to electrical hazards*

EN 50163, *Railway applications – Supply voltages of traction systems*

EN 50345, *Railway applications – Fixed installations – Electric traction – Insulating synthetic rope assemblies for support of overhead contact lines* 

EN 60529:1991 + A1:2000, *Degrees of protection provided by enclosures (IP code)* (IEC 60529:1989 + A1:1999)

EN 60898-1:2003 + A11:2005, *Electrical accessories – Circuit-breakers for overcurrent protection for household and similar installations – Part 1: Circuit-breakers for a.c. operation* (IEC 60898-1:2002, mod.)

EN 61140:2002 + A1:2006, *Protection against electric shock – Common aspects for installation and equipment* (IEC 61140:2001 + A1:2004, mod.)

HD 60364-4-41:2007, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock (IEC 60364-4-41:2005, mod.)*

HD 637 S1:1999, *Power installations exceeding 1 kV a.c.*

IEC 60050-101, *International Electrotechnical Vocabulary – Chapter 101: Mathematics*

IEC 60050-111, *International Electrotechnical Vocabulary – Chapter 111: Physics and chemistry*

IEC 60050-191, *International Electrotechnical Vocabulary – Chapter 191: Dependability and quality of service*

IEC 60050-195, *International Electrotechnical Vocabulary – Chapter 195: Earthing and protection against electric shock*

IEC 60050-442, *International Electrotechnical Vocabulary – Chapter 442: Electrical accessories*

IEC 60050-811, *International Electrotechnical Vocabulary – Chapter 811: Electric traction*

IEC 60050-821, *International Electrotechnical Vocabulary – Chapter 821: Signalling and security apparatus for railways*

IEC 60050-826, *International Electrotechnical Vocabulary – Chapter 826: Electrical installations*

IEC/TS 60479-1:2005, *Effects of current on human beings and livestock – Part 1: General aspects*

ISO 3864-1:2002, *Graphical symbols – Safety colours and safety signs – Part 1: Design principles for safety signs in workplaces and public areas*

ISO 7010:2003 + A1:2006, *Graphical symbols – Safety colours and safety signs – Safety signs used in workplaces and public areas*

3 Terms and definitions

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

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

pathophysiological effect resulting from an electric current passing through a human or animal body

[IEC 60050-826-12-01]

3.1.3

(effective) touch voltage (U_{te})

voltage between conductive parts when touched simultaneously by a person or an animal

NOTE 1 The value of the effective touch voltage can be appreciably influenced by the impedance of the person or the animal in electric contact with these conductive parts

[IEC 60050-195-05-11]

NOTE 2 The conductive path through the body is conventionally from hand to both feet (horizontal distance of 1 m) or from hand to hand.

3.1.4

prospective touch voltage (U_{tp})

voltage between simultaneously accessible conductive parts when those conductive parts are not being touched by a person or an animal

[IEC 60050-195-05-09]

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 may stand or walk about without great effort

3.1.7

protective boarding

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

3.1.8

(electrically) protective obstacle

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

[IEC 60050-195-06-16]

3.1.9

(electrically) protective barrier

part providing protection against direct contact from any usual direction of access

[IEC 60050-195-06-15]

3.1.10

anti-trespassing guard

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

3.1.11

conductive part

part which can carry electric current

[IEC 60050-195-01-06]

3.1.12

exposed conductive part

conductive part of electrical equipment, which can be touched and which is not normally live, but which can become live when basic insulation fails

NOTE A conductive part of electrical equipment which can only become live through contact with an exposed conductive part which has become live is not considered to be an exposed conductive part itself.

[IEC 60050-442-01-21]

3.1.13

live part

conductor or conductive part intended to be energised in normal use. By convention this does not include the running rails and parts connected to them

3.1.14

direct contact

electric contact of persons or animals with live parts

[IEC 60050-826-12-03]

3.1.15

indirect contact

electric contact of persons or animals with exposed conductive parts which have become live under fault conditions

[IEC 60050-826-12-04]

3.1.16

neutral conductor

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

[IEC 60050-826-14-07]

3.1.17

protective conductor (PE)

conductor, required by some measures for protection against electric shock, for electrically connecting any of the following parts:

- exposed conductive parts;
- extraneous conductive parts;
- main earthing terminal;
- earth electrode;
- earthed point of the source or artificial neutral

3.1.18

PEN conductor

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

[IEC 60050-826-13-25]

3.1.19

solid-wall design

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

3.1.20

voltage-limiting device (VLD)

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

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

[IEC 60050-826-04-01]

3.2.2

earthing

connection of conductive parts to an appropriate earth electrode

3.2.3

earth electrode

conductor or a group of conductors in intimate contact with and providing an electrical connection to earth

[IEC 60050-461-06-18]

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 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 or structure earth

3.2.6

equipotential bonding

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

[IEC 60050-826-13-19]

3.2.7

main equipotential busbar (MEB)

busbar where the equipotential conductors terminate

3.2.8

cross bond

electrical connection intended to connect in parallel the conductors of the return circuit

3.2.9

rail-to-rail cross bond

electrical bond that interconnects the running rails of the same track

3.2.10

track-to-track cross bond

electrical bond that interconnects tracks

3.2.11

rail joint bond

conductor ensuring the electrical continuity of rails at a joint

[IEC 60050-811-35-07]

3.2.12

open connection

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

3.2.13

common building

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

NOTE 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

return circuit

all conductors which form the intended path for the traction return current

EXAMPLE The conductors may be:

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

3.3.2

track return system

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

[IEC 60050-811-35-02]

3.3.3

return conductor

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

3.3.4

return conductor rail – return current rail

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

[IEC 60050-811-34-10]

3.3.5

return cable

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

NOTE Similar to IEC 60050-811-35-04.

3.3.6

traction return current

sum of the currents returning to the supply source, the substation or regenerative braking vehicles

3.3.7

rail potential (U_{RE})

voltage occurring between running rails and earth

3.3.8

closed formation

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

3.3.9

open formation

area where the running rails are laid above the surrounding surface

3.3.10

conductance per length G'_{RE}

reciprocal value of the rail to earth resistance per length (S/km)

3.3.11

insulating rail joint

mechanical rail joint which longitudinally separates the rail electrically

3.3.12

track circuit

electrical 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 In a continuous signalling system, the track circuit may be used to transmit information between the ground and the train.

[IEC 60050-821-03-01]

3.3.13

top of rail level (TOR)

common rail level tangent

3.4 Electric traction system

3.4.1

electric traction system

railway electrical distribution network used to provide energy for rolling stock

NOTE The system may comprise:

- contact line systems;
- return circuit of electric traction systems;
- running rails of non electric traction systems, 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 substations, which are utilized solely for distribution of power directly to the contact line;
- electrical installations of switching stations.

3.4.2

(traction) substation

installation to supply a contact line system and at which the voltage of a primary supply system, and in certain cases the frequency, is transformed to the voltage and the frequency of the contact line

3.4.3

(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

3.4.4

feeding section

electrical section of the route fed by individual track feeder circuit-breakers within the area supplied by the substation

[EN 50119:2009, 3.3.2]

3.4.5

fault condition

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

NOTE For the relevant fault duration the correct operation of protection devices and circuit breakers is taken into account.

3.4.6

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

[IEC 60050-195-04-11]

3.4.7

high voltage

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

3.4.8

low voltage

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

3.4.9

zone of mutual interaction

zone for which a mutual interference between a.c. railway and d.c. railway shall be considered

3.4.10

expected prospective short-circuit current

short-circuit current in d.c. traction systems that it is expected to be reached if the fault is not switched off

3.5 Contact line

3.5.1

contact line system

support network for supplying electrical energy from substations to electrically powered traction units, which covers overhead contact line systems and conductor rail systems; the electrical limits of the system are the feeding point and the contact point to the current collector

NOTE The mechanical system may comprise:

- the contact line,
- structures and foundations,
- supports and any components supporting or registering the conductors,
- head and cross spans,
- tensioning devices,
- along-track feeders, reinforcing feeders, and other lines like earth wires and return conductors as far as they are supported from contact line system structures,
- any other equipment necessary for operating the contact line,
- conductors connected permanently to the contact line for supply of other electrical equipment such as lights, signal operation,
- point control and point heating.

[EN 50119: 2009, 3.1.1]

3.5.2

contact line

conductor system for supplying traction units with electrical energy via current-collection equipment

NOTE 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.

[EN 50119:2009, 3.1.2]

3.5.3

overhead contact line system

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

[EN 50119:2009, 3.1.3]

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

[IEC 60050-811-33-02]

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

[EN 50119:2009, 3.1.5]

3.5.7

conductor rail

contact line made of a rigid metallic section or rail, mounted on insulators located near the running rails

[EN 50119:2009, 3.1.7]

3.5.8

overhead conductor rail

rigid overhead contact line, of simple or composite section, mounted above or beside the upper limit of the vehicle gauge, supplying traction units with electrical energy via roof-mounted current collection equipment

[EN 50119:2009, 3.1.6]

3.5.9

overhead contact line zone (OCLZ)

zone whose limits are in general not exceeded by a broken overhead contact line

3.5.10

current collector zone (CCZ)

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

3.5.11

contact wire

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

[IEC 60050-811-33-15]

3.5.12

stagger

displacement of the contact wire away from the track centre line at successive supports, to avoid localised wear of the pantograph wearing strips

[IEC 60050-811-33-21]

3.5.13

feeder

electrical conductor like a cable or overhead line between the contact line and a substation or a switching station which is fed by a circuit breaker

3.5.14

reinforcing feeder

overhead conductor mounted adjacent to the overhead contact line, and directly connected to it at frequent intervals, in order to increase the effective cross sectional area of the overhead contact line

[EN 50119:2009, 3.2.2]

3.5.15

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 collector

3.5.16

double insulation

insulation comprising both basic insulation and supplementary insulation

[IEC 60050-195-06-08]

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 This European Standard deals with corrosion caused by stray currents.

3.6.2

leakage current

current which, in the absence of a fault, flows to earth or to extraneous conductive parts in a circuit

3.6.3

stray current (I_s)

part of the current caused by a d.c.-traction system which follows paths other than the return circuit

3.6.4

cathodic protection

electrochemical immunity produced by an appropriate cathodic polarization

[IEC 60050-111-15-40]

3.7 Current collection

3.7.1

current collection

current transmission from contact line to a vehicle

3.7.2

current collector

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

[IEC 60050-811-32-01]

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

[IEC 60050-811-32-02]

3.7.4

shoegear

assembly of parts for collecting current from a conductor rail

[IEC 60050-811-32-19]

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

[IEC 60050-811-32-08]

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 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.

[IEC 60050-442-05-02]

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

[IEC 60050-442-05-03]

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

[IEC 60050-442-05-04]

3.9 General terms

3.9.1

(electrically) instructed person

person adequately advised or supervised by electrically skilled persons to enable him or her to perceive risks and to avoid hazards which electricity can create

[IEC 60050-195-04-02]

3.9.2

authorized trackside walking route

safe path alongside the track for use only by authorized persons

3.9.3

monitoring

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

NOTE Automatic supervision may be performed internally or externally to the item.

[IEC 60050-191-07-26]

3.9.4

public area

area to which the public has unrestricted access

3.9.5

restricted area

area for which access is only permitted for authorized persons

4 Contact line zone and current collector zone

4.1 Overhead contact line systems

These zones are defined for protective provisions in accordance with 6.3 and are the zones whose limits are in general not exceeded by a broken overhead contact line or an energised dewired or broken current collector and its fragments.

Structures and equipment may accidentally come in contact with a live broken overhead contact line or live parts of a broken or dewired current collector and thereby become live. Figure 1 defines the zone inside which such contact is considered to be probable.

NOTE 1 A current collector which has become disconnected from the overhead contact line due to a mishap may nevertheless be alive if a train has multiple current collectors which are electrically connected or if the train is braking using a regenerative brake.

The parameters X , Y , Z in Figure 1 shall be defined by national regulations.

NOTE 2 A guiding value for the parameter X is given as 4 m, Y is given as 2 m and Z is given as 2 m.

NOTE 3 The stagger has 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} in accordance with EN 50119, 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,
- the electrical clearance S_{el} in accordance with EN 50119,
- a safety distance in height S_3 for the broken pantograph.

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

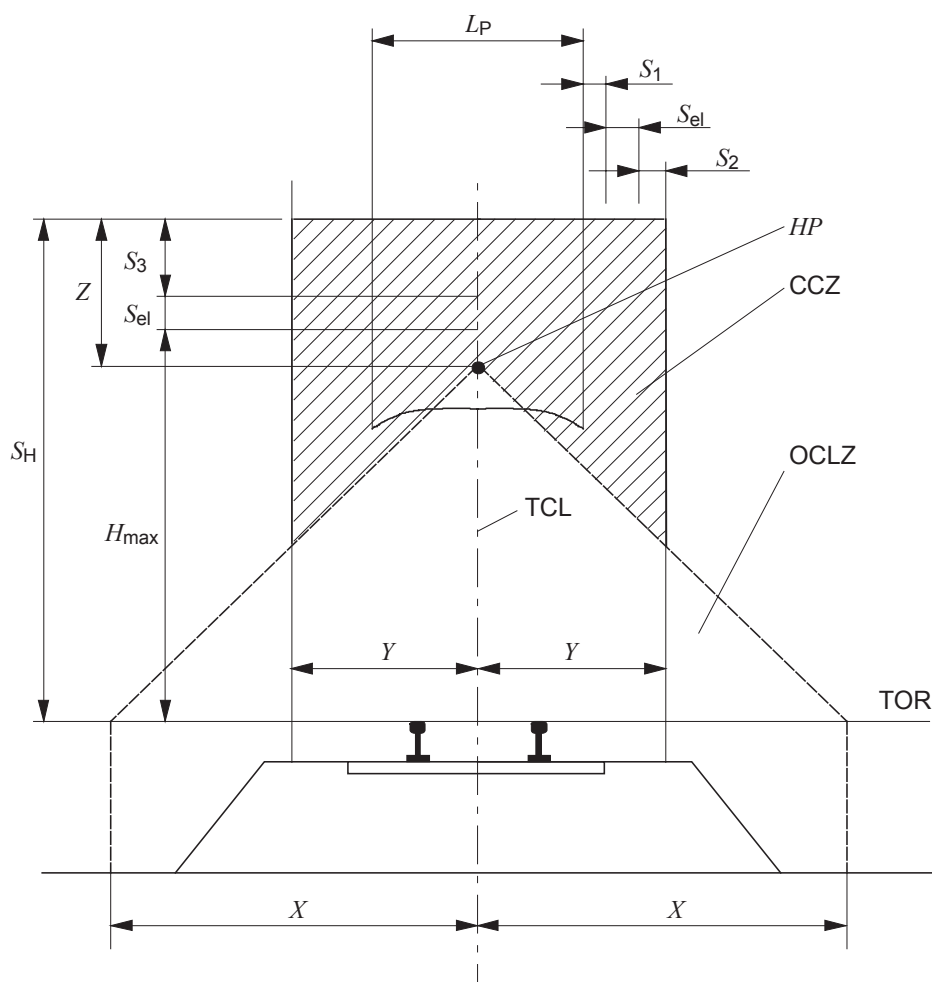
The point HP is the position of the highest conductor of the overhead contact line under all operational conditions considered in the centre of the track. The limits of the overhead contact line zone below TOR are extended vertically downwards until the earth surface is reached.

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.

When it can be proved, that it is unlikely that an overhead conductor rail will break and endanger the neighbouring area, an overhead conductor rail zone in this context is not necessary, but a current collector zone is necessary.

The current collector zone for trolleys shall be given in national regulations.



Key

TOR	top of rail
HP	highest point of the overhead contact line
OCLZ	overhead contact line zone
CCZ	current collector zone
TCL	track centre line
X	maximum unidirectional (half) horizontal OCLZ, top of rail level
Y	maximum unidirectional (half) horizontal CCZ
Z	distance between HP and SH
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 in accordance with EN 50119
S _H	maximum height of current collector zone
L _p	current collector width
H _{max}	maximum height of the fully uplifted current collector

Figure 1 — Overhead contact line zone and current collector zone

4.2 Conductor rail systems

In the case of a conductor rail close to the running rails, a contact line zone is not required.

NOTE The risk of a broken conductor rail can be neglected.

For provisions against direct contact see 5.5. The limits of the current collector zone shall be stipulated according to each specific case by the infrastructure manager.

4.3 Trolleybus systems

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 overhead contact wire or an energised dewired or broken trolley and its fragments.

Structures and equipment may accidentally come in contact with a live broken overhead contact line or live parts of a broken or dewired trolley and thereby become live. Figure 2 defines the zone inside which such contact is considered to be probable.

The parameters X , Y , Z in Figure 2 shall be defined by national regulations.

NOTE A guiding value for the parameter X is given as 4 m, Y is given as 0,6 m and Z is given as 1 m.

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

- the electrical clearance S_{el} in accordance with EN 50119, and
- a safety distance S_2 for the broken or dewired trolley.

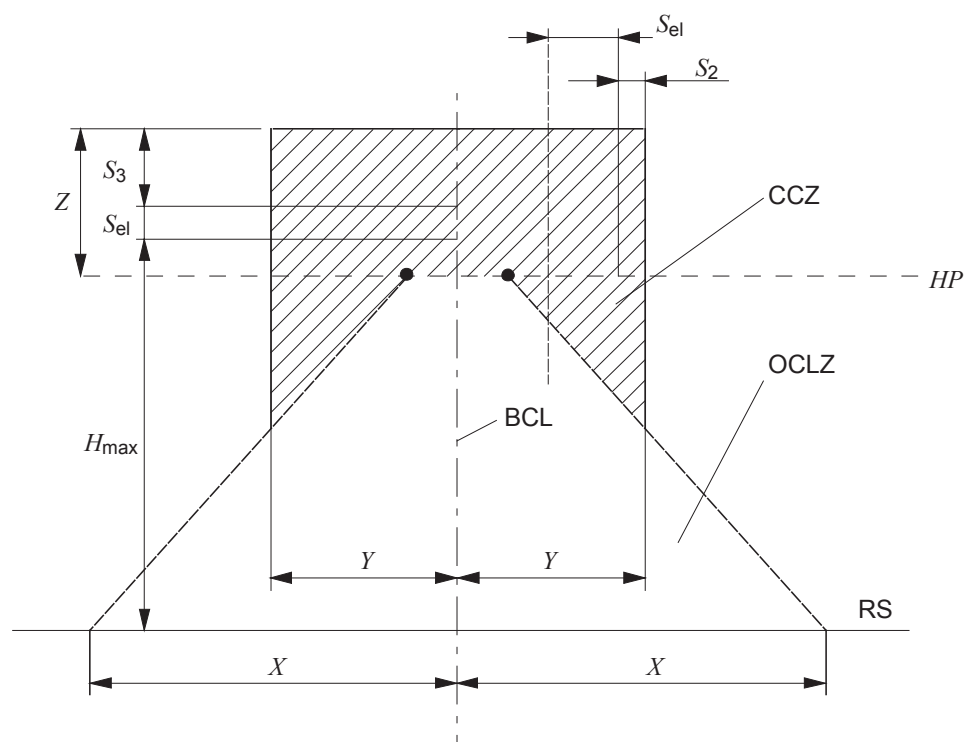
$$Y = S_{el} + S_2$$

The height of the current collector zone Z depends on:

- the maximum height of the fully uplifted trolley H_{max} measured from the road surface;
- the electrical clearance S_{el} in accordance with EN 50119;
- 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 overhead contact line 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 trolleybus-line runs over a bridge.



Key

<i>HP</i>	highest point of the overhead contact line
<i>RS</i>	road surface
<i>OCLZ</i>	overhead contact line zone
<i>CCZ</i>	current collector zone
<i>BCL</i>	bifilar centre line
<i>X</i>	maximum unidirectional (half) horizontal OCLZ, top of road surface
<i>Y</i>	maximum unidirectional (half) horizontal CCZ
<i>Z</i>	distance between <i>HP</i> and <i>S_H</i>
<i>S₂</i>	lateral safety distance for the broken or dewired current collector
<i>S₃</i>	vertical safety distance for the broken or dewired current collector
<i>S_{el}</i>	electrical clearance in accordance with EN 50119
<i>S_H</i>	maximum height of current collector zone
<i>H_{max}</i>	maximum height of the fully uplifted current collector

Figure 2 — Overhead contact line zone and current collector zone for trolley bus systems

5 Protective provisions against direct contact

5.1 General

According to HD 60364-4-41 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.

In overhead contact line systems one of the following protective provisions shall be utilized for protection against direct contact:

- protection by clearance;
- protection by obstacles.

All insulators which are directly connected to a live part shall be regarded as a live part when considering clearance dimensions in this European Standard. ^[A1] Exceptions are the parts of synthetic ropes which are further away from live parts than the creepage length (according to EN 50345) with a minimum of 1 m. ^[A1]

5.2 Protection by clearance

5.2.1 Standing surface

For standing surfaces accessible to persons, the clearance for touching in a straight line shown in Figure 3 and Figure 4 shall be provided against direct contact with live parts of an overhead contact line system as well as live parts on the outside of a vehicle (e.g. current collectors, roof conductors, resistors). This does not apply to conductor rail systems near the running rails (refer to 5.5).

