DD CLC/TS 50562:2011

BSI Standards Publication

Railway applications — Fixed installations — Process, measures and demonstration of safety for electric traction systems

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National foreword

This Draft for Development is the UK implementation of CLC/TS 50562:2011.

This publication is not to be regarded as a British Standard.

It is being issued in the Draft for Development series of publications and is of a provisional nature. It should be applied on this provisional basis, so that information and experience of its practical application can be obtained.

Comments arising from the use of this Draft for Development are requested so that UK experience can be reported to the European organization responsible for its conversion to a European standard. A review of this publication will be initiated not later than three years after its publication by the European organization so that a decision can be taken on its status. Notification of the start of the review period will be made in an announcement in the appropriate issue of Update Standards.

According to the replies received by the end of the review period, the responsible BSI Technical Committee will decide whether to support the conversion into a European Standard, to extend the life of the Technical Specification or to withdraw it. Comments should be sent to the Secretary of BSI Technical Committee GEL/9 at British Standards House, 389 Chiswick High Road, London W4 4AL.

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 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.

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

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TECHNICAL SPECIFICATION

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CLC/TS 50562

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Railway applications - Fixed installations - Process, measures and demonstration of safety for electric traction systems

Applications ferroviaires - Installations fixes - Processus, mesures et démonstration de la sécurité pour les installations fixes de traction électrique

Bahnanwendungen - Ortsfeste Anlagen - Prozess, Maßnahmen und Nachweisführung für die Sicherheit in der Bahnstromversorgung

This Technical Specification was approved by CENELEC on 2011-05-24.

CENELEC members are required to announce the existence of this TS in the same way as for an EN and to make the TS available promptly at national level in an appropriate form. It is permissible to keep conflicting national standards in force.

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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 Technical Specification 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 circulated for vote in accordance with the Internal Regulations, Part 2, Subclause 11.3.3.3 and was approved by CENELEC as CLC/TS 50562 on 2011-05-24.

The following date is proposed:

– latest date by which the existence of the CLC/TS has to be announced at national level (doa) 2011-11-24

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1 Scope

This Technical Specification defines the process, measures and demonstration of safety for the electric traction systems of

– railways,
– guided mass transport systems,
– trolleybus systems.

The systems can be elevated, at-grade and underground.

It does not apply to

– underground mine traction systems,
– cranes, transportable platforms and similar transportation equipment on rails, temporary structures (e.g. exhibition structures) in so far as these are not supplied directly or via transformers from the contact line system and are not endangered by the traction power supply system,
– suspended cable cars,
– funicular railways,
– magnetic levitated systems,
– railways with inductive power supply without contact system,
– railways with buried contact system that is required to be energised only below the train to ensure safety,

but it can support the safety considerations of such systems as far as applicable.

This Technical Specification refers to standards and common practice to demonstrate safety including the functional aspects.

This Technical Specification applies to the erecting of new lines and to all significant changes of existing lines.

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 50110 (all parts), *Operation of electrical installations*

EN 50119:2009, *Railway applications – Fixed installations – Electric traction overhead contact lines*

EN 50122 (all parts), *Railway applications – Fixed installations – Electrical safety, earthing and the return circuit*

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

EN 50123 (all parts), *Railway applications – Fixed installations – D.C. switchgear*

EN 50124 (all parts), *Railway applications – Insulation coordination*

CLC/TR / EN 50126 (all parts), *Railway applications – The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS)*

CLC/TR 50126-2:2007, *Railway applications – The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS) – Part 2: Guide to the application of EN 50126-1 for safety*

EN 50152 (all parts), *Railway applications – Fixed installations – Particular requirements for a.c. switchgear*

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

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

EN 50367, *Railway applications – Current collection systems – Technical criteria for the interaction between pantograph and overhead line (to achieve free access)*

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

CLC/TR 50488, *Railway applications – Safety measures for personnel working on or near overhead contact lines*

EN 60255 (all parts), *Measuring relays and protection equipment* (IEC 60255, all parts)

EN 60664 (all parts), *Insulation coordination for equipment within low-voltage systems* (IEC 60664, all parts)

EN 62271-1:2008, *High- voltage switchgear and controlgear – Part 1: Common specifications* (IEC 62271-1:2007)

EN 62305 (all parts), *Protection against lightning* (IEC 62305, all parts)

3 Terms and definitions

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

3.1
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]

3.2
conventional electric traction system

system constructed, operated and maintained according to relevant standards and common practice

3.3
current collector zone
CCZ
zone whose limits are in general not exceeded by an energized collector no longer in contact with the contact line or broken collector and its fragments

[EN 50122-1:2011, 3.5.10]

3.4
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.

[EN 50122-1:2011, 3.4.1]

3.5
electrical safety
freedom from unacceptable risk of harm caused by electrical systems

[EN 50122-1:2011, 3.1.1]

3.6
overhead contact line zone
OCLZ
zone whose limits are in general not exceeded by a broken overhead contact line

[EN 50122-1:2011, 3.5.9]

3.7
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.

