BS EN 50153:2014

BSI Standards Publication

Railway applications — Rolling stock — Protective provisions relating to electrical hazards

bsi.

...making excellence a habit.™

National foreword

This British Standard is the UK implementation of EN 50153:2014. It supersedes BS EN 50153:2002 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee GEL/9/2, Railway Electrotechnical Applications - Rolling stock.

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

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

ISBN 978 0 580 73001 6

ICS 45.060.10; 45.060.20

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 May 2014.

Amendments issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 50153

May 2014

ICS 45.060.01

Supersedes EN 50153:2002

English Version

Railway applications - Rolling stock - Protective provisions relating to electrical hazards

Applications ferroviaires - Matériel roulant - Mesures de protection vis-à-vis des dangers d'origine électrique

Bahnanwendungen - Fahrzeuge - Schutzmaßnahmen in Bezug auf elektrische Gefahren

This European Standard was approved by CENELEC on 2014-03-10. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

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

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN 50153:2014 E

Contents

Figure

Tables

Foreword

This document (EN 50513:2014) has been prepared by CLC/SC 9XB "Electromechanical material on board rolling stock" from CLC/TC 9X "Electrical and electronic applications for railways".

The following dates are fixed:

• latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2015-03-10
• latest date by which the national standards conflicting with this document have to be withdrawn	(dow)	2017-03-10

This document supersedes EN 50153:2002.

EN 50153:2013 includes the following significant technical changes with respect to EN 50153:2002:

– the document now takes into account EN 50122-1:2011 and UIC leaflet 533:2011;

– other normative references and some definitions have been updated;

– Annex D has been added, Annex C has been changed.

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

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

Introduction

It is generally accepted that safety depends on human factors, based on the normal behaviour of the operators involved, as well as upon technical factors.

For these reasons, this European Standard, in several instances, leaves a choice to the contracting parties between two alternatives. These alternatives consist of either the provision of operating rules, regulations and procedures, or in the application of technical measures such as mechanical or electrical interlocking devices.

A list of the cases for which the contracting parties (e.g. user and manufacturer) should reach agreement before signing the contract is included in Annex B.

1 Scope

This European Standard defines requirements to be applied in the design and manufacture of electrical installations and equipment to be used on rolling stock to protect persons from electric shocks.

This European Standard is applicable to rolling stock of rail transport systems, road transport systems, if they are powered by an external supply (e.g. trolley buses), magnetically levitated transport systems and to the electrical equipment installed in these systems.

This European Standard does not apply to:

– mine railways in mines,

– crane installations, moving platforms and similar transport systems on rails,

– funicular railways,

– temporary constructions.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 50122-1:2011[1)], *Railway applications — Fixed installations — Electrical safety, earthing and the return circuit — Part 1: Protective provisions against electric shock*

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

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

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

EN 60529, *Degrees of protection provided by enclosures (IP Code) (IEC 60529)*

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

EN 61310-1, *Safety of machinery — Indication, marking and actuation — Part 1: Requirements for visual, acoustic and tactile signals (IEC 61310-1)*

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

1) This document is currently impacted by the amendment EN 50122-1:2011/A1:2011.

3 Terms, definitions and abbreviations

3.1 Terms and definitions

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

NOTE For more information relating to definitions of parts of the fixed installations, see EN 50122-1 from which these definitions are derived.

3.1.1 Definitions concerning persons

3.1.1.1
(electrically) instructed person
person adequately advised or supervised by electrically skilled persons to enable them to perceive risks and to avoid hazards electricity can create

3.1.1.2
ordinary person
person who is neither a skilled person nor an (electrically) instructed person

3.1.1.3
skilled person
person who can judge the work assigned to him and recognize possible dangers on the basis of their professional training, knowledge and experience and of their knowledge of the relevant requirements

3.1.2 Other definitions

3.1.2.1
closed electrical operating area
room or location which serves exclusively for the operation of electrical equipment and is kept secure by a means appropriate to the voltage and location

Note 1 to entry: Access to such areas is permitted only to skilled persons and (electrically) instructed persons.

Note 2 to entry: The definition of closed electrical operating area can be suitable for underfloor or upperroof cabinets. Generally speaking, it is any location (inside or outside the car body) which is kept secured because of the voltage that can assumed to be present on the equipment inside it. Access to such areas is not allowed for ordinary persons.

3.1.2.2
contact line
conductor system for supplying electrical energy to rolling stock systems through current-collecting equipment

3.1.2.3
contact wire
electric conductor of an overhead contact line with which the current collectors make contact

3.1.2.4
cut-off
supply of electrical energy to live parts is switched off

3.1.2.5
direct contact
contact of persons or livestock with live parts

3.1.2.6
double insulation
insulation comprising both basic insulation and supplementary insulation

3.1.2.7
earth
conductive mass of the earth, whose electrical potential at any point is conventionally taken as equal to zero

3.1.2.8
electrical operating area
room or location which serves primarily for the operation of electrical equipment and is normally entered only by skilled persons or (electrically) instructed persons

Note 1 to entry: Generally speaking, an electrical operating area is any location (mainly inside the car body) where electrical equipments operate. The above is the main function of this area but not the only one. In fact, normally the area is not kept secured and protection against direct contact is achieved by other means (e.g. (electrically) protective obstacles).