The clearances given in Figure 3 and Figure 4 are minimum values which shall be maintained at all temperatures and in the full range of electrical and mechanical loads of the conductors. Due to national or regional existing practices, greater clearances or smaller mesh sizes may be prescribed by the relevant infrastructure manager.

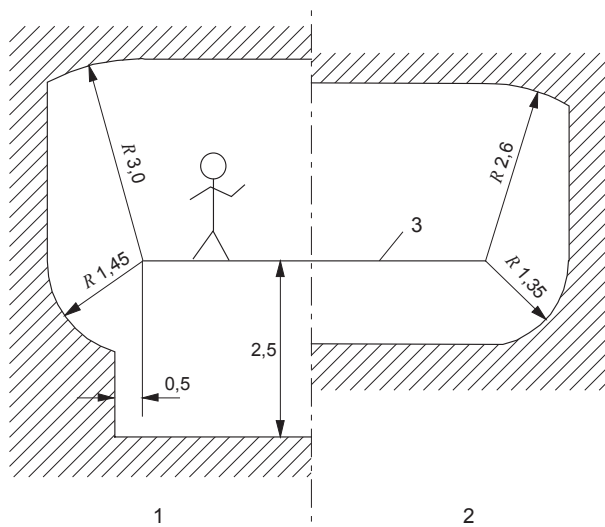
This protection is not mandatory if, although contact with live parts is possible, other provisions have been taken to ensure isolation from the supply.

NOTE 1 Touching in a straight line implies that live parts are accessible by a person from a standing surface without use of objects.

NOTE 2 Figure 3 and Figure 4 assumes that the standing surface does not afford protection against contact with live parts situated below or to the side thereof. Depending on its construction the surface may in practice meet the requirement respecting provision of obstacles. In this case the lower clearances applicable to obstacles may be applied.

NOTE 3 These clearances have been determined on the basis of the arms reach as defined in HD 60364-4-41 to which a margin of safety was added. The margin of safety has been determined depending on the voltage of the contact line system, on experience and on whether the standing surface is in a restricted area or in a public area.

Dimensions in metres

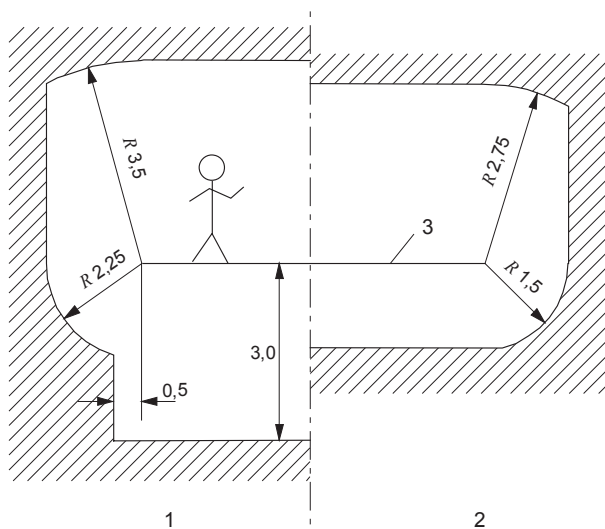


Key

- 1 public areas
- 2 restricted areas
- 3 standing surface

Figure 3 — Minimum clearances to accessible live parts on the outside of vehicles as well as to live parts of overhead contact line systems from standing surfaces accessible to persons for low voltages

Dimensions in metres



Key

- 1 public areas
- 2 restricted areas
- 3 standing surface

Figure 4 — Minimum clearances to accessible live parts on the outside of vehicles as well as to live parts of overhead contact line systems from standing surfaces accessible to persons for high voltages

5.2.2 Exceptions for working persons

The clearances to be observed for persons working near to energised contact line systems shall be defined in the operational specifications. If operational specifications do not exist, clearances shown in Figure 3 and Figure 4 or the clearances to obstacles according to 5.3 shall be used.

Standing surfaces or platforms utilized solely for the execution of work at or in the vicinity of the contact line system are not included.

NOTE Examples are station platform roofs, working platforms and working planks at signal bridges, working platforms at signals, maintenance-ladders, work cages of hydraulic working platforms, working platforms of tower cars.

5.2.3 Warning signs

Warning signs shall be used in areas where there is a serious risk of persons coming within the limits of live parts of a contact line system given in 5.2.1. Such warning signs shall be placed in a prominent position and be readily visible adjacent to the point of access. The sign shall be in accordance with ISO 3864 (see Annex B). If required an appropriate supplementary sign may be used.

5.2.4 Minimum height of overhead contact lines above roads

Where a road carrying normal vehicular traffic crosses or coincides with a railway, tramway or trolleybus electrified by means of an overhead contact line and no road traffic restrictions are specified, unless otherwise fixed by national regulation, a minimum vertical clearance as stated below shall be provided between the road surface and the lowest point of the overhead contact line and associated feeders.

The minimum vertical clearance between the road surface and the overhead contact line shall be:

- for low voltages, 4,70 m;
- for high voltages, 5,50 m.

If the required minimum clearance cannot be provided and unless otherwise specified by national regulation, the maximum height of road vehicles permitted to pass under the overhead contact line shall be limited so as to guarantee the following minimum vertical clearances between the highest point of road vehicle (load included) and the live parts:

- a) for low voltages:
 - 1) 0,50 m, where only road traffic signs indicating the maximum permissible vehicle height are utilized,
 - 2) 0,30 m, where additional fixed barriers (e.g. a rigid obstacle or a firmly fixed metallic wire made visible by means of a suspended warning sign) are erected on both sides of the crossing, physically limiting such vehicle height;
- b) for high voltages:
 - 1) 1,00 m, where only road traffic signs indicating the maximum permissible vehicle height are utilized,
 - 2) 0,50 m, where additional fixed barriers (e.g. a rigid obstacle or a firmly fixed metallic wire made visible by means of a suspended warning sign) are erected on both sides of the crossing, physically limiting such vehicle height.

5.2.5 Feeders above loading roads

Feeders or line feeders in high voltage systems should not be situated above loading roads or loading sidings. When not avoidable, there shall be a minimum vertical distance of 12,00 m between surfaces of the loading platform (ramps) and feeders.

5.2.6 Clearance between live parts of overhead contact line systems and trees

For railways with high voltage, the distance between the live parts of the overhead contact line system and branches of trees or bushes shall be at least 2,50 m with no wind or ice loading.

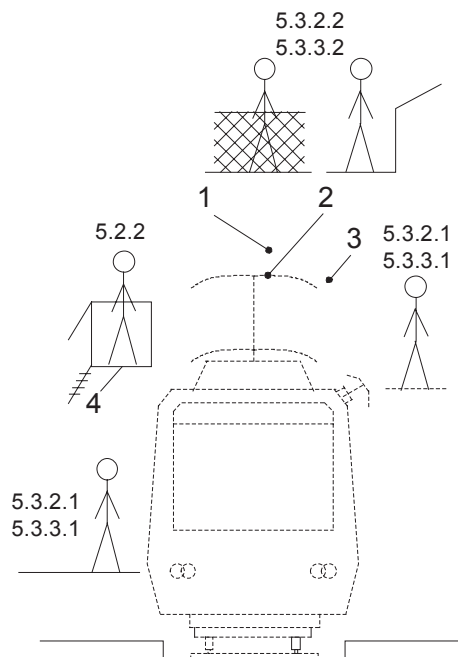
5.3 Protection by obstacles

5.3.1 General

If the clearances given in 5.2.1 to 5.2.5 cannot be maintained, obstacles shall be provided as protection against direct contact with live parts. The design of obstacles is dependent on the location of the standing surfaces shown in Figure 5 and Figure 6 relative to the live parts, on the nominal voltage, on the clearance between the obstacle and the live parts and on whether the standing surface is a restricted area or a public area.

The dimensions of the obstacles shall be such that live parts cannot be touched in a straight line by persons on a standing surface.

In case the obstacle is made of conductive material the requirements of 6.2 shall apply.

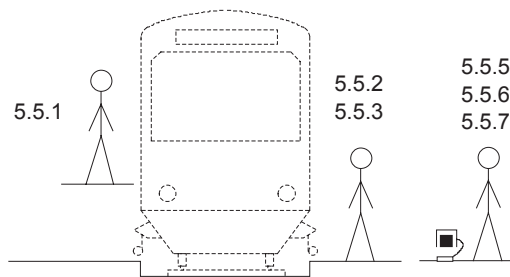


Key

- 1 catenary wire
- 2 contact wire
- 3 feeder
- 4 working platform

NOTE The numbers refer to the appropriate subclauses.

Figure 5 — Standing surfaces for persons providing access to live parts on the outside of vehicles and to overhead contact line systems



NOTE The numbers refer to the appropriate subclauses.

Figure 6 — Standing surfaces for persons providing access to live parts on the outside of vehicles and to conductor rail systems

Only obstacles of the following type may be provided:

- solid walls or solid wall doors;
- mesh constructions.

Inside the overhead contact line zone and current collector zone the following specifications shall be met by obstacles:

- a) non conductive obstacles shall be of solid walls or solid wall doors
 - 1) for systems of high voltages, obstacles within 0,60 m of live parts shall provide earthed frame;
 - 2) the materials shall be selected so that they will not become conductive as a result of the likely effects of moisture, ultra-violet radiation, chemical attack and other environmental damage, nor of contact with live parts.
- b) mesh constructions of plastic coated metal shall not be utilized.

The obstacle shall be constructed to prevent non-intentional (accidental) contact of live parts with parts of the body. Obstacles shall be fixed mechanically and reliably. They shall only be removable with tools. Obstacles shall be secured to ensure that the distance to live parts is maintained.

Minimum clearances shall be maintained between obstacles and live parts. The electrical clearance shall correspond to the relevant clearance as given in EN 50119 to which the following lengths shall be added:

- 0,03 m for solid walls or solid-wall doors, if buckling or warping cannot be excluded;
- 0,10 m for mesh constructions, where no other minimum clearance is given in 5.3.2.1 and 5.3.3.1.

5.3.2 Obstacles for standing surfaces in public areas

5.3.2.1 Obstacles for standing surfaces adjacent to live parts

The clearances shown in Figure 3 and Figure 4 shall be provided for standing surfaces to adjacent live parts of the outside of the vehicles or live parts of contact line system. If these clearances are not achieved, then, obstacles shall be provided which shall comply with the following requirements.

If the clearance in height between the top of the obstacle and live parts is at least 1,00 m (see Figure 7 a)) the obstacle shall be of solid-wall design or IP2X according to EN 60529 for low voltage 1,00 m high, surmounted by a mesh construction with a maximum 1 200 mm² mesh size to an overall height of at least 1,80 m. Such mesh shall be arranged so as to ensure that the obstacle remains unclimbable. If this clearance is not achieved, the obstacle shall be of solid-wall design (or IP2X for low voltage) 1,80 m high (see Figure 7 b)). The dimension *d* between the obstacle and live parts, shown in Figure 7, shall be determined as described in 5.3.1.

The obstacle shall have no gap to the standing surface.

The top of such obstacles shall be designed so, that it is difficult to stand or to walk on them.

1 solid-wall design or obstacle conforming to protection Class IP2X as defined in EN 60529
2 mesh screen with a maximum 1 200 mm² mesh size (can also be solid-wall design)
3 limit to live parts
d is the clearance in air between the obstacle and live parts in accordance with 5.3.1

$\max(d + x; 1, 0)$ means $(d + x)$, but at least 1, 0.

5.3.2.2 Obstacles and standing surfaces above live parts

The length of the solid-walled standing surface shall correspond to the current collector zone and extend beyond the live parts of a contact line system by at least 0,50 m on each side. In the case of conductors not being used for current collection (e.g. line feeders, reinforcing feeders, out of running overhead contact lines) there shall be a width of at least 0,50 m on each side of the conductor provided that movement due to dynamic and thermal effects has been taken into account.

Along the sides of these standing surfaces, obstacles shall be provided in order to prevent any direct contact with live parts on the outsides of vehicles and to live parts of the contact line system even where, for example, a rod or liquid jet is utilized. These obstacles shall be provided over a length that corresponds at least to the mandatory length of the standing surface which is in solid-wall design. The obstacles can either be any construction corresponding to Class IP3X according to EN 60529 or any other construction giving the same level of safety.

In case of horizontal obstacles extending beyond the vertical obstacle by at least:

- 0,50 m for low voltage,
- 1,50 m for high voltage,

then, in respect of the following:

- for low voltage a 1,45 m lateral clearance as shown in Figure 3,
- for high voltage a 2,25 m lateral clearance as shown in Figure 4

it is acceptable to refer them to the top of the vertical obstacle, instead of referring them to the edge of the standing surface (see Figure A.1 a) for low voltage and Figure A.2 a) for high voltage). The height of the vertical obstacle shall be consequently increased whenever necessary, in order to achieve this clearance. The horizontal obstacle shall be designed so that it is difficult to stand or to walk on them.

NOTE 1 To achieve this, the horizontal obstacle should be designed so that it is obviously not a standing surface, or it should be inclined upwards or downwards (see Figure A.1 a) for low voltage and Figure A.2 a) for high voltage).

Whenever this horizontal obstacle is not present, the vertical obstacle shall conform to the requirements of 5.3.2.1 (see Figure A.1 b) for low voltage and Figure A.2 b) for high voltage). The alternative solution (see Figure A.1 c) for low voltage and Figure A.2 c) for high voltage) is also acceptable.

The tops of such obstacles shall be designed so that it is difficult to stand or to walk on them.

Any vertical obstacle shall be of solid wall design, or Class IP2X as defined in EN 60529, and at least to a height of 1,00 m (see Figure A.1 for low voltage and Figure A.2 for high voltage), except in the case of the above said horizontal obstacle, where a railing is sufficient, if the clearances required by Figure 3 and Figure 4 are present.

NOTE 2 In addition to the requirements for electrical safety there may be additional requirements for obstacles to provide for security according to national regulations.

5.3.3 Obstacles for standing surfaces in restricted areas

5.3.3.1 Obstacles for standing surfaces adjacent to live parts

With standing surfaces adjacent to live parts on the outside of vehicles or adjacent to live parts of a contact line system, obstacles of mesh screens construction with a maximum 1 200 mm² mesh size and having a height h of at least 1,80 m may be used where the live parts are situated above the standing surface (see Figure 8 a) for low voltage and Figure 9 a) for high voltage).

If the live parts are situated at the same height or lower than the standing surface, the height h of the obstacle shall be such that a clearance of:

- for low voltage 1,35 m,
- for high voltage 1,50 m,

from the top of the obstacle is maintained as shown in Figure 3 (see Figure 8 b) for low voltage) and Figure 4 (see Figure 9 b) for high voltage).

The clearance between the obstacle and the live parts shall be at least:

- for low voltage 0,30 m,
- for high voltage 0,60 m.

If this clearance is not maintained, the obstacles shall be designed in accordance with 5.3.4 for low voltage or be of solid-wall design and leave no gap between the obstacle and the standing surface (see Figure 8 c) and Figure 8 d) for low voltage and Figure 9 c) and Figure 9 d) for high voltage). The dimension d between the obstacle and live parts, shown in:

- for low voltage in Figure 8, and
- for high voltage in Figure 9,

shall be determined as described in 5.3.1.

Dimensions in metres are minimum dimensions

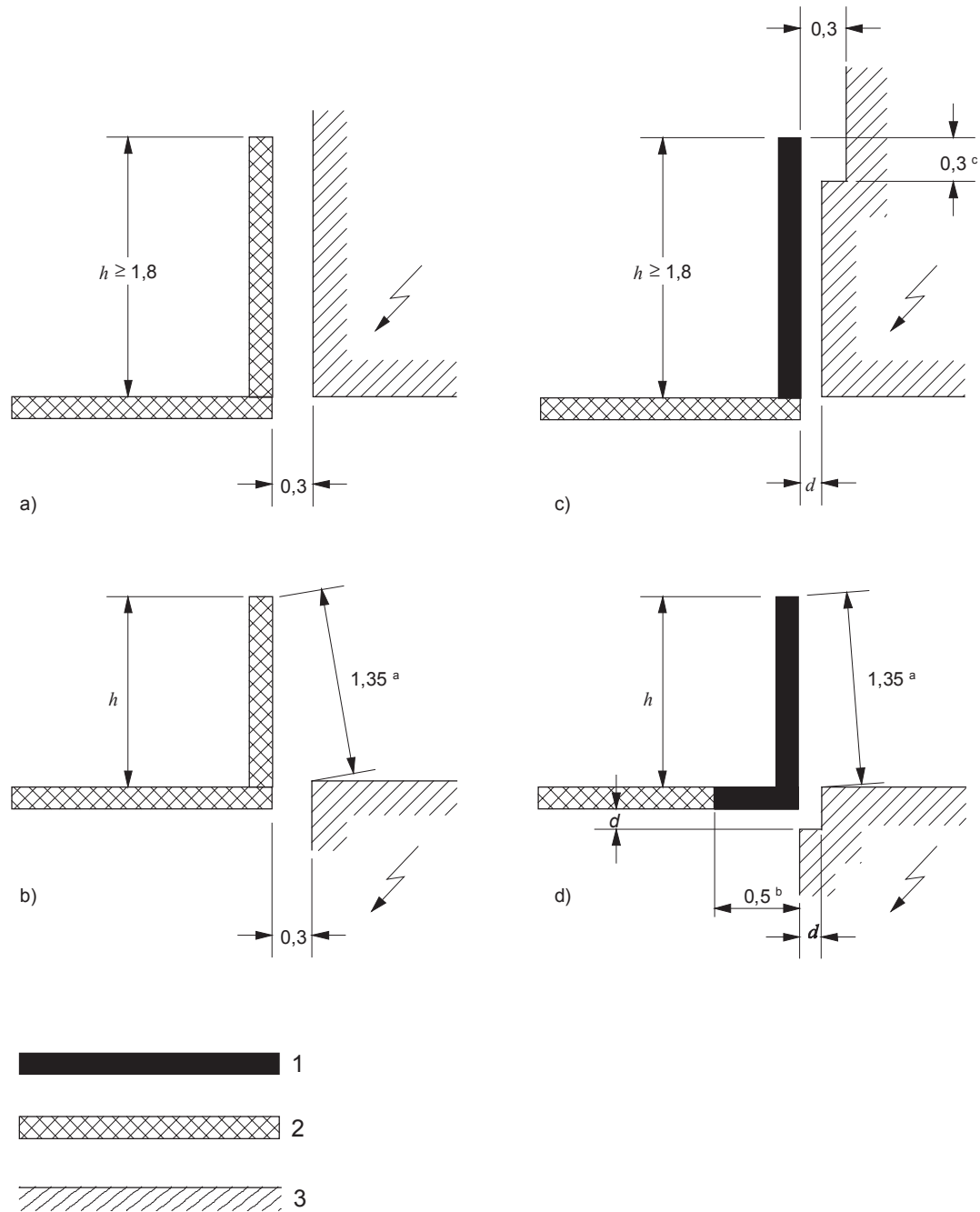


Figure 8 — Examples of obstacles for standing surfaces in restricted areas for protection against direct contact with adjacent live parts on the outside of vehicles or adjacent live parts of a contact line system for low voltages

Dimensions in metres are minimum dimensions

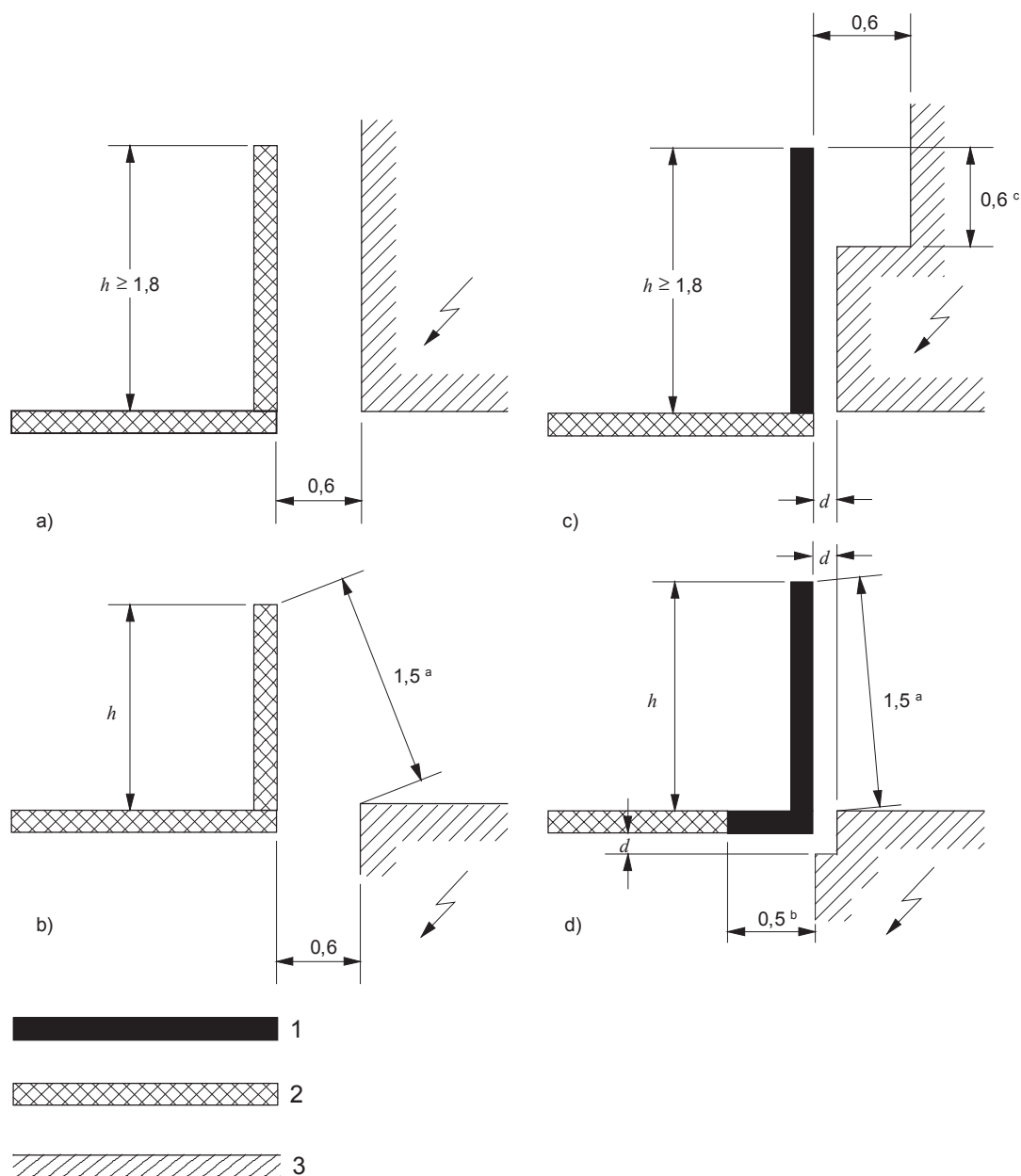


Figure 9 — Examples of obstacles for standing surfaces in restricted areas for protection against direct contact with adjacent live parts on the outside of vehicles or adjacent live parts of a contact line system for high voltages

5.3.3.2 Obstacles for standing surfaces above live parts

For standing surfaces above live parts on the outside of vehicles or above live parts of a contact line system, the obstacles shall be designed according to 5.3.4 for low voltage or shall be solid-wall design (see Figure 10 a) and Figure 11). If the clearance between the obstacles and the live parts is at least 0,60 m for low voltage, walkways which include a mesh construction with a maximum 1 200 mm² mesh size, may be provided as obstacles (see Figure 10 b)).