[EN 50122-1:2011, 3.3.5]

3.8
return circuit
all conductors which form the intended path for the traction return current under operation and fault conditions

NOTE The conductors may be

– running rails,

– return conductor rails,

– return conductors,

– return cables.

[EN 50122-1:2011, 3.3.1, mod.]

3.9
return conductor
conductor paralleling the track return system and connected to the running rails at periodic intervals

[EN 50122-1:2011, 3.3.3]

3.10
switchgear and controlgear
general term covering switching devices and their combination with associated control, measuring, protective and regulating equipment, also assemblies of such devices and equipment with associated interconnections, accessories, enclosures and supporting structures

[EN 62271-1:2008, 3.1.1]

3.11
(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.

[EN 50122-1:2011, 3.1.3]

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.

4 Safety process

4.1 General

The design, construction, operation and maintenance of electric traction systems follow the relevant standards to ensure safety. The safety process itself follows CLC/TR / EN 50126 series over the complete life cycle.

This clause describes how to

– define the subsystem electric traction system and the relevant interfaces,
– identify hazards,
– apply measures,
– demonstrate an acceptable level of safety.

For the application of this Technical Specification, the differences of the system under consideration and the reference system described in Clause 6 shall be analysed. The results in terms of measures that are identified for the reference system shall be evaluated regarding their applicability for the system under consideration. The latest versions of the relevant standards shall be considered.

The generic process, intended to be applied to conventional electric traction systems, is a process tailored from CLC/TR / EN 50126 series and it consists of the following steps as shown in Figure 1.

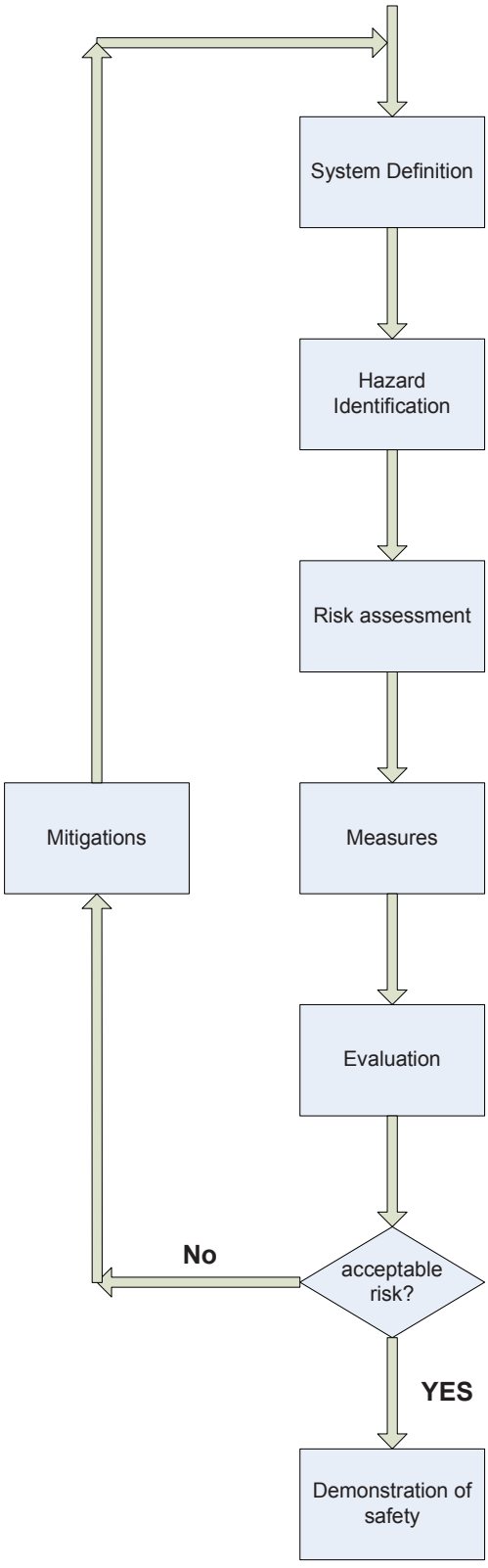

Figure 1 – Safety process for conventional electric traction system

The steps in the safety process are as follows:

– system definition;
– hazard identification;
– risk assessment;

– measures;
– evaluation;
– mitigations in case of non acceptability;
– demonstration of safety.

4.2 System definition

The electric traction system and its interfaces shall be described in a clear and manageable way. The system may be structured in subsystems as far as it is necessary. The main functions and components as well as the interfaces shall be included in the system definition. Application conditions shall be documented and taken into account.

4.3 Hazard identification

A hazard identification shall be performed and results in a list of system hazards.

The hazard identification shall start with the following list of top-level hazards (see Table 1), to ensure that the basis for the identification of system hazards is comprehensive.

A top-level hazard describes a generic situation that could lead to an accident and where only fortunate circumstances may prevent an accident. A system hazard describes the reasons, how a top-level hazard reasonably could be caused by the technical system.