3.1.2.9
electric shock
pathophysiological effect resulting from an electric current passing through a human or animal body

3.1.2.10
equipotential bond
electrical connection putting various exposed conductive parts at a substantially equal potential

Note 1 to entry: This can be abbreviated to ‘bond’ or ‘bonding’.

3.1.2.11
exposed conductive part
conductive part of electrical equipment, which can be touched and which is not normally live, but can become live when basic insulation fails

Note 1 to entry: 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.

3.1.2.12
indirect contact
electric contact of persons or livestock with exposed conductive parts which have become live under fault conditions

3.1.2.13
interlocking device
device which makes the operation of a switching device dependent upon the position or operation of one or more other pieces of equipment

3.1.2.14
interlock system
system incorporating interlocking devices on access points to electrical equipment to prevent energisation of accessible live parts

3.1.2.15
insulation/insulated
supply of electrical energy to live parts is switched off and inadvertent reconnection prevented

3.1.2.16
live part
conductor or conductive part intended to be energized in normal use

Note 1 to entry: By convention this does not include the running rails and parts connected to them.

3.1.2.17
locking system
system which comprises interlocking devices and physically prevents access to live parts unless the supply of electrical energy to the live parts has been isolated and made safe

3.1.2.18
mechanical locking
use of a lock or bolted /screwed fixings to prevent access panels or doors being opened and require the use of a key or tool to remove

3.1.2.19
multi-stage insulation
insulation which is employed in, e.g., roof or underframe-mounted traction resistors which are air-insulated

3.1.2.20
nominal voltage
voltage by which an installation or part of an installation is designated

Note 1 to entry: The voltages are expressed by the value between poles, ripple-free for DC and by the r.m.s. value between phases for AC.

Note 2 to entry: The actual voltage may differ from the nominal voltage by a quantity within permitted tolerances. For further information about traction systems supply voltages, see EN 50163.

3.1.2.21
PELV system
electric system in which the voltage cannot exceed the value of extra-low voltage:
– under normal conditions and
– under single fault conditions, except earth faults in other electric circuits

3.1.2.22
(electrically) protective obstacle
part preventing unintentional direct contact, but not preventing direct contact by deliberate action

3.1.2.23
power circuit
circuit carrying the current of the machines and equipment, such as convertors and traction motors, which transmit the traction output

3.1.2.24
protection system
means of ensuring safety against electrical hazards by means of system design as opposed to reliance on procedures

3.1.2.25
protective conductor
conductor provided for purposes of safety, for example protection against electric shock

3.1.2.26
protective-equipotential-bonding
equipotential bonding for the purposes of safety

3.1.2.27
SELV system
electric system in which the voltage cannot exceed the value of extra-low voltage:

– under normal conditions and

– under single fault conditions, including earth faults in other electric circuits

3.1.2.28
unit
<articulated> minimum operational formation of articulated cars

<non-articulated> minimum operational formation comprising one or more vehicles coupled together

3.2 Abbreviations

For the purposes of this document, the following abbreviations apply.

AC Alternating Current

DC Direct Current

SELV Safety Extra Low Voltage

PELV Protective Extra Low Voltage

r.m.s. root-mean-square value (effective value)

4 Classification of voltage bands

4.1 General principles

In this European Standard, the applicable protective measures are based on the highest value of the nominal supply voltage which the equipment or the electrical circuits are subjected to.

The voltages are classified into bands according to the nominal value as shown in Table 1. Different rules apply to each of these bands.

The power supply of the various circuits installed in railway rolling stock are of different types such as:

– batteries,

– transformers,

– voltage dividers,

– rotating machines,

– static converters,

– capacitors,

– special sources.

Table 1 – Voltage bands

Band	Nominal voltage U_n	
	AC V	**DC** V
I	$U \leq 25$	$U \leq 60$
II	$25 < U \leq 50$	$60 < U \leq 120$
III	$50 < U \leq 1\,000$	$120 < U \leq 1\,500$
IV	$U > 1\,000$	$U > 1\,500$

4.2 Connections between circuits

Circuits operating at different nominal voltages connected by power conversion equipment which provides a sufficient insulation between them are individually classified at the nominal voltage of each circuit.

If the conducting paths referred to in this subclause include capacitive or inductive connections, whose impedance is low enough to induce hazardous voltages into any circuit under either normal or fault conditions, then all the circuits so connected are classified at the nominal voltage of the highest voltage circuit.

NOTE This condition can apply to circuits connected, for example, by means of a chopper converter with impedance coupling.

Where circuits are linked conductively to a higher voltage source other than directly by circuit bonds connected to the vehicle body (for example by an auto-transformer or potential divider), all circuits in the group are treated as if energized at the nominal voltage of the source, unless the conditions of 4.3 have been met.

4.3 Exceptions

If voltage conversion from one band to another involves overvoltage detection resulting in disconnection of the primary or the secondary circuit, or having other means capable of preventing excessive voltage in the secondary circuit, then the secondary circuit is permitted to be classified according to the highest voltage at which the detection equipment will operate. Where overvoltage detection is used the integrity of the equipment should be evaluated as appropriate.

Circuits not connected to the vehicle body, for example floating supplies, are permitted to be classified in any voltage band. The band selected should be appropriate, taking due account of the various potentials possible in such circuits under normal or fault conditions so as to ensure that the requirements of this European Standard are met.

The limit between bands III and IV is allowed to be lowered to take account of special national conditions.