The length of the solid-walled or mesh construction standing surface shall correspond to the current collector zone and extend beyond the live parts of a contact line system by at least 0,50 m on each side. In the case of conductors not being used for current collection (e.g. line feeders, reinforcing feeders, out of running overhead contact lines) there shall be a width of at least 0,50 m on each side of the conductor provided that movement due to dynamic and thermal effects has been taken into account.

Obstacles of mesh screen construction with a maximum 1 200 mm² mesh size shall be at least provided at the sides of such standing surfaces. The height h of the obstacles shall be such that a clearance of:

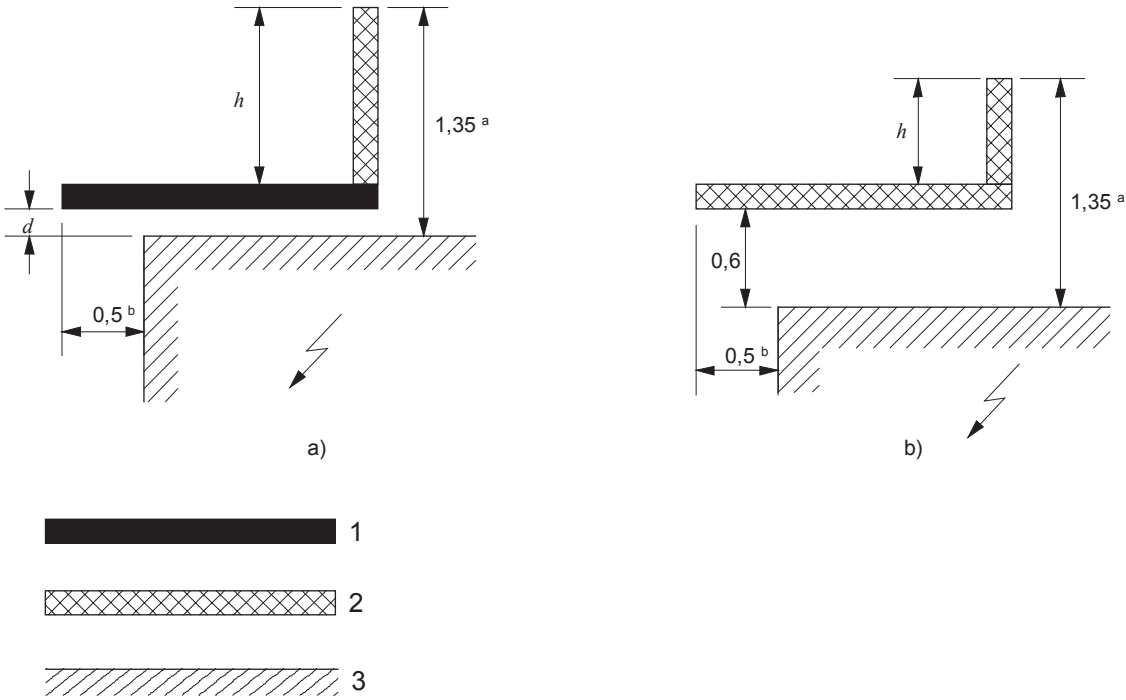
- for low voltage 1,35 m as shown in Figure 3 (see Figure 10 a) and Figure 10 b));
- for high voltage 1,50 m as shown in Figure 4 (see Figure 11);

from the top of the obstacles is maintained. These obstacles shall be at least as long as the length of the standing surface above live parts.

NOTE The height of the side obstacles, if necessary, will generally correspond to the height of the necessary safety railing but should have a height of at least 1,00 m.

The dimension d between the obstacle and live parts, shown in Figure 10 and Figure 11, shall be determined as described in 5.3.1.

Dimensions in metres are minimum dimensions



Key

- 1 solid-wall design or obstacle conforming to protection Class IP2X as defined in EN 60529
- 2 mesh screen with a maximum 1 200 mm² mesh size (can also be solid-wall design)
- 3 limit to live parts
- d is the clearance in air between the obstacle and live parts in accordance with 5.3.1

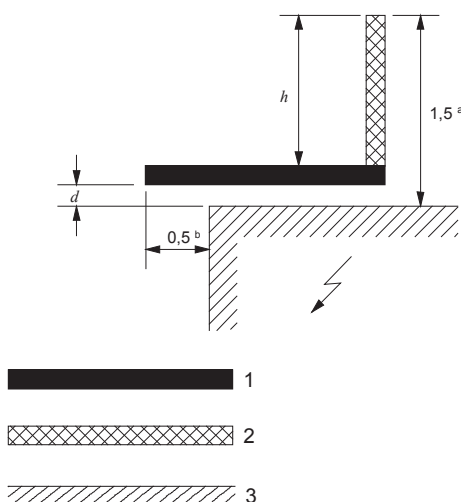
h Height (AC1)

^a is derived from Figure 3

^b is based on the requirements given in 5.3.2.2

Figure 10 — Examples of obstacles for standing surfaces in restricted areas for protection against direct contact when above live parts on the outside of vehicles or live parts of a contact line system for low voltage

Dimensions in metres are minimum dimensions



Key

- AC1** 1 Solid wall design **AC1**
- 2 mesh screen with a maximum 1 200 mm² mesh size (can also be solid-wall design)
- 3 limit to live parts
- d* is the clearance in air between the obstacle and live parts in accordance with 5.3.1
- AC1** *h* Height **AC1**
- ^a is derived from Figure 4
- ^b is based on the requirements given in 5.3.3.2.

Figure 11 — Examples of obstacles for standing surfaces in restricted areas for protection against direct contact when above live parts on the outside of vehicles or live parts of an overhead contact line system for high voltage

5.3.4 Protection degree for obstacles for low voltage

For low voltages the obstacles shall meet the requirements for protection degree IP2X according to EN 60529 with a minimum distance to live parts of 0,50 m or shall be of solid wall design.

5.3.5 Anti climbing provisions

Anti-climbing provisions are not normally necessary. In justified cases however, anti-climbing provisions can become necessary.

5.4 Protective provisions for working under live conditions

5.4.1 General

This European Standard considers protective provisions for working under live conditions in low voltage systems only.

The electrical installation shall be constructed and installed to ensure that the measures necessary for the protection of persons working in or on electrical installations can be employed. The rules for operation and maintenance of electrical power installations shall also be taken into account in the design. The working procedures shall be agreed on between manufacturer and user.

This does not apply to locations for which this requirement is technically impossible, e.g. for section insulators, crossing points of overhead contact lines of tramways and trolleybuses and for trolleybus overhead contact lines.

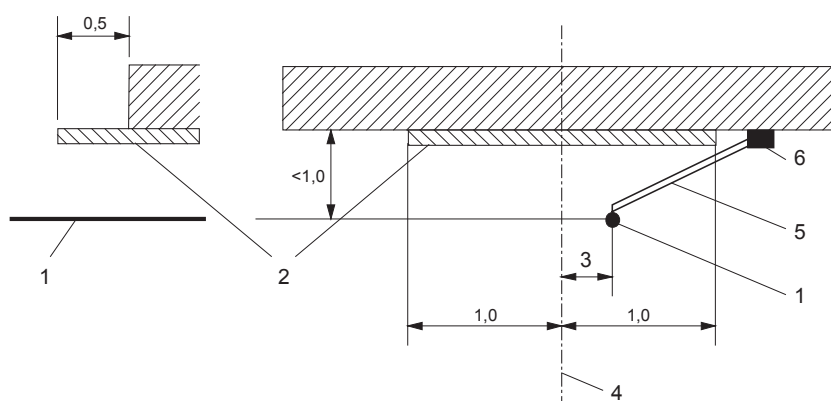
NOTE This requirement can be met, for example, by installation of additional insulation in the overhead contact line system to achieve neutral sections each at least 0,50 m long, which ensure that simultaneous contact with different potentials in the immediate working area is obviated completely or to a considerable extent.

Insulators whose design is such that supporting structures may become live under fault conditions (e.g. saddle insulators or buckle insulators) shall not be utilized for the overhead contact line system where live working shall be undertaken.

5.4.2 Overhead contact lines for railways or tramways beneath structures

In the case of overhead contact lines suspended beneath structures (tunnels, underpasses) where work is to be executed from an insulated platform whilst the line is energised, insulated obstacles or obstacles insulated with respect to the structure of minimum width 1,00 m shall be provided on both sides of the track centre if the clearance to structural elements connected to earth is less than 1,00 m (see Figure 12). These obstacles shall be 0,50 m longer than the edge of the structure.

Dimensions in metres



Key

- 1 contact wire
- 2 insulated obstacle
- 3 stagger
- 4 track centre
- 5 insulated arm
- 6 support

NOTE The stagger has been taken into consideration within the dimension of 1,00 m.

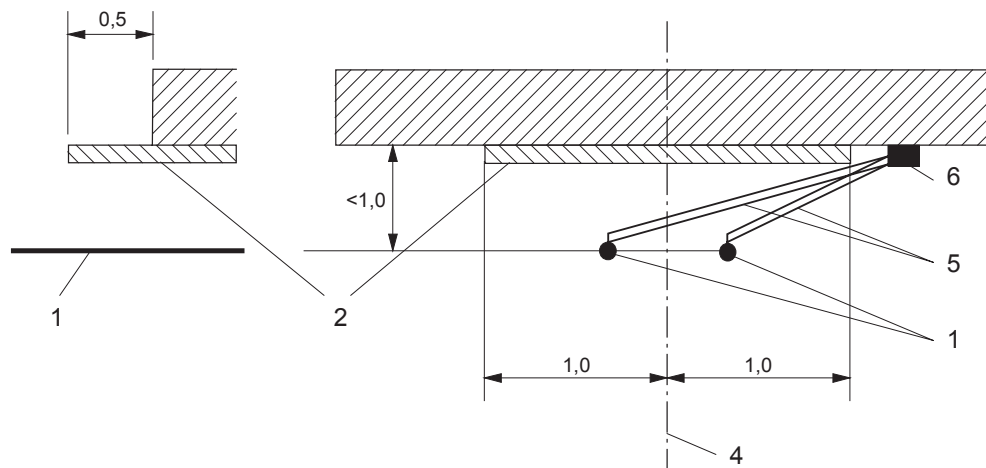
Figure 12 — Example of an insulated obstacle beneath a structure

5.4.3 Overhead contact lines for trolley bus systems beneath structures

5.4.3.1 Unearthed systems

In the case of overhead contact lines suspended beneath structures (tunnels, underpasses) where work is to be executed from an insulated platform whilst the line is energised, insulated obstacles or obstacles insulated with respect to the structure of minimum width 1,00 m shall be provided on both sides of the centre line of the contact wires if the clearance to structural elements connected to earth is less than 1,00 m (see Figure 13). These obstacles shall be 0,50 m longer than the edge of the structure.

Dimensions in metres



Key

- 1 contact wire
- 2 insulated obstacle
- 4 bifilar centre line
- 5 insulated arm
- 6 support

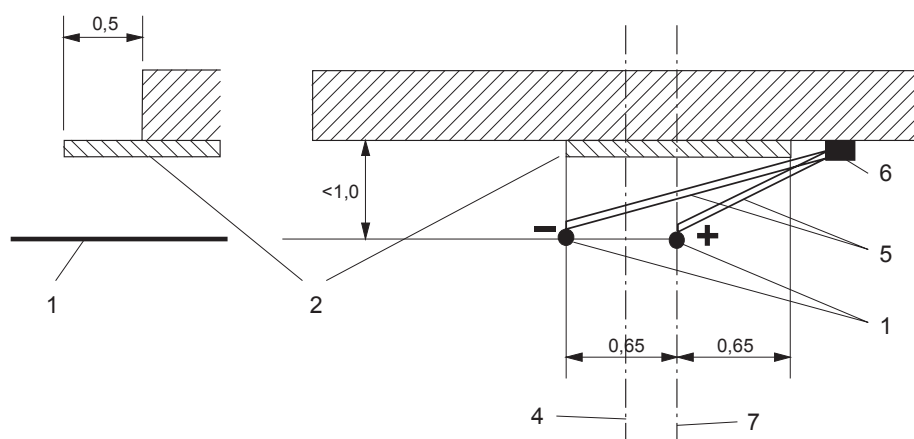
NOTE According to EN 50119 the distance between the contact wires is normally 0,60 m or 0,70 m.

Figure 13 — Example of an insulated obstacle beneath a structure for an unearthed trolley bus system

5.4.3.2 Systems in which one of the contact wires is earthed or connected to the return circuit of a tramway system

In the case of overhead contact lines suspended beneath structures (tunnels, underpasses) where work is to be executed from an insulated platform whilst the line is energised, insulated obstacles or obstacles insulated with respect to the structure of minimum width 0,65 m shall be provided on both sides of the unearthed contact wire if the clearance to structural elements connected to earth is less than 1,00 m (see Figure 14). These obstacles shall be 0,50 m longer than the edge of the structure.

Dimensions in metres



Key

- 1 contact wire
- 2 insulated obstacle
- 4 bifilar centre line
- 5 insulated arm
- 6 support
- 7 positive contact wire line

NOTE According to EN 50119 the distance between the contact wires is normally 0,60 m or 0,70 m.

Figure 14 — Example of an insulated obstacle beneath a structure for a trolley bus system in which the negative contact wire is earthed or connected to the return circuit of a tramway system

NOTE Figure 14 also applies in case of earthed positive contact wire, in which case “+” and “-” should be exchanged.

5.5 Specific protective provisions against electric shock in conductor rail systems

5.5.1 Location of conductor rail at platforms

Conductor rails shall be on the side of the track away from the platform wherever practical. This applies to all cases except where a single track lies between two platforms.

5.5.2 Exceptions

The requirements given in 5.3.3 can be waived in case of vehicles with shoe gear for conductor rails if the shoe gear does not extend considerably outside the vehicle gauge. In depots the internal operational ways shall be clearly distinguishable.

5.5.3 Protection provisions in workshops

For workshops where it may be impracticable to place a protective boarding around the conductor rail, a conductor rail system shall not be used. A trolley system or other systems shall be used for supplying the vehicle. In this case, national or locally defined working practices shall ensure safety around any live parts of a vehicle energised in a workshop, such as shoegear.

5.5.4 Protective boarding for conductor rails in restricted areas

In the case of bottom-contact conductor rail systems, the surface of the conductor rail not touched by the current collector shall be protected by means of protective boarding.

In the case of side contact conductor rail systems, the top and side surface not touched by the current collector shall be protected by means of protective boarding.

5.5.5 Requirements for top contact conductor rails in public areas

Anti-trespassing guards constructed of non-conductive material shall be installed parallel to the track for a distance of $\geq 2,00$ m when measured along the line of the track, at both public and private level crossings. The conductor rail shall be terminated $0,30$ m from the edge of the anti-trespassing guard (see Figure 15).

Dimensions in metres

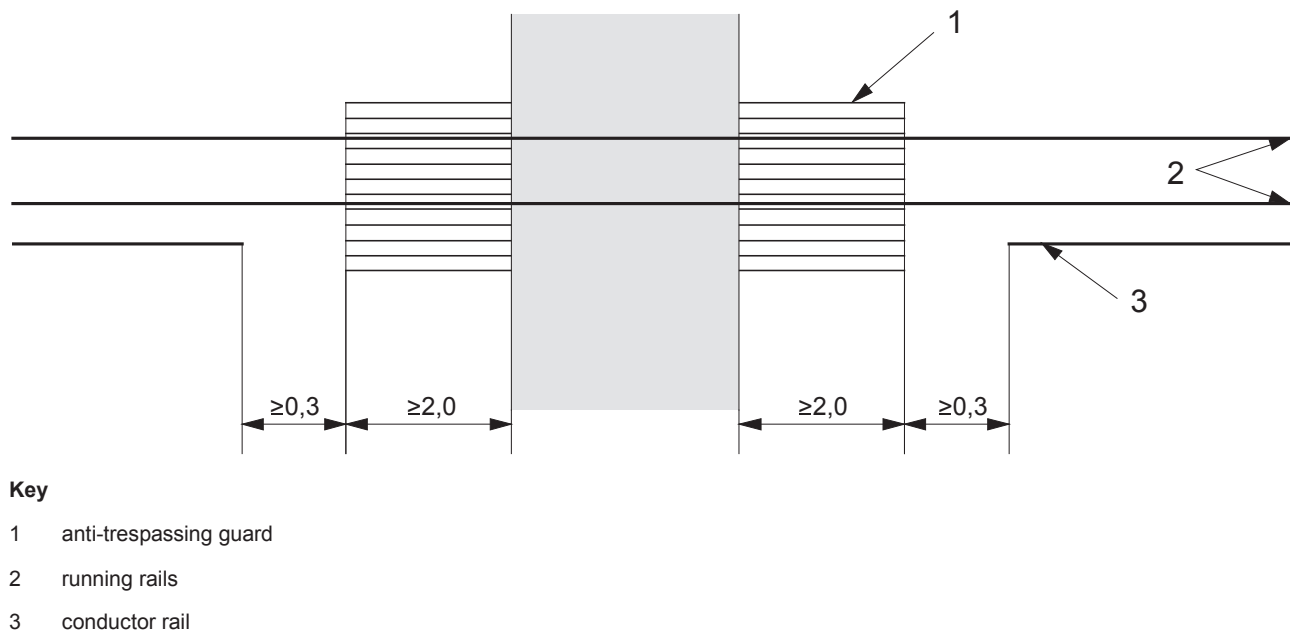


Figure 15 — Public level crossing, private level crossing

Anti-trespassing guards shall comprise a surface difficult for persons and animals to walk upon.

At public level crossings provided with gates that are protected in accordance with 5.3.2.1 except for the necessary clearance between the gate and the standing surface and which prevent access to the railway when the road is open, the conductor rail shall be terminated $0,30$ m from the edge of the crossing. No anti-trespassing guards or protective boarding are required.

At private level crossings provided with gates in accordance with the paragraph above and which prevent public access to the railway, the conductor rail shall be terminated $0,30$ m from the edge of the crossing. Double protective boarding shall be provided for a minimum distance of $2,00$ m.

NOTE Different sets of requirements apply for public and private level crossings because of differences in operational use.

5.5.6 Requirements for top contact conductor rails in restricted areas

For top contact conductor rail systems the following requirements apply:

Where the egress from a building or an equipment location facing towards the track is within 1,00 m of the conductor rail and no physical barrier is provided, then single protective boarding shall be provided on the outside of the conductor rail, extending 1,00 m either side of the location (see Figure 16).