Table 1 – List of foreseeable top-level hazards and accidents

Top-level hazard	Foreseeable accident	Identification code of foreseeable top-level hazard/accident
Access to voltages exceeding the limits for the touch voltage according to EN 50122-1	Injury due to electric shock	A1
Relative movement between objects and persons in direct vicinity	Injury due to striking / collision	A2
Unexpected or heavy acceleration or deceleration of persons	Injury due to striking / collision with surroundings or due to slipping, tripping and falling	A3
Exposure of persons to heat	Injury due to fire, heat, arcs	A4
Exposure of persons to hazardous amount and duration of smoke or toxic substances (local regulations)	Injury due to smoke, toxic substances	A5
Exposure of persons to severe pressure waves approaching	Injury due to explosion, overpressure	A6
Exposure of persons to electromagnetic fields or interferences (WHO limits, local regulations)	Injury due to electromagnetic fields or interference	A7
Inappropriate design or condition of equipment	Injury due to falling parts, trapping, clamping, cutting	A8
Excessive sound levels	Injury due to reduction or loss of hearing	A9

The following groups of persons shall be taken into account during the hazard identification:

– PAX
passengers of the railway. Characteristic: not expecting a risk;

– STAFF
railway staff, civil workers for railway construction, search and rescue etc. Characteristic: awareness that there is a risk when entering electrical rooms or the vicinity of tracks, power lines and contact systems;

– PUB
general public, e.g. neighbourhood, passer-by, but not passengers. Characteristic: not expecting a risk;

– OTHERS
trespasser, vandals etc. This group is aware of the risks when entering the vicinity of tracks, power lines and contact systems.

4.4 Risk assessment

The identified system hazards shall be assessed regarding the foreseeable accidents and groups at risk.

4.5 Measures

The measures according to the relevant standards and common practice shall be applied to the system under consideration.

4.6 Evaluation

The applicability of the identified measures shall be evaluated. Formally, the evaluation could be a statement that the identified measures are suitable for the close out of the identified hazards. The basis for the conclusion shall be outlined. If the hazard close out for one or more hazards is not successful the feed back path as per Figure 1 leads to the review of process steps and the identification of mitigations as applicable.

4.7 Demonstration of safety

The demonstration of safety is intended to document the implementation of the applicable standards and identified measures.

While applying this document, the safety demonstration shall be done as follows:

– formal statement that the Technical Specification CLC/TS 50562 is applied;

– formal statement that the system under consideration is equivalent to the reference system. By this, it is accepted that the same hazards are applicable as identified in this Technical Specification. In case of differences the differences have to be described with related argumentation that the same hazards and measures respectively apply;

– listing of all measures that are assessed to be applicable to the system under consideration as per Clause 8;

– tailoring of the applicable measures regarding scope and responsibility of the applicant including related argumentation;

– listing of all measures within the scope and responsibility of the applicant that were modified including related argumentation;

– documented evidence or argumentation for the successful implementation of the measures within the scope and responsibility of the applicant shall be given;

– formal statement that all measures within the scope and responsibility of the applicant have been implemented successfully making reference to the documented evidence or argumentation;
– formal listing and handing over of all remaining measures to support the employer or entity responsible for taking over and merging of the safety documentation of different subsystems and organisations.

Preferably, for the documented evidence or argumentation, the safety demonstration shall give the link to the project documentation but not repeat or summarise content. Such project documentation can for example comprise

– engineering input data (environmental conditions and isokeraunic level, field of application etc.),
– O&M manuals (intended use, instructions to use, basic switching procedures etc.),
– operational documentation (Operator's supplementary documentation to the O&M manuals),
– drawings,
– wiring manuals,
– equipment documentation (equipment drawings, O&M manual, T&C manuals etc.),
– test reports (routine or factory acceptance tests of equipment, commissioning test reports etc.),
– studies and calculations (insulation coordination, protection coordination, earthing concept, load flow, short circuit calculation, dimensioning of components etc.),
– etc.

The complete set of documents and arguments ensures that the system is safe. The safety demonstration shall be based on the quality management of the applicant, especially regarding the traceability of measures over future modifications.

5 Generic risk assessment

For this Technical Specification, a generic risk assessment has been performed for the generic electric traction system and related subsystems identified in Clause 6. The system hazards that could lead to the top-level hazards and foreseeable accidents listed in Clause 4 have been identified and documented in the tables in Annex A. For each hazard, the measures have been listed in the same tables. The measures that are common practice are summarised in Clause 8. Based on long experience in the field of electric traction systems the residual risk is considered as broadly acceptable if compliance with the applicable measures is achieved.

A single component may fail in performing the intended function. In general, a single point failure shall not cause an incident leading to injuries or fatalities with some exceptions or limitations. The residual risks are broadly accepted, as there was no incident reported in large networks over many years of operation.

EXAMPLE 1 With a high percentage the breakage of a contact system, e.g. catenary wire, leads to a short circuit. To ensure this, there are certain requirements regarding earthing and bonding e.g. of adjacent structures like fences. The short circuit is detected and switched off. The time between the loss of mechanic integrity and the switching off is an inevitable time at risk. There is a small residual risk that the catenary wire may break undetected without causing a short circuit.