NOTE The special national conditions are listed in Annex A.

5 Protective provisions against direct contact

5.1 General

Live parts capable of causing an electric shock shall be protected against direct contact. All types of equipment shall be capable of being operated without loss of protection against direct contact. Protection against direct contact shall be provided, where possible, by at least one of the means described in 5.2 to 5.3.

Where it is not possible to provide protective provisions in accordance with 5.2 or 5.3, then it is permitted to use protection by the use of band I voltage in accordance with the conditions of 5.4.

Additionally where required to ensure adequate protection against direct contact, warning labels as described in 5.5 shall be provided.

5.2 Protection by insulation

In addition to the requirements of EN 50124-1, the insulating materials used to cover live parts shall be appropriate to the rated equipment operating voltage and the conditions of use. Further provisions should be considered in order to minimize the consequences of damage.

5.3 Protection by prevention of access

5.3.1 Voltages in bands I to III

5.3.1.1 Protection by the use of closed electrical operating areas

Live parts within the vehicle, energized with voltages in bands I to III shall be contained within closed electrical operating areas.

Access to closed electrical operating areas containing energized live parts is permitted as follows:

– band I and II: access is permitted to (electrically) instructed persons and skilled persons;

– band III: access is only permitted to (electrically) instructed persons and skilled persons provided that precautions against unintended direct contact are taken.

Prevention of access shall be achieved by mechanical locking supported with procedures and warning labels appropriate to the location and equipment enclosed.

Means of preventing access shall comply with the following:

- in areas within vehicles, accessible to ordinary persons, screens and covers shall conform to the degree of protection IP4X according to EN 60529, or, where these are electrically connected to the vehicle body, to the degree of protection IP2XD according to EN 60529; the requirements of this subclause do not apply to plug connectors, lamp holders without lamps and fuse sockets for screw-in type fuses without inserts;

- in other areas where grid or mesh screens are used, these shall be placed at a sufficient distance to prevent any direct contact, taking into account possible buckling or warping.

5.3.1.2 Protection by the use of electrical operating areas

For live parts contained within an electrical operating area the following shall apply:

– Live parts energized within bands I and II need no protection against direct contact provided that the requirements of 8.5.2 are met.

– The use of (electrically) protective obstacles to afford a limited protection against direct contact with live parts at band III voltages may be acceptable in electrical operating areas inaccessible to ordinary persons by their location (such as underframe cases, roofs, interiors of motor units, excluding driver's cabs), provided that the hazard is readily identifiable. For example, it is acceptable for fuses and isolating links of equipment at band III voltages, whose grips are protected with an insulating material, not to be protected. Such components shall only be situated in electrical operating areas.

5.3.1.3 Protection by clearance

For live parts on the outside of the vehicle (e.g. current collectors, roof conductors, resistors) which are potentially accessible to persons in a straight line from any standing surface in, on or by vehicles, protection against direct contact by means of clearance shall be provided if no other protective measures as defined in this European Standard are used.

NOTE 1 Accessible in a straight line implies that live parts can be touched from a standing surface without use of specially shaped objects.

Protection by clearance is considered to be provided, if at least the clearances from standing surfaces to live parts depicted in EN 50122-1:2011, Figure 3, are maintained, excepting the condition of shoe gear adjacent to the platform edge as detailed in 8.2.2.

This protection is considered to be present, if contact with live parts is possible but clearance is afforded in case of the movement of the vehicle (e.g. on road and foot-crossings). Where only (electrically) instructed persons and skilled persons have access and where operation of the system makes protection by clearance impossible (e.g. systems using third and/or third and fourth rail power supplies) protection shall be afforded by procedure.

NOTE 2 Co-operation is required with the Infrastructure Manager in order to comply with this subclause.

5.3.1.4 Protection against hazards from power supply bus line

Access to live parts that may be energized with voltage band III when the supply system is likely to be energized from an external source (e.g. another vehicle, preheating equipment, shed supply, etc.) shall be prevented by an interlocking device or a procedure.

Connectors in the power supply bus line shall be fitted with warning labels in accordance with 5.5.

5.3.2 Voltages in band IV

5.3.2.1 Protection by the use of closed electrical operating areas

Access to live parts energized with voltages in band IV shall be excluded to all persons including skilled persons.

Access to live parts normally energized with voltages in band IV shall only be possible to (electrically) instructed persons and skilled persons after the live parts have been de-energized and made safe by one or more of the following methods:

– procedure;

– interlocking devices;

– protective-equipotential-bonding;

– safety or monitoring devices.

Means of preventing access and making safe live parts shall comply with the following:

- covers in areas accessible to ordinary persons in vehicles shall conform to the degree of protection IP4X according to EN 60529; areas accessible to instructed persons and skilled persons shall conform to the degree of protection IP2X according to EN 60529;
- protection of equipment requiring infrequent intervention may consist of screwed or bolted panels. It shall only be possible to remove these panels by use of a tool;
- for equipment requiring frequent intervention, a locking system shall be provided to ensure that live parts become accessible only after the electrical supply to the live parts has been isolated and the live parts have been made safe by protective bonding. The locking system shall allow tests to be performed on vehicle control equipment;
- In cases where band III voltages are not eliminated after band IV live parts have been de-energized, the precautions of 5.3.1 shall be taken to prevent direct contact with live parts which remain energized with voltages in band III.