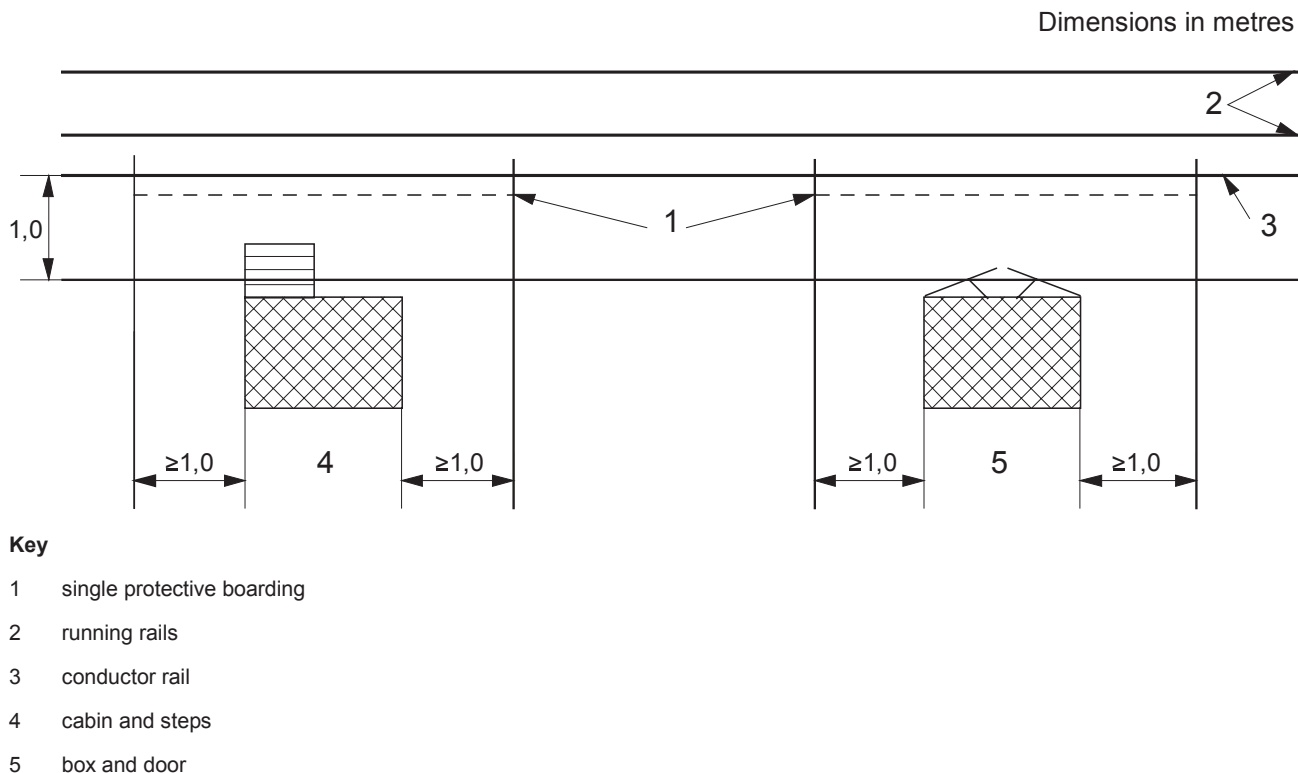
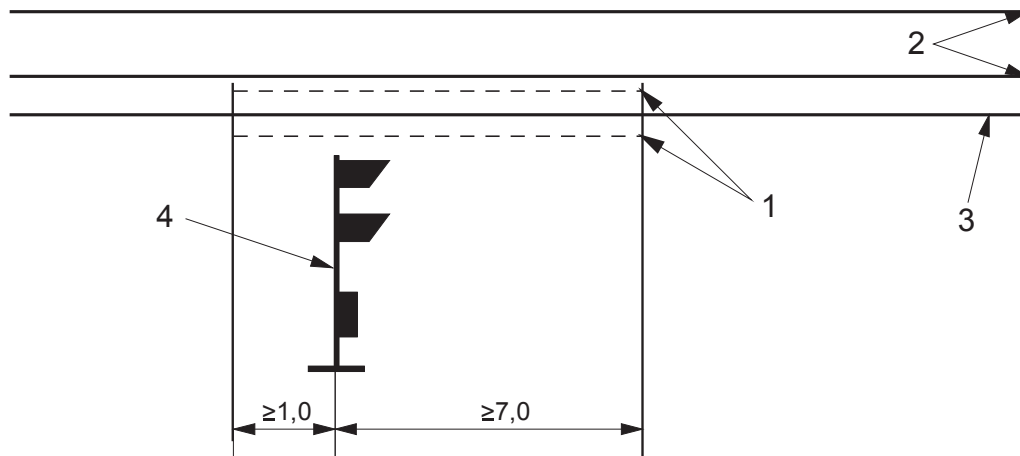


Figure 16 — Trackside structures

At signal-post telephone locations double protective boarding shall be provided for a distance of 8,00 m, commencing 7,00 m on the approach side of the signal-post with telephone (see Figure 17).

Dimensions in metres



Key

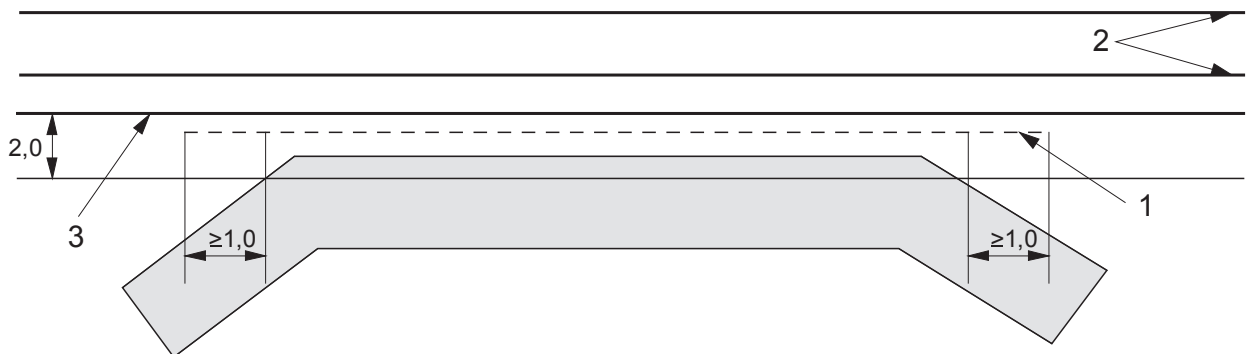
- 1 double protective boarding
- 2 running rails
- 3 conductor rail
- 4 signal with telephone

Figure 17 — Signal-post with telephone

If the telephone and the signal post are not at the same location, the location of the telephone shall be used for the projection of the protective boarding.

Where an authorized trackside walking route is located within 2,00 m of a conductor rail and no physical barrier is provided, then single protective boarding shall be provided on the outside of the conductor rail, extending 1,00 m either side of the end of the route (see Figure 18).

Dimensions in metres



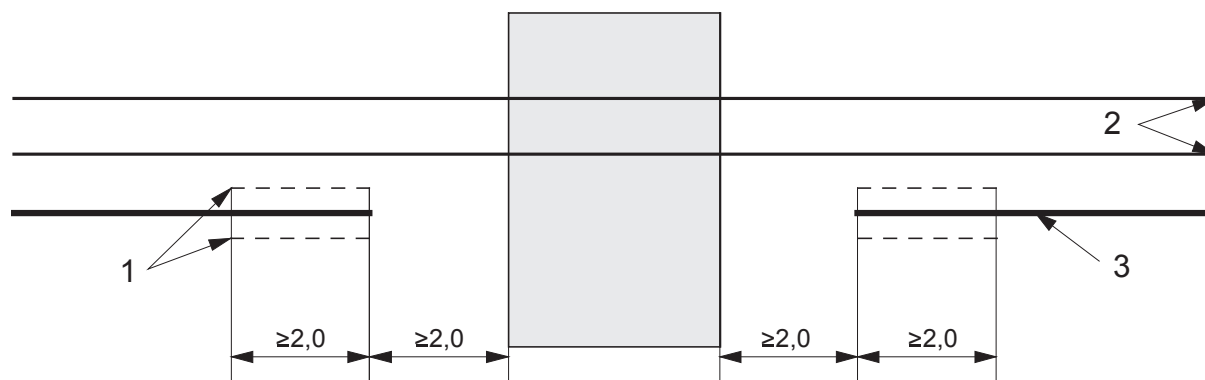
Key

- 1 single protective boarding
- 2 running rails
- 3 conductor rail

Figure 18 — Authorized trackside walking route

For railway controlled crossings the conductor rail shall be terminated 2,00 m from the crossing with double protective boarding provided for a minimum distance of 2,00 m (see Figure 19).

Dimensions in metres



Key

- 1 double protective boarding
- 2 running rails
- 3 conductor rail

Figure 19 — Railway controlled crossing (depots, goods yard, station crossing)

5.6 Specific protective provisions against electric shock in systems in which the wheels of the vehicles are not used for return circuit

5.6.1 General

This clause applies to systems which employ an insulated conductor for the return circuit so that the traction current does not flow in the running rails in normal conditions. Examples are “Third and Fourth Rail” d.c. conductor rail systems, and some kinds of three-phase a.c. systems or monorail systems and trolleybuses.

5.6.2 Railway systems

5.6.2.1 Use of the running rails as protective earth connection of vehicles

If the design of the vehicles is such that a fault on a live part of a vehicle equipment can connect a contact line or a return conductor to the running rails, then the substation equipment shall isolate automatically every earth fault which is not isolated by the equipment of the vehicles. See also 10.3.1.

5.6.2.2 Systems in which the vehicles do not require to be connected electrically to the running rails

If the equipment of the vehicles is designed so that no fault on a vehicle will connect a contact line to exposed conductive parts of the vehicle, and a connection from the vehicles to earth via the running rails is not required, 5.6.3.2 shall apply. In addition, earth faults on the contact lines shall be isolated within a sufficiently short time, to reduce to the lowest practical level the risk that multiple earth faults would cause impermissible touch voltages or thermal overload of the bonding conductors and related items.

5.6.3 Trolleybus systems

5.6.3.1 General

The insulation of each contact wire shall be appropriate to the nominal voltage of the system according to EN 50163.

5.6.3.2 Unearthed systems

Unearthed overhead contact lines shall have an insulation monitoring device for monitoring the state of the insulation between each contact wire and earth.

Whenever a feeding section has to be de-energised both contact wires shall be switched off. Sequential switching is permitted.

5.6.3.3 Earthed systems

In case of one of the both contact wires is earthed, the following conditions shall be fulfilled:

- whenever a switching device is installed in the earthed wire, another switch shall be installed in the other wire, and the switching device shall be interlocked so that it cannot be opened before the supply switch is open,
- it shall only be earthed at one point per feeding section which shall be insulated from other feeding sections.

Return cables shall conform to the requirements given in 10.3.1.

5.6.3.4 Trolleybus power supply connected to the power supply of a tramway

In case of a common traction power supply system for a trolleybus system and a tramway system, the following conditions shall be fulfilled:

- one contact wire trolleybus system shall be connected without any disconnection to the return circuit of the tramway system;
- in case a switching device is installed in the wire connected with the tramway return circuit, another switch shall be installed in the other wire, and the switching device shall be interlocked so that it cannot be opened before the supply switch is open;
- the trolleybus return circuit shall be connected at least once to the return circuit of the tramway system.

NOTE 1 Feeding sections for trolleybus and tramway should be separated one from the other and supplied by different circuit breakers inside substations.

NOTE 2 The additional return current of the tramway system in the return system of the trolleybus system and visa versa has to be considered.

6 Protective provisions against indirect contact and impermissible rail potential

6.1 Protective provisions against indirect contact

Provisions for protection against indirect contact shall be provided for exposed conductive parts and for components of contact line systems.

In traction systems connection to the return circuit is the preferred method to achieve electrical safety.

NOTE This method uses the return circuit for conduction of the current under fault conditions and causes automatic disconnection of supply.

6.2 Protective provisions for exposed conductive parts within the contact line zone or the current collector zone

6.2.1 A.C. traction systems

- A1** Except as noted below, exposed conductive parts of traction and non traction power supply which are located within the contact line or the current collector zone shall be directly connected to the return circuit.

NOTE 1 Connection to the running rails or to the return conductor is the preferred method to achieve this.

If it is determined that exposed conductive parts cannot be directly connected to the return circuit, then appropriate alternative measures shall be adopted in order to prevent dangerous touch voltages.

NOTE 2 One possible solution is the use of a voltage-limiting device (minimum functionality VLD-F) to provide a path for the current in the event of these exposed conductive parts becoming live. **A1**

6.2.2 D.C. traction systems

6.2.2.1 General

Exposed conductive parts of traction and non traction power supply which are located within the contact line zone or the current collector zone and which are not insulated from earth shall not be bonded directly to the return circuit due to the effects of stray current corrosion, see EN 50122–2. Then a voltage-limiting device (minimum functionality VLD-F) shall be used to make an open connection from the exposed conductive parts to the return circuit to create a short-circuit path and in consequence to cause the interruption of the current in a short time to keep the voltage within the limits given in Table 6 or in 9.3.2.3.

All voltage-limiting devices shall be applied in accordance with Annex F.

6.2.2.2 Exceptions in tunnels

For overhead contact line systems up to and including DC 3 kV, and where permitted by national regulations, an exception to the requirements given in 6.2.2.1 may be allowed for the metallic supports of the overhead contact line suspensions in tunnels outside the zone shown in Figure 4. This exception requires the use of insulators, restoring their dielectric property even after a flashover.

It is permitted, that such metallic parts which are normally inaccessible may not be earthed. This is due to the characteristics of such insulators and to increase maintainability, which is often difficult in tunnels. In this case the clamping of the metallic supports to the tunnel vault shall be achieved by using a grout having a good insulating property.

Where national regulations allow to perform maintenance work on structures adjacent to live parts, provisions in accordance with 5.2.2 shall apply considering the supports with floating potential are also live parts.

6.2.3 Exceptions for low voltage traction systems

6.2.3.1 General

The following exceptions to 6.2.2 are permissible, provided that all risks of electric shock are considered and reduced to acceptable levels as defined by national regulations.

6.2.3.2 Double or reinforced insulation of overhead contact line

Supporting structures including masts for overhead contact line systems need not be earthed and need not be connected to the return circuit if the insulation of the overhead contact line has been doubled or reinforced as defined in EN 61140. The instructions and procedures for maintenance shall ensure, that insulators which are defective or bridged by extraneous objects or materials shall be made good promptly so that no structure will become alive and dangerous due to an ineffective insulator.

6.2.3.3 Bonding of overhead contact line supports to the return circuit

If the supporting structures of a DC railway with low voltage are bonded to the return circuit in contradiction to 6.2.2 the structures shall be insulated from earth. The insulation shall be proved by measurements.

NOTE For the conductance per unit length of the return circuit and structures connected to it see EN 50122-2.

6.2.3.4 Precautions against the failure of conductor rail insulators

Precautions shall be taken so that no conductor rail will become connected to earth so as to cause impermissible touch voltages on the running rails, or cause a risk of fire or thermal damage to equipment. In particular the risks shall be considered of spurious connections between the conductor rail and the base plates and fixing bolts of the conductor rail insulators. If the base-plates are not open connected in accordance with 6.2.2, other precautions shall be applied in order to limit the risks to acceptable levels in accordance with national regulations, such as:

- regular cleaning of the insulators;
- prompt removal of rubbish, especially conductive rubbish, from the tracks;
- double or reinforced insulators as defined by EN 61140;
- reliably insulating the base plates and fixing bolts from the earth, for example by mounting them on wooden blocks;
- use of insulating shrouds to protect the base plates against contact with the conductor rails through extraneous objects.

6.2.4 Anchors of wooden masts

An insulator shall be installed in the anchor of wooden masts external to the zone as shown in Figure 3 and Figure 4 where the supporting structures of the overhead contact line system are not connected to the return circuit.

6.3 Protective provisions for wholly or partly conductive structures

6.3.1 Structures in the overhead contact line zone or the current collector zone

6.3.1.1 Protective provisions by means of connection to the return circuit

The protective provisions of 6.2 shall be applied to metallic structures to ensure that there is no remaining dangerous touch voltage.

NOTE 1 Such metallic structures are e.g.:

- signal gantries and signal posts;
- bridges;
- the awnings of station platforms;
- pipes;
- fences;
- huts and equipment enclosures;
- running rails of non-electric traction systems.

- A1** – running rails which are not connected to the return circuit e. g. used for track circuits. **A1**

NOTE 2 An example for partly conductive structures is a steel reinforced concrete structure.

The metallic reinforcement of concrete structures shall be treated in the same way as metallic structures except for structures for which both of the following conditions apply:

- the structure is not able to transfer a dangerous potential from the fault-location;
- the probability of contact with a live part is so low that the risk is accepted, that the overhead contact system or the structure may be damaged if the fault is not interrupted in a sufficiently short time.

These protective provisions shall be harmonized with the provisions specified for d.c. traction systems as defined in EN 50122-2 for reduction of corrosion due to stray currents.

6.3.1.2 Exceptions for small conductive parts

For conductive parts of small dimensions it is not necessary to take any protective provisions provided the following conditions and the conditions in Table 1 are fulfilled:

- the part does not support or contain electrical equipment or it contains only electrical equipment in conformity with Class II, refer to 7.3.2;
- a person approaching it from any direction can see if a live conductor is touching the part.

Table 1 — Maximum dimensions for small conductive parts

Dimensions in metres

Type of conductive parts	Low voltage		High voltage	
	Parallel to track	Horizontal, right angle to track	Parallel to track	Horizontal, right angle to track
wholly conductive	15	2	3	2
partly conductive	15	2	15	2

NOTE 1 This excludes items utilized for protective provisions given in 6.2 and 7.3.

NOTE 2 Small conductive parts are for example: gully covers, signal posts, level crossing posts, individual masts, warning labels, trash cans, fences, mesh constructions and metallic structures with maximum length as given in Table 1.

A1 In case of an assembly of several small conductive parts the basic requirements in 6.3.1.1 are valid. In particular, the assembly shall not be able to transfer dangerous potential from the fault location over a distance exceeding the maximum dimensions given in Table 1. **A1**

6.3.1.3 Exceptions for temporarily stored parts close to the rails

These protective provisions are not required for conductive materials temporarily stored in the vicinity of the track, e.g. running rails unless required by the operational specifications.

6.3.1.4 Protective provisions by means of obstacles

Instead of the protective provisions given in 6.2 specified for conductive structures or conductive structural components located in the current collector zone or overhead contact line zone, an obstacle may be installed. The obstacle shall be situated between the overhead contact line and the structures or structural components and shall have a width at least equivalent to that of the current collector and overhead contact line zone and should extend by at least 0,50 m beyond the end of the structure or structural component. The obstacle shall fulfil the insulation requirements of protection Class II or shall be connected to return circuit.

In cases when the current collector is guided by the overhead contact line (e.g. trolleybus), the current collector zone width may be reduced by extending the obstacle downwards on both sides of the overhead contact line by at least 0,05 m below the overhead contact line.

A1 6.3.1.5 Protective provisions by means of bare conductive parts connected to the return circuit

The structure or equipment to be protected does not need to be connected to the return circuit if a bare conductive part with appropriate design regarding position and current carrying capacity, connected to the return circuit, is present between the structure to be protected and an overhead contact line or a current collector. By this strategy a remaining dangerous touch voltage of the structure is unlikely because of fault tripping. The bare conductive part shall be installed (or arranged) inside of the overhead contact line zone and/or current collector zone.

NOTE The running rails fulfil this protective function for structures or equipment within 0,8 m on both sides of the running rails and below. For d.c. railways this is applicable for open formation only. **A1**

6.3.2 Parts in the vicinity of the railways

Conductive parts which are liable to become live due to inductive or capacitive coupling with the voltage of the contact line shall be connected to earth if not directly connected to the return circuit.

This applies to:

- a) metallic fences, sign boards and so on, which are installed along the railway line,
- b) parts in the overhead contact line zone or the current collector zone, when the connection to the return circuit is:
 - 1) exempted because of small dimensions,
 - 2) not direct.

NOTE Earthing via the foundations of such parts is usually sufficient, as long as no intentional insulating joints are inserted.

6.4 Limitation of rail potentials

6.4.1 A.C. systems

If continuous or permanent earthing of the return circuit is not possible, the a.c. system shall nevertheless be designed and constructed so that the touch voltages do not exceed the levels specified in 9.2. If compliance with 9.2 is not achieved, the general public shall be protected against contact with the voltage on the return circuit, and employees shall not be permitted to approach the running rails and the trains except in accordance with procedures which shall comply with national regulations concerning the safety of instructed persons.

6.4.2 D.C. systems

In order to avoid impermissible effective touch voltage, in certain cases voltage-limiting devices (minimum functionality VLD-O, see Annex F) shall be installed e.g. in passenger stations to achieve equipotential bonding between return circuit and earth.

If in depots, workshops, and industrial d.c. railway systems (e.g. surface coal mining) protection against impermissible touch voltage can only be achieved by direct earthing of the running rails, increased stray currents occur. The risks from stray currents shall be considered in accordance with EN 50122-2.

7 Protective provisions for low voltage non traction power supplies

7.1 General

This clause applies to low voltage non traction power supplies which are characterized by being able, under particular circumstances, to transfer a dangerous voltage over long distances. Therefore an electrical connection to non railway earthing systems is not desirable. In case of a connection, an agreement is necessary between the railway side network infrastructure owner and the owner of the other network infrastructure. Care shall be taken to address transferred potentials and overheating of cables (see 10.2).