EXAMPLE 2 A switchgear for feeding the contact system may not be able to switch off a short circuit caused by a switchgear failure. The next back up level switchgear will switch off the current, but will need more time. Components like cables or catenary wires are rated for this scenario; nevertheless, there is a risk that the permissible short-term touch voltages are not maintainable during those rare and short events.

The measures resulting from this generic risk assessment can be considered as a Code of Practice for the design, operation and maintenance of electric traction systems within the scope of this Technical Specification. The measures establish an adequate risk reduction with regard to the hazards identified.

6 System definition

The following system definition describes the reference system for the application of CLC/TS 50562.

6.1 Electric traction system

6.1.1 Function

The electric traction system controls, converts and transmits electric energy to the trains and other installations along the line via the contact line system and return circuit.

6.1.2 Equipment

The electric traction system comprises the following main installations and components including their auxiliary power supply as outlined in Figure 2. The nominal voltage of the electric traction system is in accordance with EN 50163.

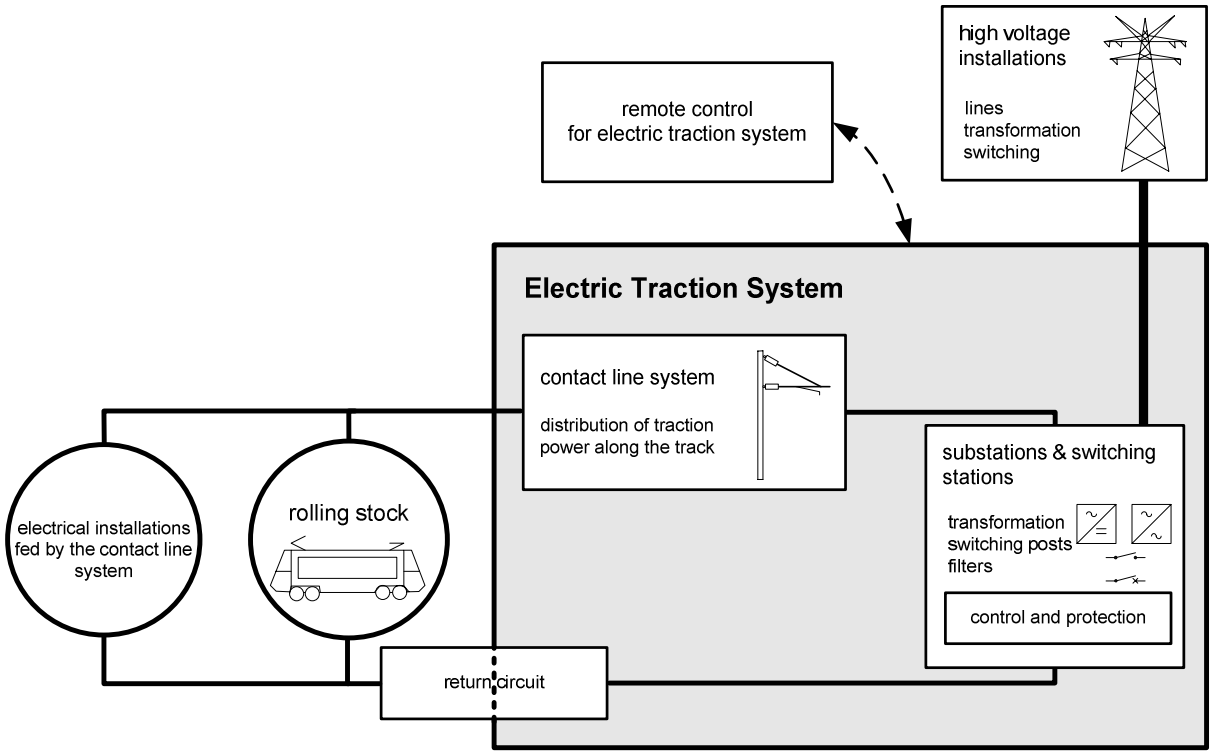

Figure 2 – Electric traction system and its interfaces

The subsystems are

– substations and switching stations including control and protection,
– contact line system,
– return circuit.

6.2 Substations and switching stations

6.2.1 Function

6.2.1.1 Introduction

The function of the substations or switching stations is the conversion, switching, control, protection and interlocking of electric traction power; in detail:

– to connect supply levels electrically;
– to ensure a sufficient galvanic separation of supply levels where necessary;
– to transform the level of voltage or frequency into the level of electrical power required for the application fed by the relevant substation;

– to ensure that sections of the subsequent contact line system can be electrically connected or isolated due to the operational requirements or due to maintenance reasons;
– to react on voltages or currents outside of the permissible limits;
– to enable regenerative braking to the feeding network where applicable;
– to store traction power in wayside energy storage devices where applicable;
– to manage the configuration of the electric traction system according to the necessities of the railway operation by control, protection and interlocking.

6.2.1.2 Control

The function of the control equipment is to enable the operation. It can comprise

– control for the operation of the switchgear by several handling levels, e.g. mechanical switching, local switching and remote switching,
– automatic functions as auto-reclose, synchro-check, line test,
– data acquisition and recording for supervision and monitoring,
– general switching off.