5.3.2.2 Protection by clearance

For live parts on the outside of the vehicle (e.g. current collectors, roof conductors, resistors), which are potentially accessible to persons in a straight line from any standing surface in, on or by vehicles, protection against direct contact by means of clearance shall be provided, excepting for the pantograph head, if no other protective measures as defined in this European Standard are used.

NOTE Accessible in a straight line implies that live parts can be touched from a standing surface without use of specially shaped objects.

Protection by clearance is considered to be provided, if at least the clearances from standing surfaces to live parts depicted in EN 50122-1:2011, Figure 4, are maintained, excepting the condition of shoe gear adjacent to the platform edge as detailed in 8.2.2.

5.3.2.3 Protection against hazards from power supply bus line

Access to live parts when the supply system is likely to be energized from an external source via a power supply bus line (e.g. another vehicle, preheating equipment, shed supply, etc.) shall be prevented by an interlocking device or procedure.

For equipment requiring frequent intervention, such as electric train supply jumpers, interlocking devices or procedures shall be provided to ensure that the live parts of the equipment become accessible only after their power supply has been cut off and the live parts have been made safe by protective bonding.

Connectors in the power supply bus line shall be fitted with warning labels in accordance with 5.5.

5.4 Protection by the use of band I

5.4.1 Requirements for power supply for band I

Where a circuit at a voltage in band I is not bonded to the vehicle body, no further protective provision is required provided that the circuit meets the requirements of HD 60364-4-41:2007 (see 414.3,

Sources for SELV and PELV and 414.4, Requirements for SELV and PELV circuits), as well as the requirements of Clause 8 of this European Standard.

5.4.2 Additional requirements for ordinary persons access at a direct contact for band I

Power supplies provided in accordance with 5.4.1 shall have protection in accordance with 411.7.2 of HD 60364-4-41:2007, if both the following conditions apply:

- ordinary persons are required to have access;
- the voltage exceeds 6 V AC or 15 V DC.

5.5 Warning labels

Warning labels for electrical hazards shall be in accordance with EN 61310-1.

If a hazard is considered to exist, after all interlocking devices or design features have been operated to gain access to equipment, then warning labels shall be fitted to identify the hazard and provide any supplementary information necessary to avoid danger to persons. The labels shall be fitted in positions that ensure that they are clearly visible and will remain so throughout the life of the equipment.

Access to elevated vehicle standing surfaces, from which live parts of a contact line system can be reached, shall be marked by means of warning labels.

A warning label shall be placed on the access points to any closed electrical operating areas containing voltages in bands III or IV. It is permitted not to provide warning labels where a locking system is used to ensure access is prohibited until the hazardous voltage is no longer present.

6 Protective provisions against indirect contact

6.1 General

Clause 6 defines the allowable methods permitted for use in order to bring vehicles and their constituent parts to earth potential via the fixed installation.

The methods described in 6.2 to 6.5 shall ensure that exposed conductive parts are incapable of causing electric shock through induction or contact with live parts in the vicinity under failure conditions.

The aim is to ensure that the exposed conductive parts which present such a risk are at the same potential. This aim may be achieved by protective bonding according to 6.2 alone or in conjunction with automatic disconnection of supply, or exceptions as described in 6.5.

Clarifications and exceptions are covered in 6.5.

Additional requirements are covered in 6.6.

6.2 Protective bonding

6.2.1 Equipotential bond

Bonding to the protective conductor shall be provided for any exposed conductive parts which are capable of causing electric shock through induction, capacitive coupling or contact with live parts under foreseeable failure conditions.

All parts of the protective equipotential bonding shall be capable of withstanding all internal and external influences (including mechanical, thermal and corrosive) which may be expected.

Conductors of a protective equipotential bonding system whether insulated or bare, shall be readily distinguishable by shape, location, marking or colour. If identification by colour is used, it shall be the bicolour combination green-and-yellow.

6.2.2 Protective bonding rating

Protective bonding shall be dimensioned to provide adequate strength and current carrying capacity to ensure that the exposed conductive parts are incapable of causing electric shock under failure conditions. See also 6.3.

For characteristic values to support the dimensioning of cross section for protective bonding, see EN 50388.

Due regard shall be paid to all currents flowing in the running rail which may affect the rating of the bonding connections.

6.2.3 Sliding contacts

Sliding contacts, e.g. earth-return brushes, shall conform to the other requirements of 6.2. The failure of any one such contact shall not cause risk of electric shock.

6.3 Disconnection of the supply

6.3.1 Application

Automatic disconnection of supply or automatic limitation of fault current, e.g. by resistance insertion, shall be used in conjunction with protective bonding, where 6.2.2 would not be achieved.

Automatic disconnection of supply shall be provided where a risk of harmful physiological effects to a person could arise when a fault occurs, due to the value and duration of the touch voltage (for guidance, see IEC/TS 60479-1).

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.

6.3.2 Disconnection characteristic

A protective device shall automatically disconnect the supply to the circuit or equipment for which the device provides protection against indirect contact so that, in the event of a fault between a live part and an exposed conductive part or a protective conductor in the circuit or equipment, a prospective touch voltage exceeding the maximum band II voltages does not persist for a time sufficient to cause a risk of harmful physiological effect to a person in contact with simultaneously accessible conductive parts. For further guidance, refer to 411 of HD 60364-4-41:2007.