The following provisions apply to those low voltage power supplies, where parts of such installations or the respective structure (earth) is likely to have connection to the return circuit of the railway system. This shall be assumed for:

- railways where the structure earth or parts of it are connected to the return circuit,
- d.c. railways where the structure earth or parts of it are connected to the return circuit via a voltage-limiting device (VLD),
- d.c. railways where stray currents in the structure earth or parts of it are likely,
- electrical installation within overhead contact line zone and/or current collector zone.

NOTE 1 Following installations are endangered for example:

- consumer installations,
- railway signalling or traffic lights installations,
- lighting systems,
- low voltage non traction power supplies,
- remote control equipment.

NOTE 2 The above installations could be endangered by:

- a broken overhead contact line or a broken or dewired current collector which can transfer the overhead contact line voltage in these installations when they are located in the overhead contact line zone or the current collector zone, or when they have conductive connections to installations which are located in these zones,
- traction return currents, which can overload protective conductors, PEN-conductors, or which can impair protective provisions where exposed conductive parts are intentionally and functionally connected to the return circuit.

According to HD 60364-4-41 protection against indirect contact for nominal voltages up to AC 50 V/DC 120 V shall be provided unless the relevant requirements as defined in HD 60364-4-41:2007, 411.1 are met.

Conductive parts carrying electrical equipment (excluding protection Class II) within the overhead contact line and current collector zone shall not be considered as parts of small dimension as given in 6.3.1.2.

7.2 Related provisions

The following protective provisions as given in 7.3 and 7.4 shall apply for stationary electrical installations as given in 7.1 in addition to provisions required by other relevant standards. These protective provisions shall be harmonized with the provisions specified for d.c. traction systems as defined in EN 50122-2 for reduction of effects due to stray currents.

7.3 Protective provisions for electrical installations in the overhead contact line zone or the current collector zone

7.3.1 Exposed conductive parts

Exposed conductive parts within the overhead contact line zone or the current collector zone shall be connected directly or via a voltage limiting device (VLD-F, see Annex F) to the return circuit, or otherwise be protected by a robust obstacle. If the obstacle is not made of insulating material, it shall be connected to the return circuit. In d.c. traction systems such obstacles shall conform to the requirements as defined in EN 50122-2.

The PE conductors of the electrical installation shall be of sufficient cross-sectional area, so that they will not be overheated by the portion of the current in the return circuit which can flow in them. The design of the return circuit and the equipotential bonding shall be coordinated with the insulation levels of the power supply cables and communications cables connected to electrical equipment which is in the overhead contact line zone or the current collector zone, or is for other reasons bonded to the return circuit, so that the cables and installations will not be damaged if there is an earth fault on the contact line system.

7.3.2 Equipment of protection Class II

If electrical equipment of protection Class II in accordance with EN 61140 is utilized then its enduring temporary overvoltage shall correspond to the nominal voltage of the contact line.

NOTE 1 EN 60664-1:2007, 3.3 defines temporary overvoltages for low voltage equipment.

Such equipment shall not be connected to a PE conductor.

For small conductive parts, carrying protection Class II equipment, the exceptions of 6.3.1.2 still apply.

In case of the use of protection Class II equipment of which the protective provisions do not correspond with the nominal contact line voltage then the requirements for exposed conductive parts within overhead contact line zone and current collector zone shall be fulfilled.

NOTE 2 Protection Class II equipment for high voltage systems is not practical due to economical reasons.

7.4 Protective provisions for installations which are endangered by the traction power supply return circuit

7.4.1 Design of auxiliary power supply

Protection against indirect contact for equipment or installations which are not protection Class II shall be realized by automatic disconnection of supply as described in HD 60364-4-41.

Exposed conductive parts shall be connected to a protective conductor.

NOTE 1 HD 60364-4-41 distinguishes installations by the kind of earth connection. For railway applications, fixed installations the TN-system and the TT-system are relevant.

Auxiliary supplies are usually fed by high voltage grid, public low voltage grid or by the traction power supply. Table 2 shows different kinds of auxiliary supplies and its characteristic connection to earth on railway side. Additionally the applicable low voltage distribution system on railway side with the respective precondition is indicated.

Table 2 — Kinds of auxiliary supplies

Supplier side		Railway side	
Kind of supply	Characteristic	Applicable system	Precondition
Public low voltage	Earth and/or neutral from non-railway earthing installations	TT system	RCD
		TN system	Separate winding transformer
High voltage	Earth and/or neutral from non-railway earthing installations	TN system	Auxiliary high voltage transformer located on railway owned structure earth
		TT system	Auxiliary high voltage transformer not located on railway owned structure earth and RCD
Traction power supply	Neutral connected to return circuit or railway owned structure earth	TN system	Auxiliary transformer located on railway owned structure earth or d.c./a.c. converter

NOTE 2 Other kinds of design, e.g. IT system, are allowed.

7.4.2 Low voltage power supply by TT system

All exposed conductive parts collectively protected by the same protective device shall be connected, together with the protective conductors, to an earthing system common to all those parts.

The supply may come from public LV supply without isolating transformer.

The incoming neutral conductor (PEN as well as N and PE separate) of the supplying non-railway system is connected to remote earth. In the railway distribution panel this neutral shall be applied as N only. The incoming PE shall be terminated at an insulated busbar and shall not be used on the railway side. The PE is derived from the MEB, which is connected to railway owned structure earth.

The resistance to earth R_A measured at the MEB shall fulfil the following requirement

$$R_A \leq U / I_a$$

where

U is in general the nominal line-to-earth voltage U_0 and in case of protection by RCD it is 50 V according to HD 60364-4-41;

I_a is the current, which leads to the automatic tripping of the protective device within 0,4 s.

NOTE 1 For circuit breaker this current depends on the tripping characteristic whereby for characteristic A the tripping current $I_a = 3 \times I_N$ (nominal current), for characteristic B: $I_a = 5 \times I_N$; for characteristic C: $I_a = 10 \times I_N$; for characteristic D: $I_a = 20 \times I_N$ (see HD 60364-4-41 and EN 60898-1); e.g. for a circuit breaker with B characteristic and a nominal current of 16 A, a maximum earth resistance of $230 \text{ V} / (16 \text{ A} \times 5) = 2,88 \Omega$ is required.

NOTE 2 When the protective device is a residual current protective device, I_a is the rated residual operating current $I_{\Delta n}$. (see HD 60364-4-41).

NOTE 3 Exceptions are possible for electric circuits with permanently installed equipment only.

The installation of RCDs is basically recommended. If the resistance to earth of the MEB is not low enough, RCDs shall be applied.

If the equipment is outside the overhead contact line zone and outside the current collector zone and if it has a connection to the main equipotential busbar, then the PE conductor incorporated in the power supply cable need not be connected to the exposed conductive part of the equipment.

7.4.3 Low voltage power supply by TN system

All exposed conductive parts of the installation shall be connected to the earth connection point of the LV-transformer windings by protective conductors which shall be earthed at or near each relevant transformer or generator.

In order to prevent the transfer of dangerous voltages or currents, separations between public earth and the railway owned structure earth are preferred. In case of separation, transformers with separate windings are required for the application of the TN system.

The supply may come from:

- public LV supply via transformer with separate windings;
- HV supply via auxiliary transformer.

The incoming non-railway earth shall be terminated at an insulated busbar and shall not be used on the railway side. The star point on the secondary winding of the transformer and its frame (exposed conductive part) shall be connected to the MEB.

NOTE In special cases it can be necessary to connect the frame to the public earth via the PE conductor or screens of incoming cables. Then an insulation between transformer frame and the railway owned structure earth is necessary.

For auxiliary transformers, which primary windings are fed from traction voltage, the neutral points on primary and secondary side shall be connected to the railway owned structure earth.

The low voltage protection system shall be a TN-S system. RCDs are recommended in the final circuits of distribution. Overcurrent protective devices shall be applied according to HD 60364-4-41. The maximum disconnecting times for TN-systems shall be kept.

If the equipment is outside the overhead contact line zone and outside the current collector zone and if it has a connection to the main equipotential busbar, then the PE conductor incorporated in the power supply cable shall not be connected to the exposed conductive part of the equipment.

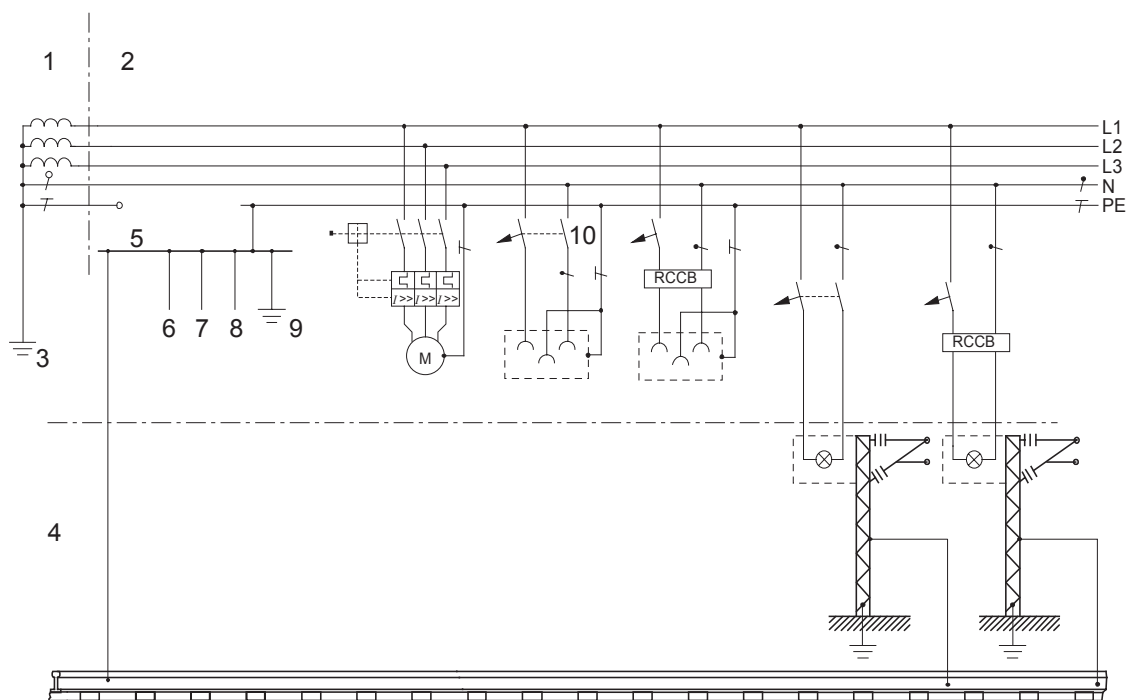
7.4.4 Special provisions

7.4.4.1 A.C. railways

The running rails of a.c. railways are connected to the structure earth consisting of mast foundations, slabtrack reinforcement and foundations of other wayside structures like tunnels and viaducts. Due to signalling constraints the connection can contain e.g. impedance bonds. Running rails and main equipotential busbar of the auxiliary power supply system shall be connected together. For equipment within the overhead contact line zone and current collector zone the PE conductor shall be able to carry the maximum short-circuit current. If this is not possible a direct connection to the return circuit shall be carried out. In this case the PE conductor shall not be connected to the exposed conductive part of the equipment.

Overcurrent protective devices shall also be applied in the neutral conductor for electric circuits without RCD, i.e. circuit breaker with two- or four-protected poles according to EN 60898-1, if the rail potential is > 50 V. In case of a tripping, all conductors shall be switched-off simultaneously. Fuses shall not be used.

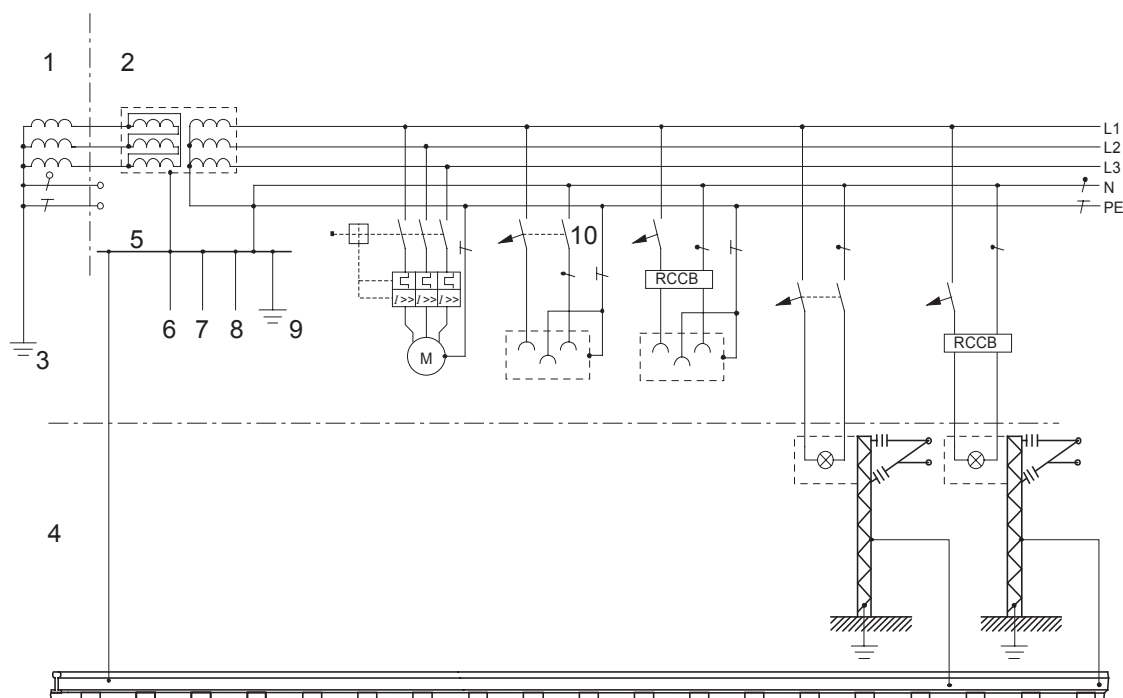
Figure 20 shows the provisions for a TT system and Figure 21 for a TN system applied in an a.c. railway system.



Key

- | | | | |
|---|--|----|---|
| 1 | electricity supply network | 6 | water and gas pipes |
| 2 | railway network | 7 | heating |
| 3 | public earth | 8 | lightning protection |
| 4 | overhead contact line and current collector zone | 9 | railway structure earth |
| 5 | MEB | 10 | only required for rail potential > 50 V |

Figure 20 — TT system for a.c. railways



Key

- | | | | |
|---|--|----|---|
| 1 | electricity supply network | 6 | water and gas pipes |
| 2 | railway network | 7 | heating |
| 3 | public earth | 8 | lightning protection |
| 4 | overhead contact line and current collector zone | 9 | railway structure earth |
| 5 | MEB | 10 | only required for rail potential > 50 V |

Figure 21 — TN system for a.c. railways

NOTE 1 The earthing symbol at masts does not indicate that each mast needs an additional earthing electrode.

NOTE 2 It is also possible to use a RCBO (IEC 60050-442-05-04) instead of circuit breaker in combination with RCCB.

7.4.4.2 D.C. railways

The running rails of d.c. railways are not connected to structure earth and earth. The running rails and the MEB of the auxiliary power supply system are normally not connected directly for stray current reasons. For equipment within the overhead contact line zone or within the current collector zone, the PE conductor shall be able to carry the relevant traction fault current. Voltage limiting devices (VLD) shall provide a connection between MEB and return circuit in case of an earth fault of the contact line system.

If such equipment is mounted on a mast a connection between the equipment and the return circuit via VLD-F shall be installed.

The PE conductor shall not be connected to the exposed conductive parts of the equipment.

The exposed conductive parts may alternatively be connected to the PE conductor of the supply cable via an appropriate device such as a capacitor. A discharge resistor shall be connected in parallel to the appropriate device.

The dimensioning of the capacitor shall guarantee the tripping current to fulfil the permissible touch voltage.

NOTE 1 The appropriate device prevents traction return currents flowing via the protective conductor.

If electrical equipment of protection Class II is used (see 7.3.2) the provisions for parts of small dimension may be applied.

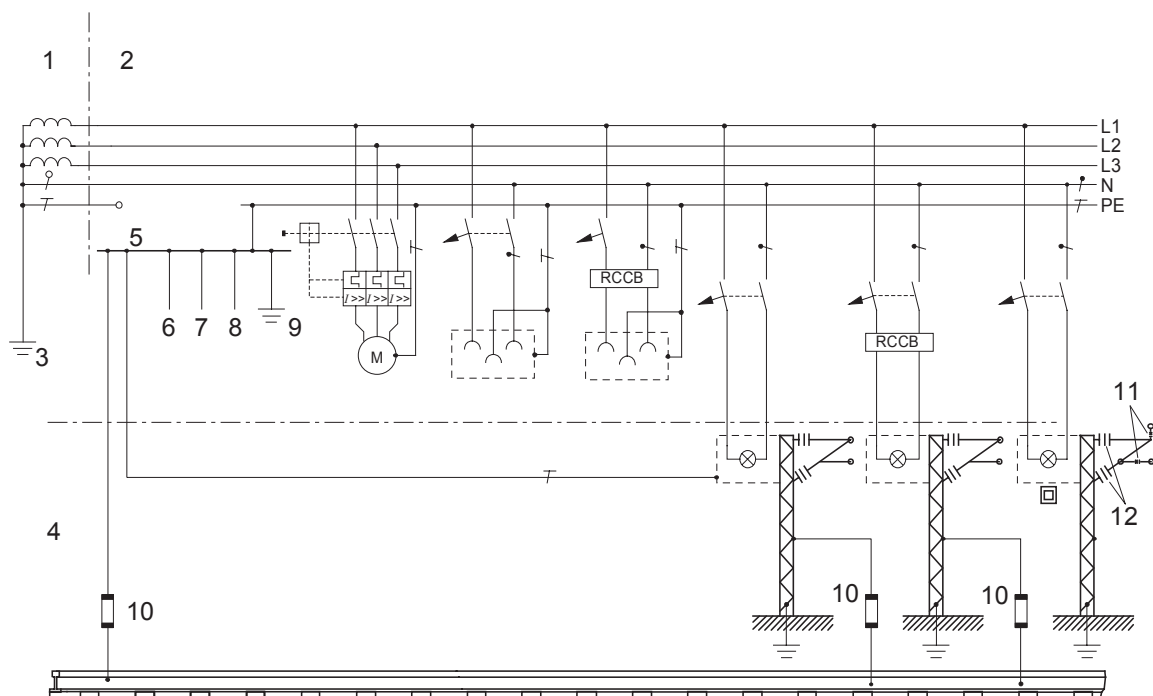
Low voltage equipment mounted on traction power equipment or parts which is protected by a frame fault protection device may not be connected to the PE conductor of low voltage supply cable. The device shall be equipotentially bonded to the traction power equipment frame.

If work is carried out on vehicles, on running rails, or on conductive parts which are connected to the return circuit, using protection Class I electrical equipment which is plugged into sockets supplied from the railway network, these wall sockets shall be connected to the railway network by residual-current protective devices or by transformers with separate windings. If residual-current protective devices are used, the protective conductor shall be connected to PE conductor via an appropriate device such as a capacitor. A discharge resistor shall be connected in parallel with a capacitor.

Overcurrent protective devices shall also be applied in the neutral conductor for electric circuits without RCD, i.e. circuit breaker with two- or four-protected poles according to EN 60898-1. In case of a tripping, all conductors shall be switched-off simultaneously. Fuses shall not be used.

Figure 22 shows the provisions for a TT system and Figure 23 for a TN system applied in a d.c. railway system.

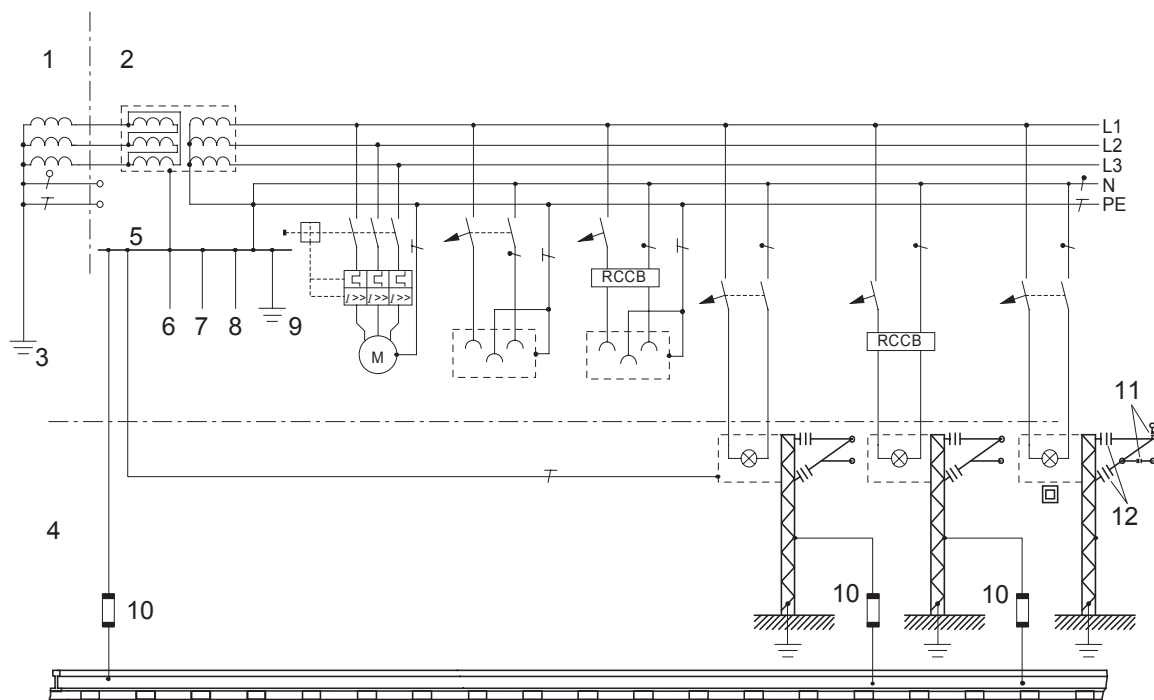
In workshops and similar locations where the running rails are insulated from the main line MEB and running rails may be directly connected in order to reduce the effect of touch voltage.