6.2.1.3 Protection

The function of the protection equipment is to provide protection against process values outside the permissible range in case of operation and fault conditions, e.g. over current or over and under voltage. The main aim is to prevent damage of equipment. For an accident, it is at least necessary that a failure in the system occurs, the protection function fails on demand and a person has to be in the relevant area.

6.2.1.4 Switchgear interlocking

The switchgear interlocking supports the switching activities of the staff in order to avoid switching activities that could cause unintended status.

6.2.2 Equipment

The substation and switching station equipment for conversion and switching can comprise

– transformers,
– rectifiers, inverters and frequency converters,
– switchgear, e.g. circuit breakers, isolators, sectioning and earthing switches,
– cables and conductor bars,
– surge arrestors,
– resistors, capacitors and reactors,
– installations for short circuit current limitation,
– control and protection equipment,
– measurement equipment like voltage and current transducers,
– connections to the return circuit,
– voltage limiting devices,
– earthing installations and equipment,
– wayside energy storage device.

The control, protection and interlocking equipment can comprise

– electronic hardware and software for control, protection and switchgear interlocking,
– mechanical switchgear interlocking,
– fuses for control and protection installation,

– sensors for the measurement,
– human machine interface (HMI),
– interface to remote control,
– communication cabling inside the electric traction system.

6.3 Contact line system

6.3.1 Function

The contact line system distributes energy along the line together with the return circuit. The contact line system is a live part and conducts the currents for traction and regenerative braking between substation and current collectors of rolling stock and other consumers.

6.3.2 Equipment

The contact line system equipment can comprise

– contact line, e.g. overhead contact line, third rail,
– foundations and wall anchoring,
– masts and their fixing elements,
– portals and other cross spans,
– cantilevers, suspension and support for conductor rails,
– tensioning devices and dilatations,
– feeders,
– negative feeders for auto transformer systems,
– return feeder for booster transformer systems,
– cables,
– switches,
– isolators,
– transformers,
– section insulators,
– sections for system separation or phase change over.

6.4 Return circuit

6.4.1 Functions

The return circuit collects and conducts the return currents for traction and regenerative braking between substation and rolling stock and other consumers.

6.4.2 Equipment

The return circuit consists of all conductors that form the intended path for the traction return current. Therefore parts of the return circuit can be allocated to different systems of railway applications. The return circuit can comprise:

– running rails,
– return conductor rails,
– return conductors,
– return cables,
– impedance bonds,
– insulating rail joints.

6.5 Interfaces of the electric traction system

6.5.1 General

Interfaces of the electric traction system taken into account are

– remote control for electric traction system,
– rolling stock and electrical installations fed by the contact line system,
– track,
– signalling,
– railway related communication systems,
– high voltage installations,
– conductive equipment in the current collector zone (CCZ) and overhead contact line zone (OCLZ),
– civil and metallic structures,
– installations within the railway boundary.

6.5.2 Remote control of electric traction system

Transmission of control signals between different locations, e.g. OCC, substations etc.

Aspects: standards of communication and interface equipment, e.g. EN 60870-5-104

6.5.3 Installations in the railway boundary

Technical influence of the electric traction system to or from systems outside of the railway system, e.g. by

– installations with EMC-sensitive equipment, e.g. hospitals or computer centres,
– other power supply systems in the vicinity like national grids,
– other railways with other electrical system or non electrified railways,
– pipelines e.g. for gas or oil,
– communication systems and power cables,
– storage of dangerous goods.

The installations within the railway boundary can be influenced by the presence of the electromagnetic fields of substations and switching stations, related cables and contact line system.

Aspects: Existing installations within the railway boundary shall be taken into account during the design, installation and modification of an electric traction system. New or modified installations within the railway boundary shall take existing electric traction systems into account. Obvious future changes on both sides shall be handled accordingly.

6.6 Interfaces to substations and switching stations

6.6.1 Rolling stock and electrical installations fed by the contact line system

Power characteristics of rolling stock in motoring and regenerative braking (static and dynamic, stability)

Aspects: permissible load, unbalance, harmonics, quality of power, handling of internal faults like short circuits, protection coordination

6.6.2 Track

Power characteristics of track side consumers

Aspects: permissible load, unbalance, harmonics, quality of power, handling of internal faults like short circuits

6.6.3 Signalling

None.

Assumption: sufficient distance between substation and signalling equipment

Aspects: None

6.6.4 Railway related communication systems

None.

Aspects: earthing requirements

6.6.5 High voltage feeding network

Transfer of electric energy between supplying network and electric traction power supply system. Exchange of electric energy at the terminations of the incoming feeder of the substation

Aspects: protection coordination, permissible load, unbalance, harmonics, quality of power, handling of internal faults like short circuits

6.7 Interfaces to contact line system

6.7.1 Rolling stock and electrical installations fed by the contact line system

Rolling stock and wayside equipment fed by the contact line system. Exchange of electric energy at mobile or stationary interconnection points like pantographs or terminations; e.g. for the air condition of rolling stock in parking position

Aspects: permissible load, handling of inherent short circuits, current collectors and their characteristics, dynamic envelope

6.7.2 Track

Running rails and related superstructure. Geometry of assembly to ensure guidance to rolling stock and by that also the correct position of the current collectors of rolling stock.