6.4 Main protective bonding

6.4.1 Introduction

The following applies to all vehicles operating on systems employing a protective conductor. This protective conductor may be separated from or combined with the running rails which form a part of the return circuit for the traction return current. For insulated wheel or levitation systems without a protective conductor, refer to 6.5.5.

6.4.2 General

Vehicle bodies shall be bonded in accordance with 6.4.3 and 6.4.4.

6.4.3 Bonding paths

There shall be at least two protective bonding paths between a vehicle body and the protective conductors of the fixed installation so that, if a failure occurs in one path, there shall be no risk of electric shock. Both paths shall be visible for inspection.

For the design of bonding path on vehicles it should be considered that the current values of EN 50388 will be reduced by the vehicle impedance. Main protection can be assumed to operate normally. Even for the thermal design of earthing conductors on vehicles this main protection tripping time can be applied.

Additionally for DC systems main protection will further limit the maximum current to a value below the prospective current.

NOTE 1 Experience shows that in DC systems current peaks for faults to the vehicle typically do not exceed values of 50 kA for 20 ms.

The probability of a fault on the vehicle which is not seen by its circuit-breaker (e.g. current collector short-circuit) and an outage of the main protection in the traction power substation at the same time is low. For such cases the overheating of earthing conductors is acceptable if they remain in place until the fault is cleared. This includes cases where auto-reclosure in the traction power substation doubles the thermal stress. Maintenance rules should be in place to check their condition afterwards.

Any protective bonding path of a vehicle body to the protective conductors of the fixed installation could be direct within the vehicle or via another vehicle.

NOTE 2 The protective connections between vehicle(s) and substation are normally the running rails (see EN 50122-1).

An example of the design of a main protective bond can be found in Annex C (informative).

NOTE 3 This design has been derived from UIC leaflet 533:2011.

6.4.4 Impedance

The impedance between the unit and the protective conductor of the fixed installation, e.g. the running rails, shall be low enough to prevent the existence of a hazardous voltage between them, according to the criteria of EN 50122-1:2011, Clause 6.

The maximum impedance between the unit and the protective conductor of the fixed installation are given as a guide in Table 2. Lower figures shall be used if these values could cause the occurrence of a hazardous voltage. Consideration should also be given to the possible rail potentials referred to in EN 50122-1:2011, Clause 6. This should be demonstrated both by calculation with an assumption of 1 mΩ per earth brush and verification by measurement (max. values according to Table 2).

Table 2 — Maximum impedance between each vehicle body of a unit and protective conductor of the fixed installation

Type of vehicle	Maximum impedance Ω
Tractive stock Coaches	0,05
Wagons	0,15

These values shall be measured with a constant current of 50 A, whereby the open-circuit voltage shall not exceed 50 V. The measurement shall be carried out with a clean wheel to rail interface.

Resistance of protective bonding path can be calculated.

The calculated resistance should be smaller than 10 mΩ in DC and 15 kV AC systems and 20 mΩ in 25 kV AC systems.

Experience suggests that values in Table 2 are indicative of an impedance at high current which is substantially lower.

6.4.5 Contact line fault

In the event of contact between an external electric traction power supply and a vehicle body (i.e. a broken contact wire), the system design shall reduce any excessive voltage at or within the vehicle body, to the levels required in 6.3 in the shortest practicable time.

Since the fault would normally be cleared by the fixed installations, in order to determine the voltage likely to occur at the vehicle, reference should be made to EN 50122-1.

The vehicle protective bonding shall take account of the above aim, and shall remain intact.

6.5 Clarifications and exceptions with reference to indirect contact

6.5.1 Parts requiring protective provisions

Protective provisions shall be made for exposed conductive parts in the proximity of electrical equipment, for example: sinks, metal cupboards, aerial ground planes and other similar parts.

Where no electrical equipment is fixed to covers, doors and cover plates of the electronic equipment, the normal metal screws and locking devices as well as conducting corrosion-proof hinges are considered to be sufficient protective bonding. Where electrical equipment is attached to these movable parts of electronic equipment, the exposed conductive parts of the particular electrical equipment need a protective bonding. The protective bonding to these movable parts of electronic equipment should be made via a protective conductor.

6.5.2 Parts not requiring protective provisions

6.5.2.1 Exceptions of protective provisions

Protective provisions are not needed for exposed conductive parts separated from any source which may cause electric shock.

Furthermore, no protective provisions are required for equipment defined in 6.5.2.2, 6.5.2.3 and 6.5.2.4, tested and marked to the relevant standards.

6.5.2.2 Band II voltage

Protection against indirect contact may be dispensed with for the exposed conductive parts of equipment energized at voltages in band II, if the circuits meet the requirements of SELV or PELV (reference HD 60364-4-41).

6.5.2.3 Double insulation

Electrical equipment having double or reinforced insulation shall comply with the requirements of EN 50124-1 or HD 60364-4-41.

6.5.2.4 Total insulation (for voltages in band III only)

Assemblies of electrical equipment having total insulation shall meet the requirements of EN 61140.

6.5.3 Multi-stage insulation

When multi-stage insulation is employed, for example in roof or underframe- mounted traction resistors which are air-insulated, exposed conductive parts located between the basic and supplementary insulation shall be regarded as live parts and the provisions of Clause 5 shall apply.

6.5.4 Floating supplies

Circuits at voltages in bands III or IV not bonded to the vehicle body (floating supplies) shall not be used to provide sole protection against indirect contact. The provisions of either 6.2 or 6.3 shall also be applied. Account shall also be taken of the requirements of 7.1.