Key

- | | | | |
|---|--|----|---|
| 1 | electricity supply network | 7 | heating |
| 2 | railway network | 8 | lightning protection |
| 3 | public earth | 9 | railway structure earth |
| 4 | overhead contact line and current collector zone | 10 | VLD |
| 5 | MEB | 11 | 1 st insulation |
| 6 | water and gas pipes | 12 | 2 nd insulation (only for LV traction systems) |

Figure 22 — TT system for d.c. railways



Key

1	electricity supply network	7	heating
2	railway network	8	lightning protection
3	public earth	9	railway structure earth
4	overhead contact line and current collector zone	10	VLD
5	MEB	11	1 st insulation
6	water and gas pipes	12	2 nd insulation (only for LV traction systems)

Figure 23 — TN system for d.c. railways

NOTE 2 The earthing symbol at masts does not indicate that each mast needs an additional earthing electrode.

NOTE 3 It is also possible to use a RCBO (IEC 60050-442-05-04) instead of circuit breaker in combination with RCCB.

8 Protective provisions where track systems, which are utilized for carrying traction return current, or/and contact line systems pass through hazardous zones

8.1 General

The requirements given in 8.2 to 8.6 shall apply to installations where protective provisions against explosion due to sparking are prescribed by other standards if a dangerous inductive, conductive or capacitive influence from the railway cannot be excluded.

NOTE 1 Hazardous zones are defined in national safety regulations.

NOTE 2 Explosion due to sparking may, for example, result from:

- contact with an contact line;
- rupture of a contact wire;
- voltage between running rails utilized for carrying traction return current and earth (rail potential);
- discharge of static electricity to the return circuit;
- disconnecting of a conductive part carrying a part of the return current.

NOTE 3 Examples of such installations are loading installations or parts of refineries or chemical firms or tank depots.

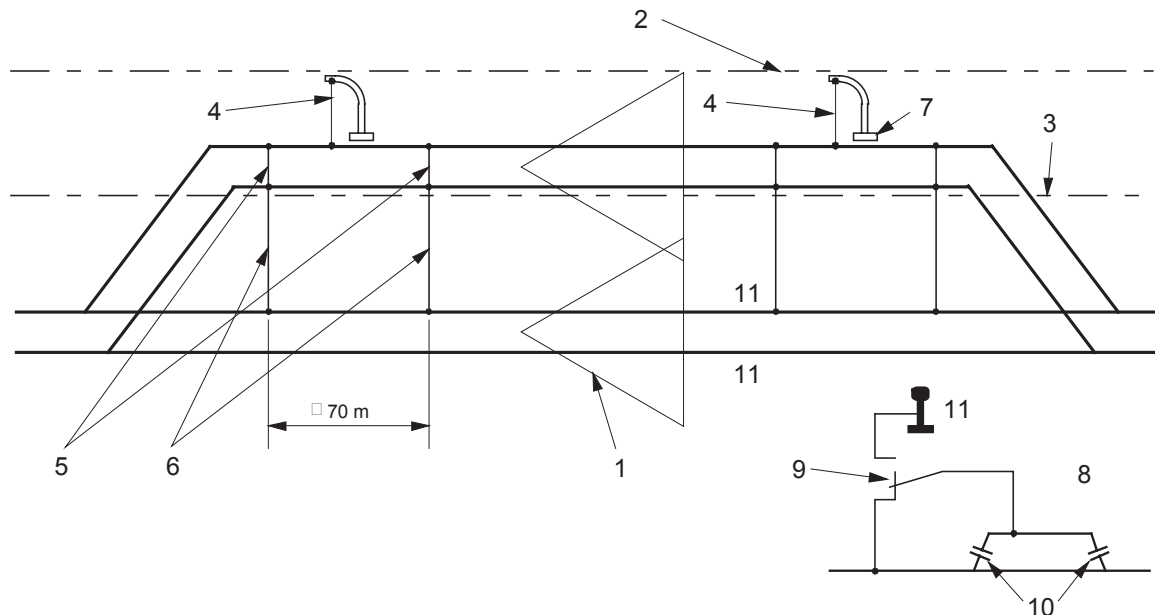
8.2 Equipotential bonding

Each charging nozzle shall be connected directly to the return circuit.

Cross bonds shall be provided at intervals not exceeding 70 m between:

- the rails of a track;
- neighbouring tracks (see Figure 24).

Tracks and adjacent conductive installations shall be conductively interconnected.



Key

- | | | | |
|---|--|----|--------------------------------------|
| 1 | overhead contact line zone according to Figure 1 | 6 | track-to-track cross bonds |
| 2 | border of the overhead contact line zone | 7 | charging nozzle |
| 3 | border of the hazardous zone | 8 | overhead contact line wiring diagram |
| 4 | connection to the return circuit and equipotential bonding | 9 | switch with contact to earth |
| 5 | rail-to-rail cross bonds | 10 | section insulators |
| | | 11 | return circuit (running rails) |

Figure 24 — Disposition of rail-to-rail cross bonds and track-to-track cross bonds (double-rail illustration) and connection of the contact line in case of the loading siding having a contact line

8.3 Parallel pipework

A pipework carrying explosive liquids or gases shall not be used intentionally as a parallel return conductor.

A common pipework inside the contact line or pantograph zone feeding several charging nozzles shall be insulated between each charging nozzle.

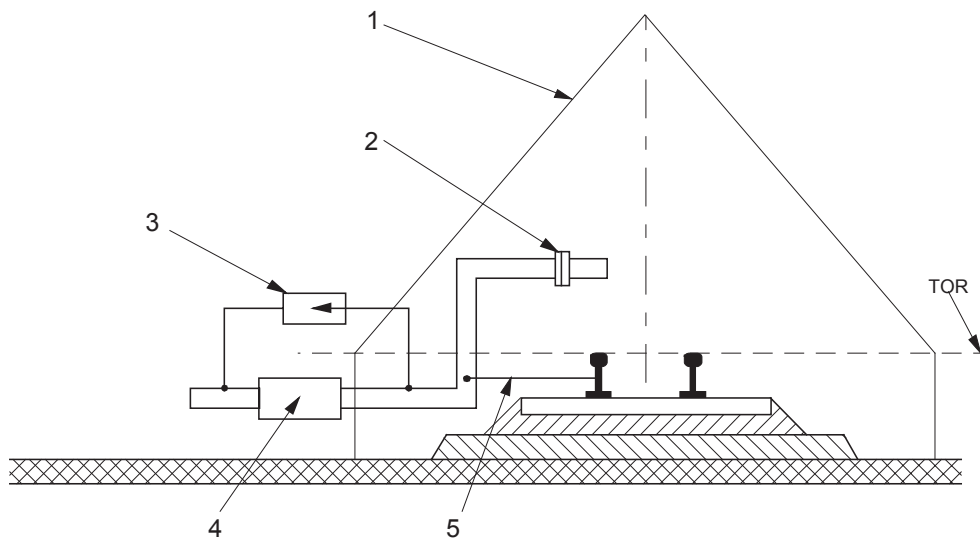
Each conductive part which is connected to the return circuit shall be insulated from earth. This applies both to a.c. railways and to d.c. railways as well.

8.4 Insulating joints

Conductive pipework carrying explosive liquids or gases leaving the contact line or pantograph zone shall be insulated outside of the contact line or pantograph zone (see Figure 24). The insulating joint shall withstand the voltage of the contact line. If the voltage over the insulating joint is bridgeable by a person, the voltage shall not exceed the limits given in Clause 9.

8.5 Surge arrester

If flashover or voltage breakdown of the insulating pieces is likely due to lightning strike, the insulating pieces shall be bridged by means of surge arresters (see Figure 25). Surge arresters used in hazardous zones shall be of flameproof design. Care shall be taken to ensure that accidental bridging of isolation pieces or surge arresters (e.g. by tools) is prevented.



Key

- 1 overhead contact line zone according to Figure 1
- 2 charging nozzle
- 3 surge arrester
- 4 insulating piece
- 5 connection to the return circuit and equipotential bonding
- TOR top of rail

Figure 25 — Location of a surge arrester outside the overhead contact line zone of a loading siding if there is a possibility of flashovers of the insulating pieces through lightning strikes

8.6 Contact line of loading sidings

The contact line of the loading siding shall be interruptible and shall be connectable to the return circuit by a means which ensures that the loading procedure is not initiated unless the contact line is connected with the return circuit (see Figure 24).

9 Limits for touch voltage and protection against the danger of rail potential

9.1 General

9.1.1 Rail potential

The local and time-dependent rail potential is the main reason for touch voltages under operating and fault conditions. The permissible touch voltage therefore is subdivided in long-term values for operation and short-term values for fault conditions including specific short-term operational situations.

For voltages which vary significantly, particular care shall be given to the choice of the time interval so as to ensure that the most unfavourable condition has been considered.

NOTE The values given in the tables of Clause 9 are based on the assumption, that the current path through the human body is from hand to both feet. This includes the current path hand to hand, see Annex D. For maintenance purposes it can be necessary to consider more dangerous currents paths through the human body. Additional protective provisions can then be necessary.

9.1.2 Body voltage and touch voltage

The values for the touch voltage and body voltage given in Clause 9 shall be the maximum values considered acceptable. All voltages (including d.c. voltages) given in Clause 9 are r.m.s. values, over the considered interval in accordance with IEC 60050-101-14-15.

The resistance of the standing surface, according to HD 637 S1, may be taken into account additionally at any time interval.

NOTE 1 The calculation methods for the values in the following tables are shown in Annex D.

NOTE 2 Measurement methods for effective/prospective touch voltages are given in Annex E.

NOTE 3 For all tables of Clause 9 the values for intermediate durations may be calculated by linear interpolation.

9.1.3 Touch voltage at vehicles

Attention is directed to the problem that can occur, if a vehicle is touched in case of a fault to or in the vehicle. The voltage acting as the source voltage in the touching circuit is caused by the voltage drop over the vehicle impedance to the running rail and the whole or a part of the rail potential. For impedance values between the vehicle body and rail see EN 50153:2002, 6.4.3. According to EN 50153:2002, 6.4.4 the voltage drop over the vehicle including the relevant part of the rail potential shall not exceed the values given in Clause 9.

NOTE If the fault current is unknown, short-circuit currents according to EN 50388:2008, Table 7 may be used for worst case calculations.

9.1.4 Fault duration condition

For the evaluation of the relevant fault duration in order to assess the permissible touch voltage, the correct operation of the protection devices and switches shall be assumed. Multiple simultaneously occurring faults do not need to be considered.

9.1.5 Voltage limits and time duration aspects

For any moment in time and any time interval at that moment, the maximum r.m.s voltage value over the time interval shall not surpass the voltage given for the applicable time interval as specified in Table 3 and Table 4 for a.c. systems and in Table 5 and Table 6 for d.c. systems.

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

9.2 A.C. traction systems

9.2.1 General

In order to determine whether an impermissible high touch voltage can occur, the rail potential at the relevant point shall be evaluated both for operation and for fault conditions.

If the rail potential is determined by calculation, such calculation shall employ the maximum operating current and short-circuit current and also the initial short-circuit current.

NOTE Guiding values for the normalized rail potential gradient can be found in C.1.

9.2.2 A.C. voltage limits for the safety of persons

9.2.2.1 Basic values of the body voltage U_b

The body voltages U_b shall not exceed the values shown in Table 3 for the corresponding time durations.

Table 3 — Maximum permissible body voltages $U_{b, \max}$ in a.c. traction systems as a function of time duration

t s	$U_{b, \max}$ V
> 300	60
300	65
1	75
0,9	80
0,8	85
0,7	90
0,6	100
0,5	120
0,4	150
0,3	230
0,2	295
0,1	345
0,05	360
0,02	370
Key t time duration $U_{b, \max}$ permissible body voltage	

9.2.2.2 Effective touch voltage limits

For long-term conditions $t \geq 0,7$ s, the effective touch voltage shall not exceed the values shown in Table 4.

For short-term conditions, $t < 0,7$ s, the permissible body voltages are considered to be complied with, if the values for the effective touch voltage in Table 4 are not exceeded.

NOTE An additional resistance of 1 000 Ω for old wet shoes is included in the values, see D.1.

**Table 4 — Maximum permissible effective touch voltages $U_{te, max}$
in a.c. traction systems as a function of time duration**

t s	$U_{te, max}$ long-term V	$U_{te, max}$ short-term V
> 300	60	-
300	65	-
1	75	-
0,9	80	-
0,8	85	-
0,7	90	-
< 0,7	-	155
0,6	-	180
0,5	-	220
0,4	-	295
0,3	-	480
0,2	-	645
0,1	-	785
0,05	-	835
0,02	-	865
Key t time duration $U_{te, max}$ permissible effective touch voltage		

Residual touch voltages caused by different tripping times shall be switched off within the corresponding duration time according to Table 4.

NOTE Different tripping times are caused for example by relay coordination, different types of relays and different opening times.

9.2.2.3 Workshops and similar locations

In workshops and similar locations the effective touch voltage shall not exceed the 25 V limit of let go. For short-term conditions 9.2.2.2 shall apply.

NOTE The reduced level for touch voltages in workshops has been chosen considering the high risk of injury for persons due to uncontrolled reactions caused by touch voltages during work. Injuries through the direct effect of electrical voltage and current are not expected on this level.

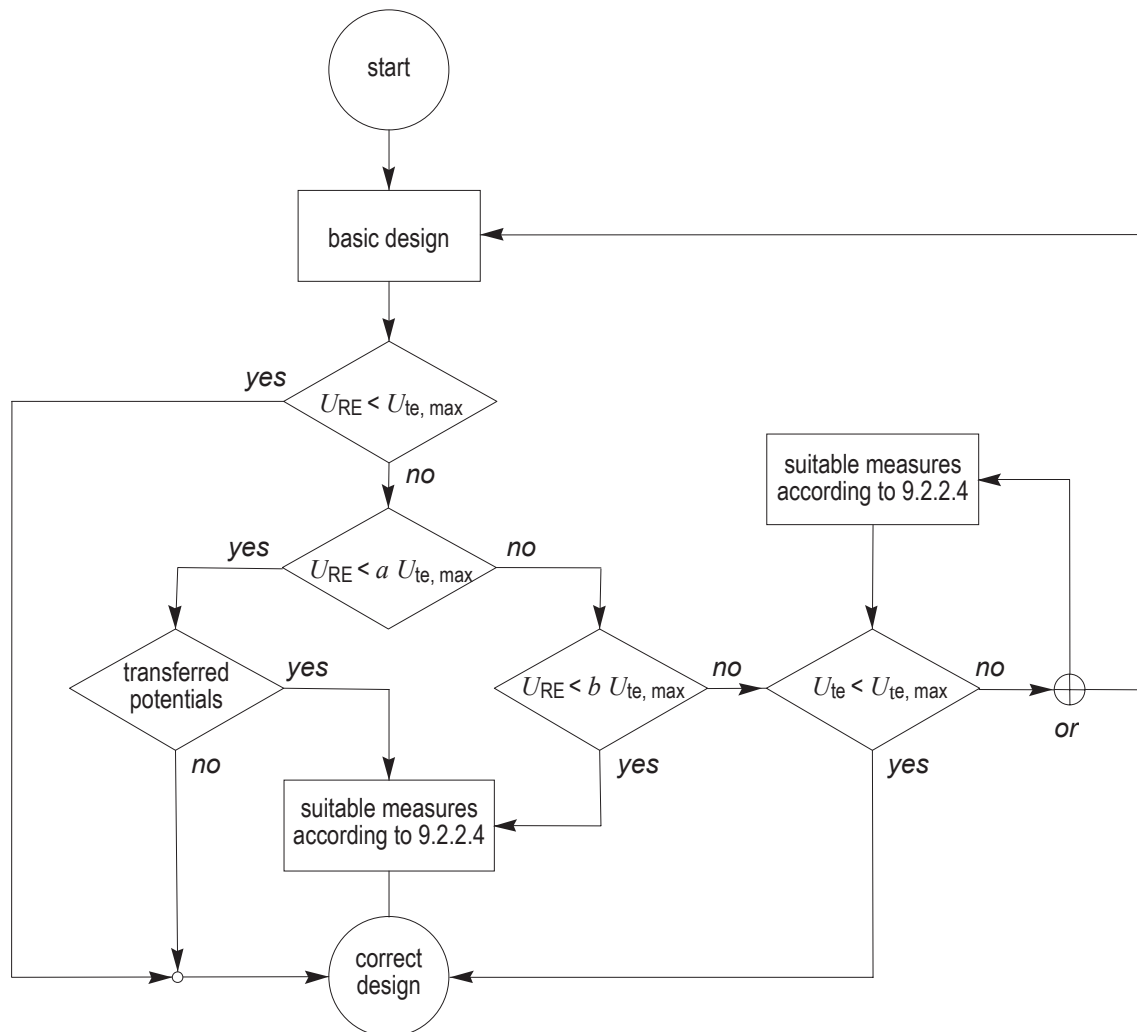
9.2.2.4 Measures to reduce the risks from touch voltages

If the limits given in 9.2.2.2 or in 9.2.2.3 are exceeded, the following provisions with help of Figure 26 shall be considered to reduce the risks from touch voltages directly, or by means of a rail potential reduction, or by management.

The following list contains some examples of measures:

- reduction of the rail to earth resistance, e.g. by means of improved or additional earth electrodes;
- equipotential bonding;
- improvement of the return circuit taking electromagnetic coupling into account;

- insulation of the standing surface;
- potential grading by means of appropriate surface earth electrodes;
- obstacles or insulated accessible parts;
- access restrictions (fences) including instructions for maintenance staff;
- reduction of fault and/or operation currents;
- voltage-limiting device;
- reduction of the tripping time needed to interrupt the short-circuit current.



Key

U_{RE} rail potential

U_{te} effective touch voltage

$U_{te, max}$ permissible effective touch voltage

$a = 2$ factor for 50 % potential decrease, according to Figure 9.2 in HD 637 S1:1999, see Figure C.1

$b = 3,3$ factor for 30 % potential decrease, see Figure C.2

Figure 26 — Design of return circuit, with regard to permissible effective touch voltage by checking the rail potential or the effective touch voltage

9.3 D.C. traction systems

9.3.1 General

In order to determine whether an impermissible high touch voltage can occur, the rail potential at the relevant point shall be evaluated both for normal operation and for fault conditions on the basis of the voltage drop in the return circuit.

If the rail potential is determined by calculation, such calculation shall employ the maximum operating current flowing in the running rails. For short-circuits the maximum current during the disconnection time of the fault shall be taken into account (see also C.2).

9.3.2 D.C. voltage limits for the safety of persons

9.3.2.1 Basic values of the body voltage

Table 5 — Maximum permissible body voltages $U_{b, \max}$ in d.c. traction systems as a function of time duration

t s	$U_{b, \max}$ V
> 300	120
300	150
1	160
0,9	165
0,8	170
0,7	175
0,6	180
0,5	190
0,4	205
0,3	220
0,2	245
0,1	285
0,05	325
0,02	370
Key t time duration $U_{b, \max}$ permissible body voltage	

9.3.2.2 Effective touch voltage limits

For long-term conditions $t \geq 0,7$ s the effective touch voltage shall not exceed the values for the body voltage shown in Table 6.

For short-term conditions, $t < 0,7$ s, the body voltages are considered to be satisfied, if the values for the effective touch voltage in Table 6 are not exceed.

NOTE An additional resistance of 1 000 Ω for old wet shoes is included in the values, see D.1.

Table 6 — Maximum permissible effective touch voltages $U_{te, max}$ in d.c. traction systems as a function of time duration

t s	$U_{te, max}$ long-term V	$U_{te, max}$ short-term V
> 300	120	-
300	150	-
1	160	-
0,9	165	-
0,8	170	-
0,7	175	-
< 0,7	-	350
0,6	-	360
0,5	-	385
0,4	-	420
0,3	-	460
0,2	-	520
0,1	-	625
0,05	-	735
0,02	-	870
Key t time duration $U_{te, max}$ permissible effective touch voltage		

9.3.2.3 Workshops and similar locations

In workshops and similar locations the effective touch voltage shall not exceed 60 V. For short-term conditions 9.3.2.2 shall apply.

NOTE The reduced level for touch voltages in workshops has been chosen considering the high risk of injury for persons due to uncontrolled reactions caused by touch voltages during work. Injuries through the direct effect of electrical voltage and current are not expected on this level.