Aspects: position of contact wire and supporting structures (masts, portals ...) with respect to the track

6.7.3 Signalling

Installations of signals on contact line supporting structures, signalling equipment within the OCLZ and CCZ

Aspects: permissible mechanical loads, clearance to live equipment, electromagnetic interference

6.7.4 Communication systems

Communication equipment installed in the vicinity or within the OCLZ and CCZ

Aspects: permissible mechanical loads, clearance to live equipment, electromagnetic interference

6.7.5 High voltage feeding network

Crossing with overhead lines, parallel routes of overhead lines, power cables and contact lines

Aspects: electromagnetic interference, distance between installations

6.7.6 Conductive equipment in the CCZ and OCLZ

Presence of buildings or conductive equipment in the current collector zone or in the overhead contact line zone

Aspects: voltage propagation

6.8 Interfaces to return circuit

6.8.1 Rolling stock and electrical installations fed by the contact line system

Transfer of return currents from wheel-sets or current collectors

Aspects: earthing and bonding requirements

6.8.2 Track

Running rails can form part of the return circuit.

Aspects: Continuity of return circuit, electrical dimensioning of running rails and connectors, rail potential.

6.8.3 Signalling

Track circuits, axle counters.

Aspects: electromagnetic interference, harmonics, induced voltages, earthing and bonding

6.8.4 Communication systems

Communication equipment installed in the vicinity of return circuit

Aspects: electromagnetic interference, harmonics, induced voltages, earthing and bonding

6.8.5 High voltage feeding network

Transfer of return currents in case of operation and faults

Aspects: earthing and bonding

6.8.6 Conductive equipment in the CCZ and OCLZ

Transfer of return currents in case of operation and faults

Aspects: earthing and bonding

6.8.7 Civil and metallic structures

Transfer of return currents in case of operation and faults. Conductive equipment within civil or metallic structures can come in contact with live equipment or can serve as return current paths.

Aspects: earthing and bonding, voltage propagation, stray current corrosion within the vicinity of d.c.-electric traction systems.

7 Hazard identification

The top-level hazards and related foreseeable accidents listed in Table 1 were identified systematically and were used as a basis for the risk assessment. As it is not intended to give a normative definition for the structure of the hazard log, the hazard log for the reference system as per Clause 6 is given in the informative Annex A.2.5 and A.3. The results in terms of identified measures are given in Clause 8.

8 Measures

8.1 General

Within this document, the measures identified in the generic risk assessment are interpreted as requirements to ensure safety within the framework of the applicable standards.

Some measures may only reasonably be applicable to a certain application. This has to be considered when using the measures listed in this clause as a code of practice.

The following measures are valid for all subsystems of the electric traction system:

– it is anticipated that all applicants have a quality management system established and in place;
– the application of European or International Standards for equipment and dimensioning of equipment is anticipated for implementation, modification and renewal;
– relevant standards shall be identified and applied. Preferably standards can be taken from the list of standards as per Annex A;
– adequate design of insulation coordination according to EN 50124 series (insulation coordination), EN 50123 series (d.c. switchgear), EN 50152 series (a.c. switchgear) and applicable equipment standards;
– an earthing concept shall be established and implemented;
– adequate design for lightning protection of buildings according to EN 62305 series;
– rules regarding permission for access and permission for work shall be established and applied, e.g. EN 50110 series, CLC/TR 50488;
– the system shall be kept within the specified ambient conditions, operational limits and the intended use for all time and under all conditions;
– instructions for operation and maintenance in the O&M manual shall be elaborated and applied;
– personal protective equipment and the safety instructions shall be applied according to the local regulations and the applicable O&M manuals;
– the standards for electrical safety and local regulations, e.g. qualification of personnel, responsibility for the safety at work shall be followed; e. g. EN 50110 series, CLC/TR 50488, EN 50122-1;
– appropriate civil structure design (e.g. to contain oil in case of fault, fire protecting wall) according to the relevant civil standards is anticipated;
– for tunnel sections and underground stations, material with improved properties of low flammability, low fire spread, low toxicity and low smoke density shall be used if the material could be exposed to fire;

– as far as reasonably practicable, equipment shall be installed in such a way that adverse effects on areas for public and passengers by destruction even through severe overload are minimised;

– the storage of inflammable goods in the vicinity of electric traction system has to fulfil the relevant rules, see also EN 50122-1;

– for systems covered by CLC/TR 50488, the connection of equipment to return circuit/protective earth during work shall be done consequently for systems with overhead contact lines;

– for systems not covered by CLC/TR 50488, live working can be permitted if the conditions of EN 50122-1 are fulfilled, see also local regulations. The use of special equipment like insulated tools and hoisting platforms is highly recommended;

– rules for regular and specific assessment of qualification and training for personnel shall be established and applied;

– periodic tests of the functionality shall be addressed in the O&M manuals;

– regular inspection shall be addressed in the O&M manuals.