Equipment that is isolated and remains floating should be viewed as not protected with respect to indirect touch.

6.5.5 Insulated wheel or levitation systems without a protective conductor

6.5.5.1 In this case, 6.4 does not apply. The vehicle body including its exposed conductive parts shall be insulated from the power supply system.

No supply circuit derived from within the unit or vehicle shall be capable of acquiring a voltage above the design range under normal or fault conditions either between poles or with respect to any exposed conductive parts.

For trolleybuses or other transport systems with no means of connection to the protective conductor of the fixed installation when stationary, all electrical equipment shall be double insulated. Any failure of either level of insulation shall be detectable either by procedure or by the use of monitoring devices.

6.5.5.2 Such transport systems shall only be used on power supply systems that meet the requirements of EN 50122-1.

6.6 Additional requirements – Bearings

Bearings on vehicles other than wagons shall not be used to connect exposed conductive parts.

Bearings on wagons should not be used to connect exposed conductive parts, if there is a risk of damage to the bearings caused by electrical current.

7 Power circuit

7.1 General principles

Power circuit design shall ensure that all currents are returned to the source of supply without resulting in damage or risk of electric shock.

Where sliding or flexing connections between the body or bogie and the running rail are employed, there shall be at least two separate paths per unit and a failure in one path shall not cause damage or risk of electric shock.

Paths shall be dimensioned to carry all currents which may flow through them. Due regard shall be paid to fault currents and currents flowing in the running rail.

Bearings in general shall not be used as part of the return path. Dedicated current limits of the bearing manufacture may be considered.

If any part of the return path is combined with the vehicle protective bonding at any point, the requirements of Clause 6 shall additionally apply.

To prevent damage or risk of electric shock from circuits directly fed from an external power supply, failures in the return current paths shall be detectable by an appropriate means, e.g. procedure or monitoring device.

Current return may conform to either of the methods below. The method chosen shall be the responsibility of the railway authorities and shall comply with either 7.2 or 7.3.

7.2 Power circuit insulated from the vehicle body or bogie

A path or paths insulated from the vehicle, or from any exposed conductive parts thereof, shall be provided to conduct current from the return of the power equipment to the return conductor of the supply system.

7.3 Power circuit using the vehicle body or bogie

Where returns are connected to the vehicle body, the connections shall be through members of sufficient cross-section to comply with the clauses below.

Current flowing in any paths through the body or bogie frame shall not cause damage or unacceptable deterioration to the structure or any mechanical parts.

Voltage differences between two different parts of the body or bogie sections shall not be sufficient to cause electric shock under any normal or failure condition.

In the event of contact between an external electric power supply and the vehicle body, additionally 6.4.5 shall apply.

8 Additional requirements

8.1 General

Means shall be provided for any live parts which may be sufficiently energized to cause electric shock after disconnection from the supply to be secured against electric shock.

8.2 Current collectors

8.2.1 In addition to the requirements of Clause 5, means shall be provided to separate the overhead current collector from the contact wire and prevent accidental contact of the current collector with the wire.

For overhead current collectors and associated live parts normally energized in band III, see also 5.3.1.3.

For overhead current collectors and associated live parts normally energized in band IV, see also 5.3.2.1.

8.2.2 Shoe gear adjacent to the platform edge shall comply with 5.3.

8.3 Capacitors

For capacitors, which may retain charge when they become accessible to direct contact, means shall be provided to ensure that there is no risk of electric shock. This may be by means of integral design of discharge circuits, additional circuits or procedure.

8.3.1 An integral discharge circuit shall be a reliable and, if necessary, redundant discharge system connected directly across the capacitors, unless another suitable piece of electrical equipment is connected directly across the capacitors, thus constituting a discharge path. The discharge path shall only include devices which are operated as part of the means of gaining access to the capacitor or related circuits and shall exclude devices which could cause automatic disconnection of the discharge path.

8.3.2 The discharge system shall be capable, after the equipment has been switched off, of bringing the residual voltage down to 60 V, within a defined time period commensurate with the maintenance methods to be employed.

8.3.3 The requirement may also be met by means of additional discharge circuits which may be switched automatically by unlocking operations as described in 5.3, or by separate connectable discharge devices. These methods may also be used to achieve a shorter discharge time.

8.3.4 Where separate connectable devices are used, the equipment shall be fitted with suitable connection points for checking the de-energized condition, and, if necessary, for discharging the equipment.

8.3.5 In addition to the above, a clearly visible warning label, identifying the hazard and the appropriate procedure shall be permanently attached to the equipment or its cover.

8.4 Plug and socket devices

8.4.1 Portable apparatus

The following subclauses cover plug and socket devices for the supply of power to portable equipment from a power source up to band III on the train.

8.4.1.1 Sockets or couplers providing power supply to various devices used while running the train (ovens, cash registers, bottle heaters, etc.) and for maintenance (vacuum cleaners, etc.) shall be fitted with a protective-equipotential-bonding.

As additional protection, these sockets should be protected by a residual current device as recommended in HD 60364-4-41:2007, 415.1.

Sockets situated in passenger compartments and reserved for maintenance purposes shall be protected by an external flap or a shutter within the socket.