9.3.2.4 Measures to reduce the risks from touch voltages

If the limits given in 9.3.2.2 or 9.3.2.3 are exceeded, the following provisions shall be considered to reduce the risks from touch voltages directly, or by means of a rail potential reduction, or by management. The following list contains some examples:

- reduced length of feeding section;
- increasing of conductance of the return circuit;
- insulation of the standing surface;
- reduction of the tripping time needed to interrupt the short-circuit current;
- voltage-limiting device.

10 Additional protective provisions

10.1 Traction substations and traction switching stations

Substations and switching stations shall conform to HD 637 S1 for all matters concerning electrical safety and earthing. This shall apply also with respect to the presence of a.c. or d.c. electric systems relating to electrical traction, with the following additional requirements:

- the effective touch voltages caused by the traction system shall not exceed values given in 9.2.2 and 9.3.2;
- in a.c. traction systems a direct connection shall be made between the return circuit and the earthing system of the substation or the switching station;
- in d.c. traction systems connections between return circuit and earthing system of the substation shall be designed in accordance with EN 50122–2, except where safety considerations require direct earthing (e.g. workshops and depots);
- for insulation co-ordination of equipment connected to the contact line system, EN 50124-1 shall apply;
- switchgear shall have sufficient performance to clear any fault current on the contact line system.

10.2 Cables

10.2.1 General requirements

Multiple connection of metallic sheaths, armour or shields of power cables to the return circuit is permissible only where an impermissible temperature rise cannot occur as a result of such connections. If multiple connection of metallic sheaths, armour or shields of power cable to the return circuit is necessary, it shall be ensured that the metallic sheaths, armour or shields of power cables do not carry impermissible high traction return currents.

10.2.2 Cables in a.c. traction power supply systems

The metallic sheaths, armour or shields of single-phase a.c. feeder cables shall be connected to the return circuit. Where necessary, special provisions shall be adopted to ensure that an impermissible temperature rise does not occur in the metallic sheaths, armour or shields due to induction with the supply current as a result of earthing at both ends or an impermissible high voltage as a result of earthing at one end only.

10.2.3 Cables in d.c. traction power supply systems

The metallic sheaths, armour or shields of d.c. feeder cables shall be insulated with respect to earth if they are connected to the return circuit. If any metallic sheaths, armour or shields of d.c. feeder cables are not insulated with respect to earth, then measures shall be applied, to protect persons against impermissible high touch voltages. Measures shall be applied, to avoid excessive heating of the metallic sheaths, armour or shields of d.c. feeder cables by the current which flows in them.

10.3 Return circuit connections and earthing conductors

10.3.1 General requirements

The return current busbar of the substation shall be connected to the running rails, return conductors or return conductor rails by at least two return cables, either directly or via the midpoint of impedance bonds. The return cables shall be sufficient for the maximum load current. The number of connecting cables to the running rails shall take into account that one cable connection can be interrupted. The return circuit shall not include fuses, non lockable switches and joint straps which can be released without a tool.

All conductors shall be designed in such a way that they satisfy the thermal loads which can be produced by the traction return current as well in normal operations and during short-circuits. For mechanical reasons conductors directly connected to rails shall have a minimum cross-section of 50 mm². For d.c. railways insulated conductors shall be used.

All earthing conductors and earthing electrodes, which are not connected to and not a part of the return circuit, shall be designed and constructed as required in HD 637 S1. This applies in particular to materials choice and to dimensioning, in consideration of mechanical strength, and thermal effects and corrosion.

In d.c. traction systems the thermal dimensioning of such conductors shall be based on the value of the expected prospective short-circuit current and the maximum time to clear it at the location.

Whenever a switching device is installed in the track return system, another switch shall be installed in the supply circuit, and the switching device shall be interlocked so that it cannot be opened before the supply switch is open. For trolleybuses see 5.6.3.2. For railway systems in which the traction current is confined within conductors insulated with respect to earth the same solution shall be used.

For d.c. railways see also EN 50122-2.

10.3.2 Continuity of the return circuit

Rail joints in running rails used for carrying traction return current shall be provided with rail joint bonds. This also applies to the components of crossings and points. In the case of high voltage a.c. traction systems, the tight joint fish-plates generally provide an adequate conducting bridge.

In the case of track circuits for which rail joint bonds are impossible for technical reasons, the traction return current shall, where necessary, be returned by means of impedance bonds.

At interruptions in tracks, for example at movable bridges or track weighbridges, conductors shall be arranged so as to ensure that the return circuit is continuous.

10.3.3 Cross bonding of the return circuit

Track-to-track cross bonding shall be provided at suitable intervals in order to ensure the continuity of the traction return current path and the proper distribution of the traction return currents, so that the touch voltages will not exceed the permissible levels, under both operating and fault conditions.

The specific arrangements for connections of track-to-track cross bonding shall take account of the track-circuiting arrangements in use and the overall traction power supply system design.

In areas without track circuits only, the running rails of each track shall be connected by rail-to-rail cross bonds, as required for electrical safety.

NOTE Steel sleepers or riveted or screwed rail tie bars between the running rails provide sufficient transverse connection if the running rails are fixed to them without any intermediate insulating layers.

10.3.4 Railway systems in which the traction current is confined within insulated conductors

If the running rails are not used by the traction return current in normal operation, at least one running rail of each track shall nevertheless be electrically continuous as in 10.3.1 to 10.3.3 in order to simplify the detection and localisation of earth faults on the contact lines.

10.4 Removing of decommissioned overhead contact lines

For a track which is permanently decommissioned, the overhead contact line and associated feeders shall be removed.

10.5 Means of achieving safe isolation between sections

10.5.1 Section insulators

If section insulators are used as isolating gaps in overhead contact lines to isolate feeding sections, the minimum clearance in air may be reduced compared with the requirements given in EN 50119 and EN 50124-1. A smaller clearance than the normal minimum clearance in air is allowable. The reduced clearances shall not be less than the dynamic electrical clearance defined in EN 50119.

NOTE Section insulators which are inserted in the contact wires have contact with the current collector. Therefore their mechanical design should comply with the current collection requirements of EN 50119. These requirements impose limits concerning the possible clearances between different live parts, between live parts and earthed parts and the size and the weight. Because of that, it is necessary to allow these smaller distances.

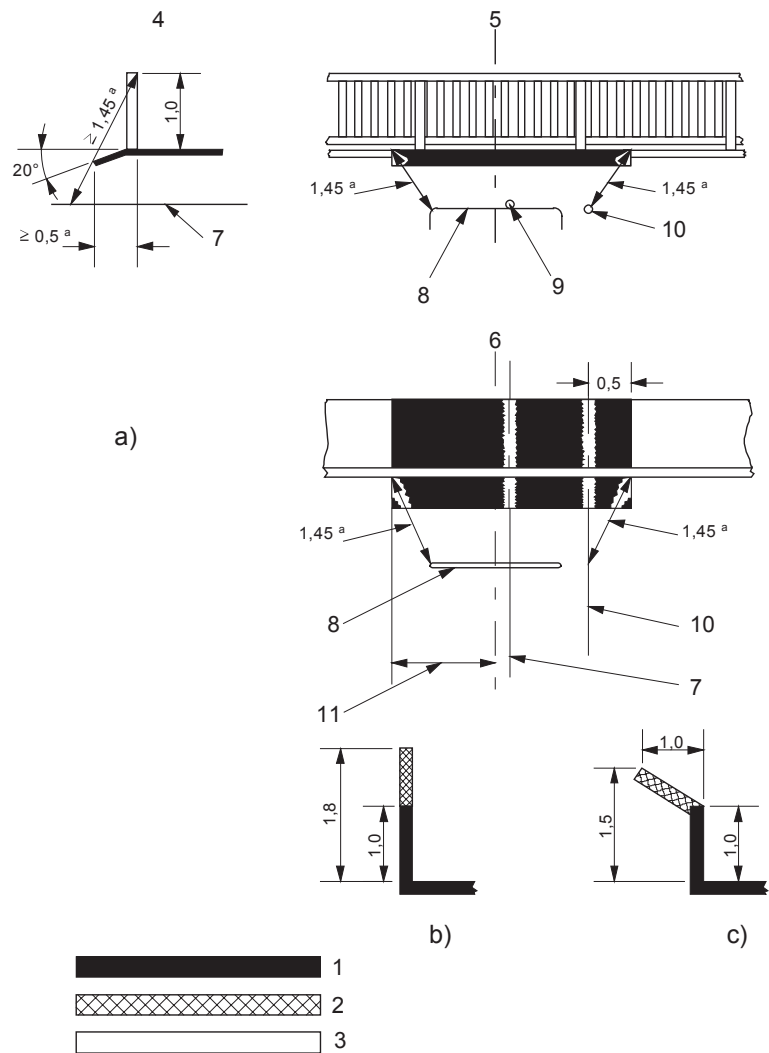
10.5.2 Isolating gaps

Isolating gaps between overhead contact line sections may be bridged by insulators without provisions against leakage currents if regulations impose that maintenance work shall be performed only on overhead contact line sections which are connected to the return circuit (running rails).

Annex A
(informative)

Typical obstacles

Dimensions in metres

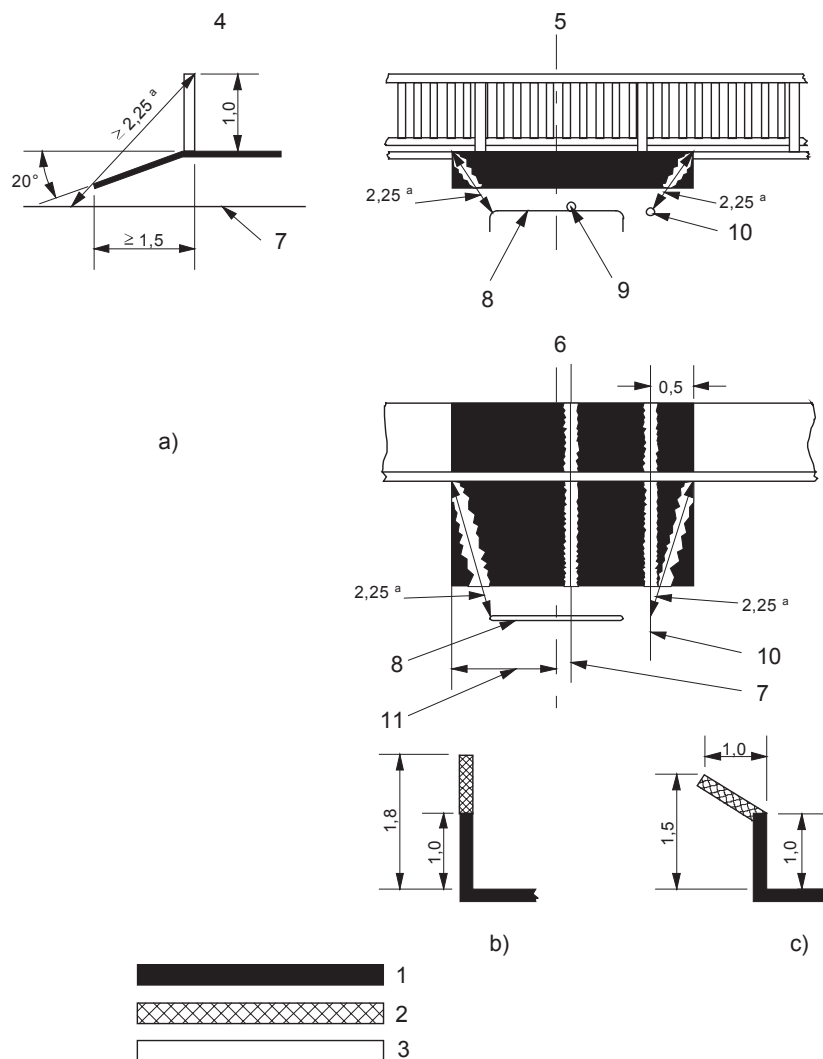


Key

- | | | | |
|---|--|----|--------------------------------------|
| 1 | solid-wall design or obstacle conforming to degree of protection IP3X as defined in EN 60529 | 6 | plan view |
| 2 | mesh screen with a maximum 1 200 mm ² mesh size (can also be solid-wall design) | 7 | contact wire catenary line Feeder |
| 3 | railing, mesh construction (can also be solid-wall design) | 8 | pantograph |
| 4 | side view | 9 | contact wire |
| 5 | front view | 10 | line feeder |
| | | 11 | half pantograph zone |
| | | a | the dimension is taken from Figure 3 |

Figure A.1 — Examples of obstacles along the sides of standing surfaces in public areas for protection against direct contact when above live parts on the outside of vehicles or live parts of an overhead contact line system for low voltages (see 5.3.2.2)

Dimensions in metres



Key

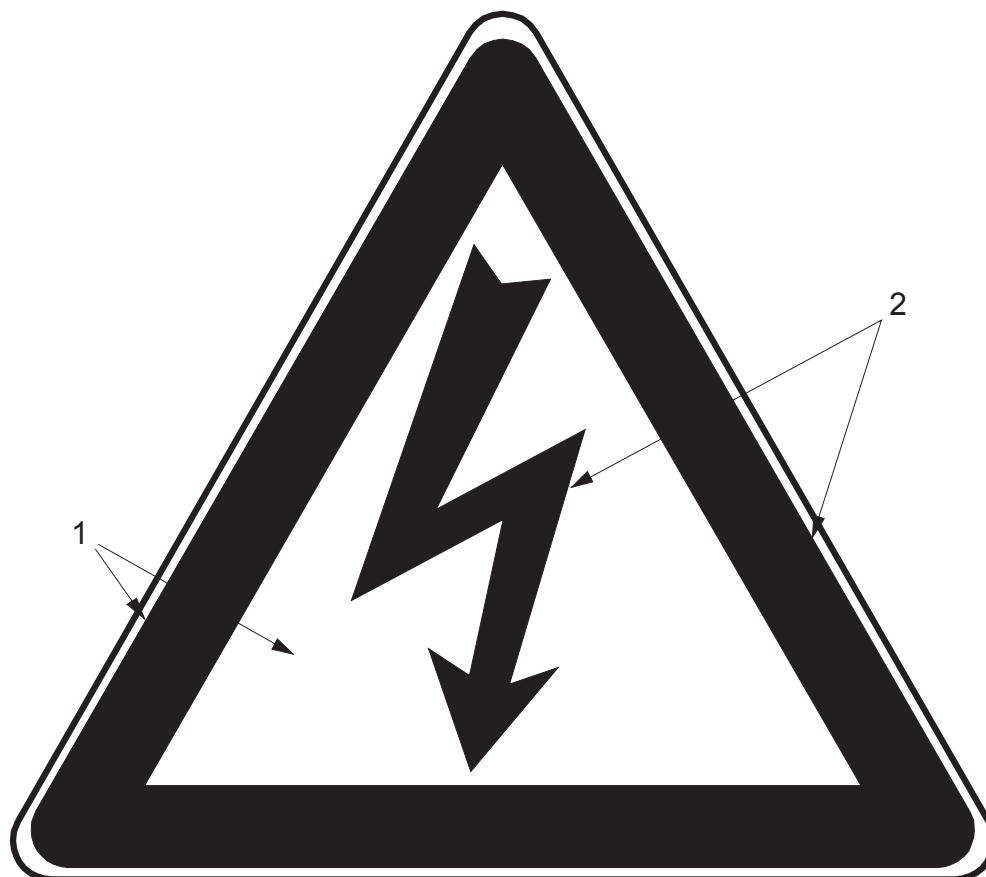
- | | | | |
|---|--|----|--------------------------------------|
| 1 | solid-wall design or obstacle conforming to degree of protection IP3X as defined in EN 60529 | 6 | plan view |
| 2 | mesh screen with a maximum 1 200 mm ² mesh size (can also be solid-wall design) | 7 | contact wire catenary line Feeder |
| 3 | railing, mesh construction (can also be solid-wall design) | 8 | pantograph |
| 4 | side view | 9 | contact wire |
| 5 | front view | 10 | line feeder |
| | | 11 | half pantograph zone |
| | | a | the dimension is taken from Figure 3 |

Figure A.2 — Examples of obstacles along the sides of standing surfaces in public areas for protection against direct contact when above live parts on the outside of vehicles or live parts of an overhead contact line system for high voltages (see 5.3.2.2)

Annex B (normative)

Warning sign

Figure B.1 shows the warning sign, the broken arrow, as given in ISO 3864-1:2002 and ISO 7010:2003 + A1:2006, which means "Caution, risk of electric shock".



Key

- 1 reflective yellow
- 2 black

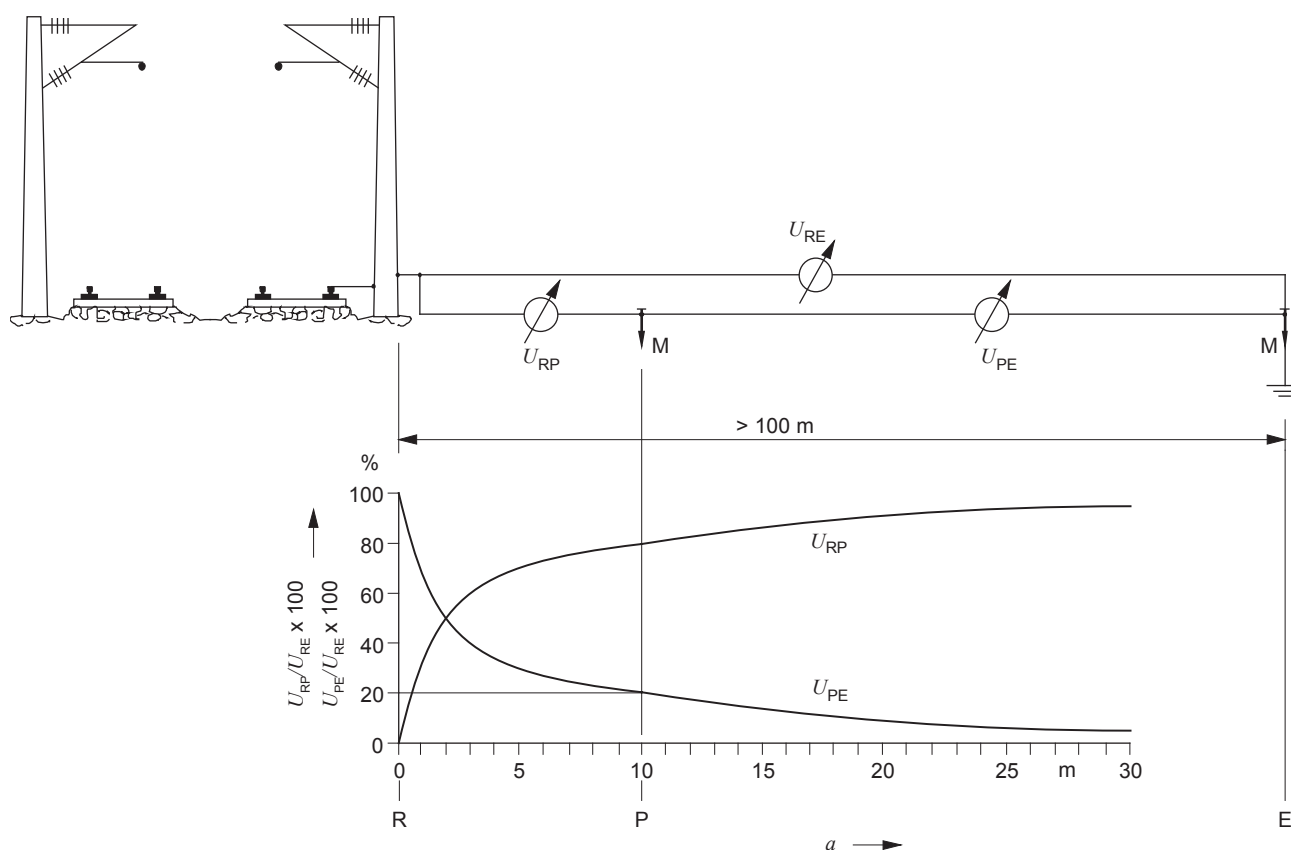
Figure B.1 — Warning sign

Annex C (informative)

Guiding values for rail potential gradient

C.1 A.C. traction systems

The value at which the rail potential for a.c. traction systems, given in 9.2 can act as a touch voltage should be investigated. Guiding values for the rail potential gradient measured at right angle away from the track of a.c. traction systems, where the running rails are directly earthed, are given in Figure C.1 and Table C.1 for homogenous soil resistivity.



Key

a	distance between running rail (mast) and measuring point
E	earth
M	measuring electrode
P	measuring point
R	rail
U_{RE}	rail potential
U_{RP}	voltage between running rail (mast) and measuring point
U_{PE}	voltage between measuring point and earth

Figure C.1 — Guidance values for the rail potential gradient measured at the mast in a right angle to the track in an a.c. traction system

Table C.1 — Guidance values for the rail potential gradient (see Figure C.1)

a m	$U_{PE}/U_{RE} \times 100$ %	$U_{RP}/U_{RE} \times 100$ %
1	70	30
2	50	50
5	30	70
10	20	80
20	10	90
50	5	95
100	0	100
Key a distance between running rail (mast) and measuring point U_{RE} rail potential U_{RP} voltage between running rail (mast) and measuring point U_{PE} voltage between measuring point and earth		

C.2 D.C. traction systems

Due to the fact that running rails are insulated with respect to soil, the rail voltage gradient can be very steep. Therefore the whole rail potential can act as a touch voltage.