8.2 Substations and switching stations

8.2.1 General

The following measures are valid for all substations and switching stations:

– protection of equipment against overload;

– the operator shall have a functional redundancy for switching off electric traction power;

– adequate construction of switchgear compartment and buildings regarding pressure release;

– automatic tripping in case of impermissible currents, e.g. during short circuit shall be implemented. Automatic reclosure is common practice. Rules have to be implemented for the blocking of the automatic reclosure after a certain number of failed attempts.

8.2.2 Control and protection

The following measures are valid for all control and protection systems:

– the coordination of protection functions has to be documented in a protection coordination concept;

– generally, the operation of switchgear requires skilled staff with switching authorisation;

– electronic hardware for protection shall comply with standards, e.g. EN 60255 series, EN 60664 series;

– protection architecture shall ensure that a single fault in the power circuits can be cleared even with one single fault present in the protection system;

– electronic protection devices shall have built in self-test functions;

– software failure detection during run time, e.g. time out monitoring, shadow RAM, code memory monitoring are recommended;

– electronic protection device failure to be transmitted to local control;

– testing procedure and maintenance to be specified in accordance with EN 60255 series;

– detection of missing signals from measurement sensors (built-in monitoring or periodic tests or periodic inspections);

– tripping wires shall be protected by suitable means like strain relieve, fixation or covering;

– the bus communication shall continuously be monitored if no hard wired connection is used;

– software for protection shall comply with EN 60255-27 and the other relevant parts of EN 60255 series for each protection function;

– software developed and certified according to standards like EN 61508 series can be cross accepted;

– transmission of failure information to the control centre (e.g. time out monitoring failure etc.) is recommended;
– the application of the safety rules shall ensure safety during maintenance even if the control system does not work properly.

8.3 Contact line system

The following measures are valid for all contact line systems:

– the protection systems between the train and substation shall be coordinated, see also EN 50388;
– the construction shall respect the dynamic envelope of trains and interface to the pantograph as per relevant standards, e. g. EN 50119, EN 50367;
– the height of a contact line is given in the relevant standards, e.g. EN 50119. If the traffic road profile, e.g. at level crossings cannot be maintained, warning signs to indicate the maximum permissible height of road vehicles or suitable barriers shall be in place;
– conductive parts in the OCLZ and CCZ shall be connected to the return circuit according to EN 50122-1;
– fall-arrest wheels or other suitable means shall be installed to reduce the probability of counter-weights of overhead contact line tensioning devices falling down. Barriers or protective coverings shall prevent access of persons to falling weights in public areas;
– rolling stock is assumed to fulfil EN 50153;
– it is assumed that the design standards for rolling stock shall be applied; e.g. regarding mechanic robustness of windscreens;
– warning signs for indicating dangerous voltage or barriers shall be in place; dangerous voltages as per EN 50122-1.

8.4 Return circuit

The following measures are valid for all return circuits:

– sufficient laying depth for additional return conductors and wires laid in ground (e.g. mechanical tamper);
– regular inspection and inspection after track work shall be applied;
– the construction shall respect the dynamic envelope of trains e. g. EN 50119, EN 50367;
– additional return conductors shall be installed out of the traffic road profile according to the local regulations;
– adequate design on monitoring of track insulation to prevent stray currents in DC systems according to EN 50122-2 and EN 50122-3;
– track circuits and axle counters shall fulfil EN 50122 series;
– the return conductors of some d.c. systems are live, e.g. trolley bus or four rail systems, so the return conductors of those systems shall be treated accordingly.

9 Safety evaluation for the reference system

The safety assessment as described above has been done in accordance with CLC/TR / EN 50126 series. Measures identified in Clause 8, when implemented, are sufficient to demonstrate the compliance with safety requirements and ensure a broadly acceptable level of safety.

This conclusion is based on field data from accident statistics have been collected from several European railways that are equivalent to the reference system described in this Technical Specification. The field data represent more than 1 200 000 year km operational experience which amounts to the equivalent of operational experience of a comparable network size of about 80 000 km over a period of 15 years of service. No fatality was reported caused by a failure of a specified function of electric traction systems.

Based on the field data experience a system designed, constructed, operated and maintained according to the standards and the identified mitigations is regarded safe. Components designed, produced, tested and applied according to standards like EN, HD and IEC respectively are regarded to be safe. No additional safety analysis on components is required as long as the permissible application conditions and the intended use are met. The safety margins already included in the relevant standards are the results of risk assessments in the standardisation groups.

Annex A
(informative)

Hazard log resulting from the generic risk assessment

A.1 General

The identified measures in Clause 8 may not be applicable for all future applications. To support the use of these measures as a 'Code of practice' or for similarity analyses, the risk assessment process resulting in the measures in Clause 8 is described in the following subclauses.

For each identified hazard, the measures defined in standards or implemented as common practice (state of the art) have been listed. These measures are the railway industry's 'good practice' to ensure that the identified hazards do not easily develop into any of the foreseeable accidents.