8.4.1.2 Sockets for electric shavers shall only be supplied from an isolating transformer with protective separation between the input winding(s) and output winding(s), or by other protective measure achieving an equivalent level of protection against electric shock originating from other circuits.

8.4.1.3 Sockets for the use of portable power tools which might be used outside the train shall be protected by the use of one of the following:

– SELV in accordance with 5.4;

– automatic disconnection of the supply either by a residual current device or by an interlocking device upon removal of the plug;

– safe electrical separation of the circuit by an isolating transformer.

8.4.2 Vehicle and intervehicle connectors

Plug and socket devices for shed or trolley traction and also for train auxiliary supplies which present the risk of electric shock or arcing if disconnected when energized, shall not be disconnected in this condition. This may be achieved by an interlocking device or procedure.

8.5 Special sources

8.5.1 General

The following subclauses cover the requirements for protection against direct contact for live parts energized by sources for which the rules of Clause 5 are unreasonable or inadequate. Examples are batteries, high voltage sources for electronic equipment, high current inductors, etc.

8.5.2 Live parts not requiring protective provisions

Protective provisions are not required for live parts energized with voltages above band I where the source satisfies the conditions for safe insulation and the current and the stored energy are both limited to safe values according to the criteria contained in IEC/TS 60479-1.

8.5.3 Live parts requiring protective provisions

8.5.3.1 Protective provisions are required for live parts energized with voltages in band II or below which have high stored energy and may present a risk of electric shock**.**

8.5.3.2 Protective provisions are required for live parts energized with voltages in band II or below which are not protected by an over current protection device or for which the rating of the over current protection device may still present a hazard, for example battery circuits in which the hazard is mainly from burning by objects making contact.

Annex A
(normative)

Special national conditions

Special national condition: National characteristic or practice that cannot be changed even over a long period, e. g. climatic conditions, electrical earthing conditions.

NOTE If it affects harmonization, it forms part of the 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.

Subclause Special national condition

4.1 France

All French rolling stock have additional protection according to Annex A to protect people with a locking system (Fichet keys to U > AC 500 V and U > DC 750 V, in particular to DC 1 500 V).

Replace Table 1 by:

Table 1 — Voltage bands

Band	Nominal voltage U_n	
	AC V	**DC** V
I	$U \leq 25$	$U \leq 60$
II	$25 < U \leq 50$	$60 < U \leq 120$
III	$50 < U \leq 500$	$120 < U \leq 750$
IV	$U > 500$	$U > 750$

6.4.3 Great Britain

On vehicles that have to operate over the 750 V DC third rail electrified lines in Great Britain, it is permitted to have only a single protective bonding path between a vehicle body and the protective conductors of the fixed installation, as described in Annex D.

Annex B
(normative)

List of items where contracting parties shall co-operate

5.3.1.3	Protection by clearance
5.3.1.4	Protection against hazards from power supply bus line
5.3.2.1	Protection by the use of closed electrical operating areas
5.3.2.3	Protection against hazards from power supply bus line
6.5.5.1	Insulated wheel or levitation systems without a protective conductor
7.1	Power circuit - General principles
8.2.2	Current collectors
8.3	Capacitors
8.4.2	Vehicle and intervehicle connectors

Annex C [2)]
(informative)

Proposals for design of main protective connections

C.1 General

Earth conductors (earthing wires) should comply with C.2 and the following design features:

– the maximum length of earth conductors for freight wagons is 700 mm,

– the minimum useful cross-section of copper earth conductors (earthing wires) should be 35 mm².

The following conditions should be observed for earth conductors in materials other than copper:

- the minimum useful cross-section of steel earth conductors should be 100 mm²,
- the electrical resistance of earth conductors not made of copper or steel, should be equal to or lower than that of copper conductors with a useful cross-section of 35 mm²,
- earthing wires should be made of fine strands to ensure sufficient flexibility and adequate dynamic resistance.

C.2 contains a model specification for copper earthing wire (see Figure C.1).

C.3 contains an example of specification for steel earthing wire.

2) For information: these are parts of UIC leaflet 533:2011.