Annex D (informative)

Effective touch voltage and body voltage with respect to the body current

D.1 Preconditions for the calculation

All voltages and currents in Annex D are r.m.s. values in accordance with IEC 60050-101-14-15.

The calculation of the values for the permissible effective touch voltage and body voltage in 9.2 and 9.3 are based on:

- IEC/TS 60479-1:2005;
- HD 637 S1.

Following assumptions are made:

- current path: one hand to both feet;
- body impedance for large surface areas of contact in dry conditions;
- 50 % probability of body impedance higher than assumed value;
- 0 % probability of ventricular fibrillation (see IEC/TS 60479-1:2005, curve c_1);
- additional resistance $R_a = 1\,000\ \Omega$ for old wet shoes for short-term conditions.

NOTE Proceeding on the assumption that in most cases there is an additional resistance to the total body resistance because of shoes and moreover that the probability of danger is very small within time intervals of less than 1 s, an additional resistance of $1\,000\ \Omega$, to the values of U_{c1} (curve c_1) is taken into account for the calculation of the effective touch voltage for short-term conditions. This value of old wet shoes corresponds to HD 637 S1.

The resistance of the standing surface, according to HD 637 S1, may be taken into account additionally at any time interval.

Regarding the risk of heart fibrillation the current path hand to hand is less restrictive than the current path hand to feet, even when an additional resistance of $1\,000\ \Omega$ is included for old wet shoes.

For the limit of let go in workshops hand to hand is the more restrictive current path considering the presence of shoes for employees (workers at site).

D.2 Impedances

D.2.1 Body impedance for a.c. and d.c. voltages

The total human body impedance at 50 % probability is indicated in IEC/TS 60479-1:2005, Table 1, relating hand to hand current path. By applying the reduction factor $r = 0,75$ (IEC/TS 60479-1:2005, Figure 3) for the hand to feet current path, Table D.1 is obtained.

Table D.1 — Body impedance Z_b and body current I_b

	a.c. system $r = 0,75$			d.c. system $r = 0,75$		
U_b V	$Z_b(100)$ Ω	$Z_b(75)$ Ω	$I_b(75)$ mA	$R_b(100)$ Ω	$R_b(75)$ Ω	$I_b(75)$ mA
25	3 250	2 438	10	3 875	2 906	9
50	2 500	1 875	27	2 900	2 175	23
75	2 000	1 500	50	2 275	1 706	44
100	1 725	1 294	77	1 900	1 425	70
125	1 550	1 163	108	1 675	1 256	100
150	1 400	1 050	143	1 475	1 106	136
175	1 325	994	176	1 350	1 013	173
200	1 275	956	209	1 275	956	209
225	1 225	919	245	1 225	919	245
400	950	713	561	950	713	561
500	850	638	784	850	638	784
700	775	581	1 204	775	581	1 204
1 000	775	581	1 720	775	581	1 720

Key

$I_b(75) = U_b/Z_b(75) \times 10^3$ or $I_b(75) = U_b/R_b(75) \times 10^3$ body current in milliamperes

U_b body voltage

$I_b(75)$ body current relating to $Z_b(75)$

$Z_b(100)$ total body impedance

$Z_b(75)$ 75 % of the total body impedance

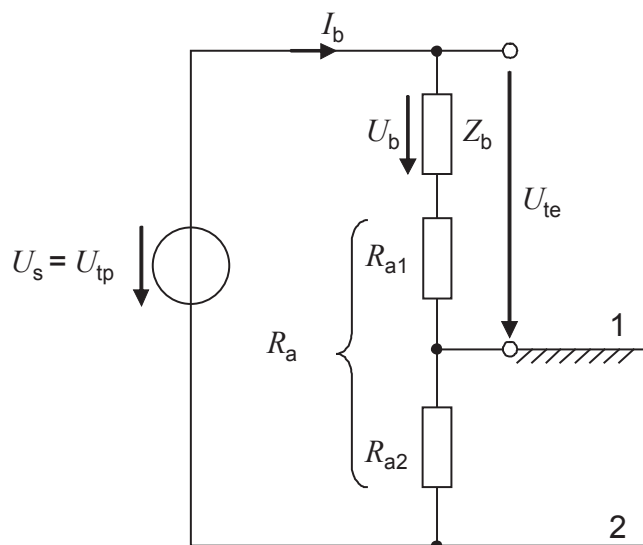
$R_b(100)$ total body resistance

$R_b(75)$ 75 % of the total body resistance

r reduction factor

D.2.2 Additional resistances

Taking into account additional resistances, leads to Figure D.1.



Key

1 standing surface

2 earth

U_s source voltage

U_{tp} prospective touch voltage

U_{te} effective touch voltage

U_b body voltage

I_b body current

Z_b total body impedance

R_{a1} additional resistance for shoes

R_{a2} additional resistance of standing surface

$$R_{a2} = \rho_s \times 1,5 \text{ m}^{-1}$$

ρ_s soil resistivity at the standing surface in ohm metres (Ωm)

$$U_{tp, \max}(t) = U_{te, \max}(t) + I_b(t) \times R_{a2}$$

Figure D.1 — Equivalent circuit for the calculation of the permissible touch voltage

In case of a.c. railway lines, U_{tp} corresponds to U_{RP} of Figure C.1.

Table D.2 provides an example for $R_{a2} = 150 \Omega$ of the standing surface and $R_{a1} = 1\,000 \Omega$ for old wet shoes and short-term conditions.

Table D.2 — Example of the maximum permissible prospective touch voltage for a.c. railways
for short-term conditions and $R_a = 1\,150\ \Omega$

t s	$U_{tp, \max}$ V
0,7	165
0,6	190
0,5	235
0,4	320
0,3	520
0,2	695
0,1	850
0,05	905
0,02	940
Key t time duration $U_{tp, \max}$ maximum permissible prospective touch voltage	

D.3 Body current and related body voltage

D.3.1 General

The values in Table D.3 and Table D.4 are based on:

- current versus time curve c_1 shown in IEC/TS 60479-1:2005;
- body voltage $U_b = f(I_b)$ obtained from the values in Table D.1.

D.3.2 A.C. traction systems

Table D.3 — Body currents, body voltages and touch voltages as function of time duration in a.c. traction systems

t s	I_{c1} mA	U_{c1} V	$U_{b, \max}$ V	$U_{te, \max}$ long-term V	$U_{te, \max}$ short-term V
> 300	37	62	60	60	-
300	38	64	65	65	-
1,0	50	75	75	75	-
0,9	52	77	80	80	-
0,8	58	83	85	85	-
0,7	66	91	90	90	-
< 0,7	66	91	90	-	155
0,6	78	101	100	-	180
0,5	100	119	120	-	220
0,4	145	152	155	-	295
0,3	252	230	230	-	480
0,2	350	293	295	-	645
0,1	440	343	345	-	785
0,05	475	361	360	-	835
0,02	495	370	370	-	865

NOTE Columns t and I_{c1} are applied from IEC/TS 60479-1. Column U_{c1} is a result of iterative calculations with column I_{c1} and Table D.1. Column $U_{b, \max}$ is gained by good experience and differs slightly from the calculated ones from U_{c1} . Column $U_{te, \max}$ short-term indicates the relevant touch voltages for short-term conditions considering an additional resistance for old wet shoes. Column $U_{te, \max}$ long-term indicates the relevant touch voltages for long-term conditions.

Key

$$U_{te, \max} = U_{c1} + R_{a1} \times I_{c1} \times 10^{-3} \text{ (short-term)}$$

t time duration of current flow

I_{c1} body current which corresponds to curve c_1 in IEC/TS 60479-1:2005

R_{a1} resistance for old wet shoes ($R_{a1} = 1\,000\ \Omega$)

U_{c1} body voltage, corresponds to I_{c1}

$U_{b, \max}$ maximum body voltage

$U_{te, \max}$ maximum permissible effective touch voltage

D.3.3 D.C. traction systems

Table D.4 — Body currents, body voltages and touch voltages as function of time duration in d.c. traction systems

t s	I_{c1} mA	U_{c1} V	$U_{b, \max}$ V	$U_{te, \max}$ long-term V	$U_{te, \max}$ short-term V
> 300	140	153	120	120	-
300	140	153	150	150	-
1,0	150	160	160	160	-
0,9	160	167	165	165	-
0,8	165	170	170	170	-
0,7	175	177	175	175	-
< 0,7	175	177	175	-	350
0,6	180	180	180	-	360
0,5	195	191	190	-	385
0,4	215	204	205	-	420
0,3	240	222	220	-	460
0,2	275	246	245	-	520
0,1	340	287	285	-	625
0,05	410	327	325	-	735
0,02	500	372	370	-	870

NOTE Columns t and I_{c1} are applied from IEC/TS 60479-1. Column U_{c1} is a result of iterative calculations with column I_{c1} and Table D.1. Column $U_{b, \max}$ is gained by good experience and differs slightly from the calculated ones from U_{c1} . Column $U_{te, \max}$ short-term indicates the relevant touch voltages for short-term conditions considering an additional resistance for old wet shoes. Column $U_{te, \max}$ long-term indicates the relevant touch voltages for long-term conditions.

Key

$$U_{te, \max} = U_{c1} + R_{a1} \times I_{c1} \times 10^{-3} \text{ (short-term)}$$

t time duration of current flow

I_{c1} body current which corresponds to curve c_1 in IEC/TS 60479-1:2005

R_{a1} resistance for old wet shoes ($R_{a1} = 1\,000\ \Omega$)

U_{c1} body voltage, corresponds to I_{c1}

$U_{te, \max}$ permissible effective touch voltage

Annex E (normative)

Measurement methods for effective touch voltages

The measurement of the effective touch voltage shall be carried out as follows:

The effective touch voltage shall be measured over a resistance which corresponds to the human body resistance Z_b and to the additional resistance R_{a1} , see Figure D.1. It shall be at least:

- $Z_b + R_{a1} = 1\,000\ \Omega + 1\,000\ \Omega = 2\,000\ \Omega$ for short-term conditions;
- $Z_b + R_{a1} = 2\,200\ \Omega + 0\ \Omega = 2\,200\ \Omega$ for long-term conditions;

NOTE 1 For practical applications a value of 2 200 Ω may be used for all conditions.

The measuring electrode, for the simulation of feet, shall have a total area of 400 cm² and shall be pressed to the earth with a minimum force of 500 N. Alternatively, a measuring electrode with 2 cm diameter and 30 cm length may be used. This corresponds to an earth electrode with 2,2 $\Omega/\Omega\text{m}$.

To measure the effective touch voltage for concrete or dried up soil a wet cloth or water film shall be placed between the foot electrodes and earth. The foot electrodes shall be placed at a distance not less than 1 m from the exposed conductive part.

A measuring electrode, e.g. a tip electrode, shall be used for simulation of a hand. In this case paint coatings (but not insulation) shall be pierced reliably.

One clamp of the voltmeter shall be connected to the hand-electrode, the other clamp shall be connected to the feet electrode. It is sufficient to carry out such measurements by random checks of an installation.

NOTE 2 The effective touch voltage is always lower than the prospective touch voltage. Therefore a simple assessment is possible by using a simple measurement of the prospective touch voltage by a voltmeter with a high internal resistance and an appropriate earth electrode.

At measuring points where the resistance to earth of the measuring electrode for the simulation of feet does not exceed several hundred ohms, a measurement with and without parallel resistance is recommended. The resistance represents the human body resistance Z_b and to the additional resistance R_{a1} . If the voltage breaks down when using the parallel resistance, it can be concluded that effective touch voltage is considerably lower than the prospective touch voltage, e.g. the rail potential.

Annex F (normative)

The use of voltage-limiting devices

F.1 General

A voltage-limiting device (VLD) has a high resistance when the applied voltage is less than a specified level and becomes conductive, when the specified level is exceeded. It can remain as non permanent or permanent connection when the voltage decreases below the specified value.

F.2 Types

VLDs protect against impermissible touch voltages in case of faults and in case of operation. The requirements are fulfilled by VLD-F or VLD-O types, where also one device can fulfill both requirements.

Type 1 (VLD-F):

- For the case of a fault with a connection between a live part of the traction power supply system and a conductive part not intentionally bonded to the return circuit, the VLD-F protects against an impermissible touch voltage by becoming conductive and causing tripping of the power supply. The VLD-F is normally connected between the part to be protected and the return circuit.

NOTE This includes:

- objects in overhead contact line zone or current collector zone, which can be hit by wire or dewired current collector;
- mast, which can become live due to insulation failure.

Type 2 (VLD-O):

- The VLD-O protects against impermissible voltage caused by rail potential in case of Operation and short-circuits. In case of short-circuits the current path is identical to the operational one. The VLD-O acts as an equipotential bonding device and thus limits the possible touch voltage. Only a part of the return current flows through it. The permissible touch voltage according to 9.2 and 9.3 shall not be exceeded. Tripping of the line circuit breakers caused by the VLD-O is not intended. The VLD-O is normally connected between the return circuit and structure earth, e.g. in passenger stations or substations.

F.3 Technical requirements

Each VLD shall be able to conduct the levels of current which will flow in it.

A VLD shall not open unless the levels of current flowing in it are lower than the levels which the device can interrupt safely.

The VLD shall be reset automatically or renewed before significant damage like e.g. stray current corrosion is caused by the current which flows through it.

If the VLD has operated and is not reset automatically a procedure or systems shall be put in place to note and rectify the cause of such event rapidly.

NOTE 1 For some kinds of systems a closed VLD can be reset automatically after a defined time considering acceleration times and auto reclose cycles of protection.

NOTE 2 A guide value for the maximum reset time of VLD-O is 60 s, which may be adapted on the typical traffic circumstances.

If maintenance for VLDs is required, then their electrical connections shall be arranged so that it is possible to bypass the VLD in order to protect the workers against hazards of touch voltages or arcing.

Annex G (normative)

Special national conditions

Special national condition: National characteristic or practice which cannot be changed even over a long period, e.g. climatic conditions, electrical earthing conditions. If it affects harmonization, it forms part of this European Standard or Harmonization Document.

For the countries in which the relevant special national conditions apply these provisions are normative, for other countries they are informative.

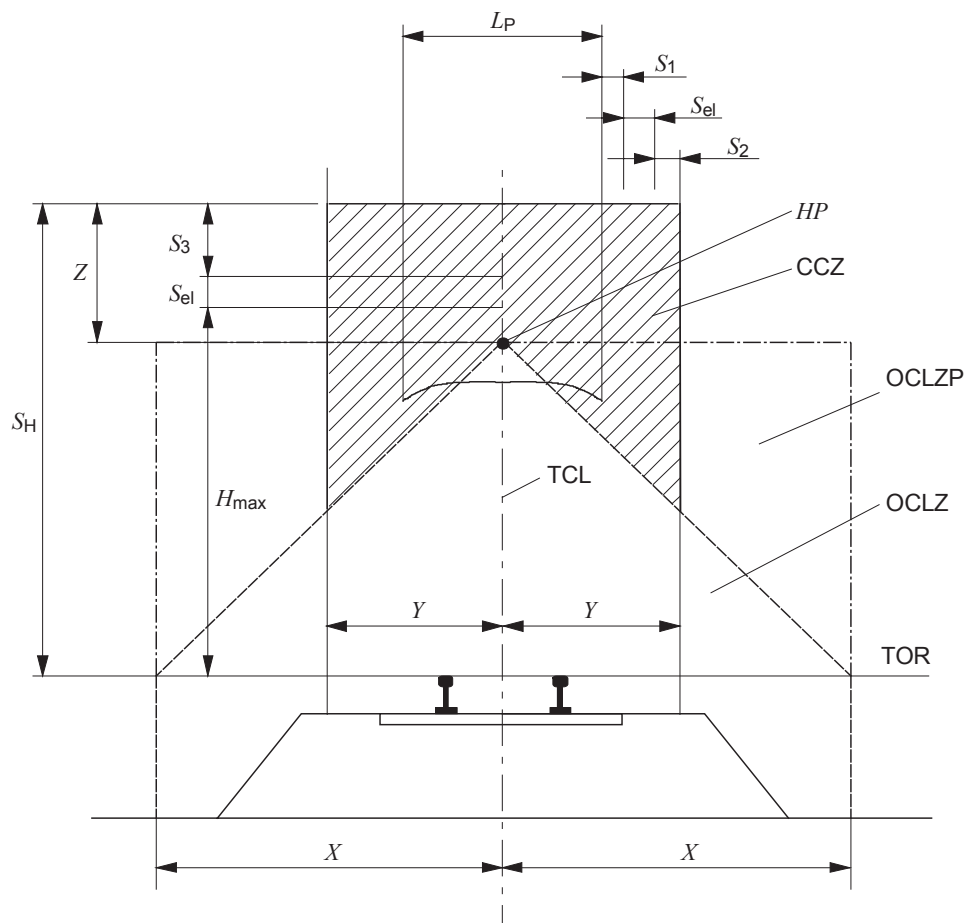
Clause Special National Conditions

4.1 Denmark

In Denmark the parameters X , Y and Z , which define the dimensions of the overhead contact line and current collector zones according to 4.1, Figure 1, are set to be the following:

- $X = 5,0$ m;
- $Y = 2,5$ m;
- $Z = 2,5$ m.

Furthermore, the overhead contact line zone is expanded at platforms, workshops and similar locations as shown in the figure below.



Key

OCLZP overhead contact line zone at platforms, workshops and similar locations

4.1 France

The overhead contact line and current collector zone according to 4.1, Figure 1 has to be defined by the infrastructure owner.

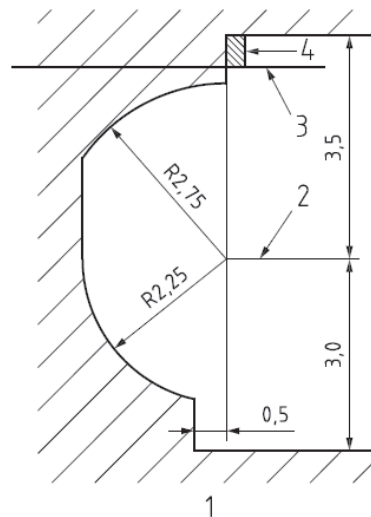
In absence of such a definition the following values shall be applied:

- $X = 4,0 \text{ m}$;
- $Y = 2,0 \text{ m}$;
- $Z = 2,0 \text{ m}$ in the limit of $SH = 8,0 \text{ m}$.

5.2.1 United Kingdom

The public area clearances shown in Figure 4 shall be replaced by the arrangements shown in the figure below. In addition, in cases of special difficulty up to half the earthed end of an insulator may extend over the standing surface, subject to a maximum horizontal incursion of 300 mm. In this case the vertical position of the insulator shall be no lower than the contact wire height at the location under consideration.

NOTE The revised clearance is due to restricted infrastructure clearances. In order to comply with the public area dimension in Figure 4 it would be necessary to change a large number of civil engineering structures, at a very high cost.



Key

- 1 public areas
- 2 standing surface
- 3 contact wire height
- 4 support insulator incursion space

Annex H (normative)

A-deviations

Clause

AC₁ text deleted **AC₁**

9.2 Switzerland

In Switzerland the maximum permissible touch voltage for a.c. railway systems given in Table 4 shall be replaced by the ones defined in the Regulation SR 734.2 (Directive on the Electrical Power Installations) Articles 54 and 55.

9.3 Switzerland

In Switzerland the maximum permissible touch voltage for d.c. railway systems given in Table 6 shall be replaced by the ones defined in the Regulation SR 734.2 (Directive on the Electrical Power Installations) Articles 54 and 55.

Annex ZZ (informative)

Coverage of Essential Requirements of EC Directives

This European Standard has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association and within its scope the standard covers all relevant essential requirements as given in Annex III of the EC Directive 96/48/EC (HSR), in Annex III of the EC Directive 2001/16/EC (CONRAIL) and in Annex III of the EC Directive 2008/57/EC (RAIL).

Compliance with this standard provides one means of conformity with the specified essential requirements of the Directive(s) concerned.

WARNING: Other requirements and other EC Directives may be applicable to the products falling within the scope of this standard.

Bibliography

EN 50122-3, *Railway applications – Fixed installations – Electrical safety, earthing and the return circuit – Part 3: Mutual interaction of a.c. and d.c. traction systems*

EN 50388:2008, *Railway applications – Power supply and rolling stock – Technical criteria for the coordination between power supply (substation) and rolling stock to achieve interoperability*

EN 60664-1:2007, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests (IEC 60664-1:2007)*

EN 60721 (all parts), *Classification of environmental conditions (IEC 60721 series)*

EN 61219, *Live working – Earthing or earthing and short-circuiting equipment using lances as short-circuiting device – Lance earthing (IEC 61219)*

EN 61558-2-6, *Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V – Part 2-6: Particular requirements and tests for safety isolating transformers and power supply units incorporating safety isolating transformers (IEC 61558-2-6)*

IEC 60050-551, *International Electrotechnical Vocabulary – Chapter 551: Power electronics*

IEC 60364-1, *Low-voltage electrical installations – Part 1: Fundamental principles, assessment of general characteristics, definitions*

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