C.2 Example for main earth connections

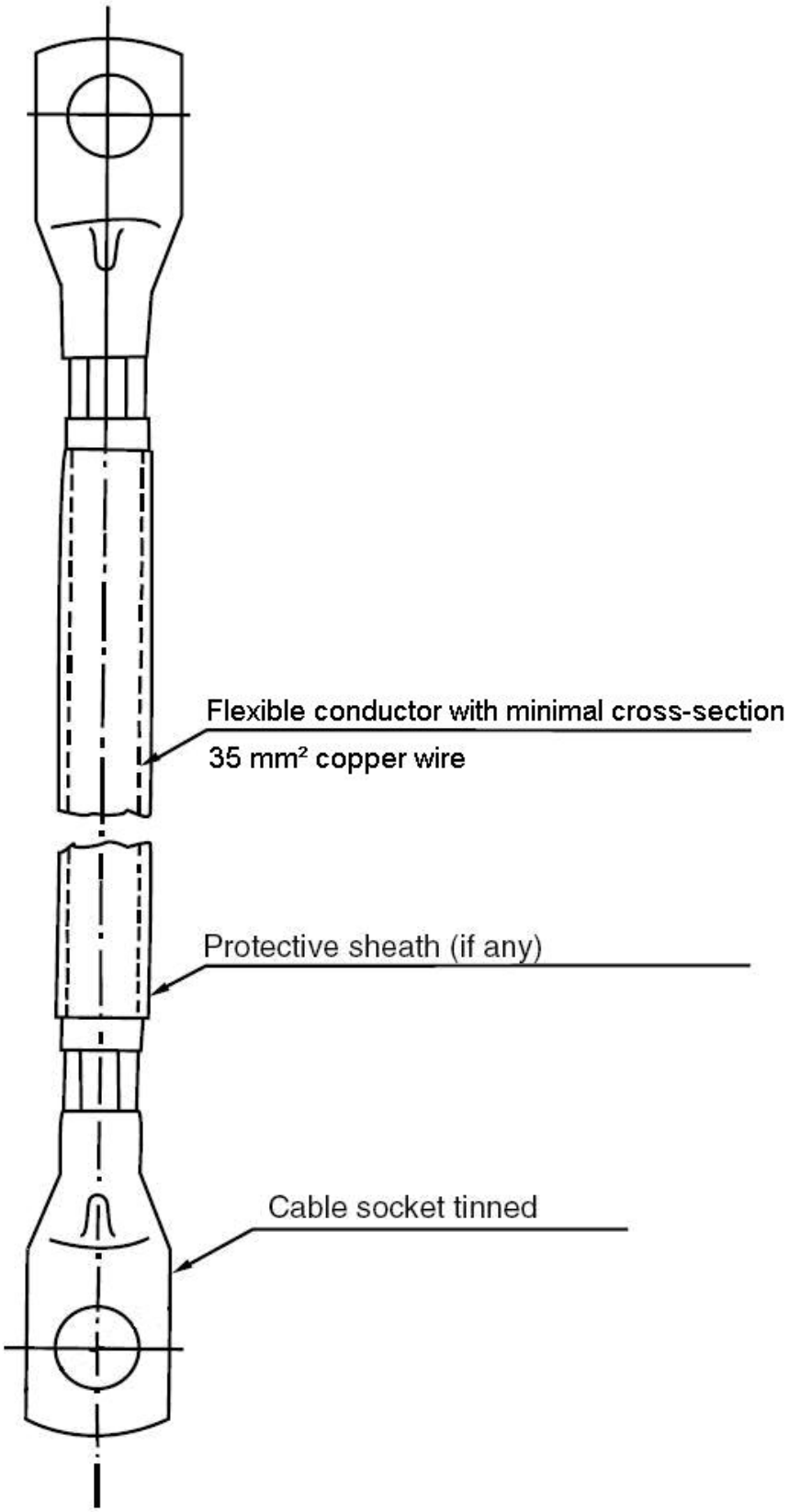

Figure C.1 — Earthing wire

C.3 Examples of technical specification for steel earthing wires

1) Only galvanised and lubricated steel wires as prescribed by EN 12385-4 should be used for coating purposes. The manufacturer should confirm the anti-corrosion properties of earthing cables throughout the service life of the vehicle.

2) Socket coating should be performed by specialized staff, in accordance with an established procedure.

3) The sockets should be coated locally on the steel earthing wire. A mechanical tensile strength test as indicated in EN 61238-1 should be carried out to demonstrate that the connection is sufficiently resistant. The minimum tensile loads to be achieved should match those obtained with copper material.

4) At least one of the sockets of the earthing cables should be suitably marked for easily identification of the corresponding batch in case a series of damage should occur.

Annex D
(informative)

Operate over 750 V DC third rail electrified lines in Great Britain

D.1 Introduction

Annex D applies to all rail vehicles that are intended to operate over 750 V DC third rail electrified lines in Great Britain.

D.2 Bonding between rail vehicle main body to bogie

Equipotential bonding of the rail vehicle main body should be provided by a single bond fitted between the vehicle main body and one bogie only.

The above equipotential bond should be provided by a bonding cable.

The frame of the other bogie should be electrically insulated from the vehicle main body structure.

There should be no low resistance conducting paths between the rail vehicle main body structure and the bogie frames, for example via suspension components.

Provision of bonding at both bogies results in current flow between the bonded axles via the vehicle components.

D.3 Inter-vehicle bonding

Inter-vehicle frame bonding should not be used on multiple unit vehicles where power is derived from a trackside DC substation.

Bibliography

[1] EN 12385-4, *Steel wire ropes – Safety – Part 4: Stranded ropes for general lifting applications*

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

[3] EN 61238-1, *Compression and mechanical connectors for power cables for rated voltages up to 36 kV (U_m = 42 kV) – Part 1: Test methods and requirements (IEC 61238-1)*

[4] EN 61439-1:2011, *Low-voltage switchgear and controlgear assemblies – Part 1: General rules (IEC 61439-1:2011)*

[5] UIC leaflet 533:2011, *Vehicles, protection by earthing of metal parts*

This page deliberately left blank

This page deliberately left blank

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards -based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email bsmusales@bsigroup.com.

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Copyright

Useful Contacts:

Customer Services
Tel: +44 845 086 9001
Email (orders): orders@bsigroup.com
Email (enquiries): cservices@bsigroup.com

Subscriptions
Tel: +44 845 086 9001
Email: subscriptions@bsigroup.com

Knowledge Centre
Tel: +44 20 8996 7004
Email: knowledgecentre@bsigroup.com

Copyright & Licensing
Tel: +44 20 8996 7070
Email: copyright@bsigroup.com

bsi.

...making excellence a habit.™