The risk of the individual hazards has not been estimated because the global risk posed by the traction power supply systems of the railway is generally acceptable if the state of the art measures are properly implemented.

The purpose of the generic risk assessment was

– to systematically identify the hazards of the electric traction systems,
– identify the measures that can be considered as state of the art to control the hazards and to achieve the generally accepted low risk. These measures can be used as 'Code of practice' for future electric traction systems (either new systems or significant changes to existing systems).

A.2 Risk assessment process

A.2.1 Preparation

For a systematic hazard analysis, the following steps were performed:

– preparation of a list of generic systems to be considered (see A.2.3);
– system definition with list of subsystems and interfaces as per Clause 6;
– identification of foreseeable accidents and top-level hazards as per 4.3 and A.2.4 respectively.

A.2.2 Identification and analysis of system and subsystem hazards

For each generic system and each subsystem, the conditions that could lead to any of the listed foreseeable accidents have been identified. These conditions (failures, false handling etc.) are the system and subsystem hazards. For each identified hazard, the possible hazard causes have been described. Special attention has been paid to the interfaces between the systems and subsystems.

A.2.3 List of generic systems

S1: AC system with overhead contact line

S2: DC system with overhead contact line

S3: DC system with third rail, return through running rails

S4: DC system with third and fourth rail

A.2.4 Foreseeable top level hazards and accidents

Table A.1 – List of foreseeable top-level hazards and accidents

Top-level hazard	Foreseeable accident	Identification code of foreseeable top-level hazard/ accident
Access to voltages exceeding the limits for the touch voltage according to EN 50122-1	Injury due to electric shock	A1
Relative movement between objects and persons in direct vicinity	Injury due to striking / collision	A2
Unexpected or heavy acceleration or deceleration of persons	Injury due to striking / collision with surroundings or due to slipping, tripping and falling	A3
Exposure of persons to heat	Injury due to fire, heat, arcs	A4
Exposure of persons to hazardous amount and duration of smoke or toxic substances (local regulations)	Injury due to smoke, toxic substances	A5
Exposure of persons to severe pressure waves approaching	Injury due to explosion, overpressure	A6
Exposure of persons to electromagnetic fields or interferences (WHO limits, local regulations)	Injury due to electromagnetic fields or interference	A7
Inappropriate design or condition of equipment	Injury due to falling parts, trapping, clamping, cutting	A8
Excessive sound levels	Injury due to reduction or loss of hearing	A9

A.2.5 Explanation of fields in the hazard log table

Table A.2 – Fields of hazard log

Field	Explanation
System	In this column it is stated for which generic system the hazard and the measures are applicable. The measures, in particular the standards used to control the risk, may not be the same for the different types of power supply systems.
Subsystem	Subsystem for which the hazard is relevant.
Hazard cause for the top-level hazard/accident	Description of the conditions (failures, malfunction, wrong handling, human error) of this subsystem that could lead to the top-level hazard/accident. Several failures etc. have been described in the same top-level hazard, if the effects and the measures to prevent the accident are the same.
Top-level hazard	Foreseeable accident / top-level hazard that could be caused by the hazard cause. Only credible accident scenarios have been considered. If the same hazard can lead to more than one type of accident, then the measures can be different for the different accident categories, even if the hazard is the same.
Groups at risk	Relevant groups at risk for the described hazard. PAX = passengers of the railway. Characteristic: not expecting a risk STAFF = railway staff, civil workers for railway construction, search and rescue etc. Characteristic: awareness that there is a risk when entering electrical rooms or the vicinity of tracks, power lines and contact systems PUB = general public, e.g. neighbourhood, passer-by, but not passengers. Characteristic: not expecting a risk OTHERS = trespasser, vandals etc. This group is aware of the risks when entering the vicinity of tracks, power lines and contact systems
Measure	Measures taken to prevent that the described hazard leads to an accident or to detect the hazard and reduce or eliminate the risk. Examples are design rules, periodic inspections, preventive maintenance, protection systems etc. Mitigating actions can refer to applicable standards (see next field)
Standards	Standards that have to be followed as part of the defined measures. In some cases, only parts of the standard are relevant to mitigate the hazard.

A.3 Hazard Log

A.3.1 General

Annex A represents a top-down analysis of the generic system starting form the top-level hazards. The hazard causes give an idea under which conditions a top-level hazard could arise. It is not intended to express that all hazard causes for every application are explicitly listed or that every hazard cause applies to every application condition. Inevitable hazards of life are neglected, as they are omnipresent and not specific for the electric traction systems.

The measures listed in Clause 8 and in this hazard log respectively are state of the art and, depending on the application, are in place. The mitigations do not guarantee that no hazard and no accident will occur, but the related residual risk is broadly acceptable as explained in Clause 5.

The general measures according to 8.1 are applicable to all hazard causes. The subsystem specific measures that are summarised in 8.2 to 8.4 are taken from this Annex A. The list of generic electric traction systems S1 to S4 is given in A.2.3.

Table A.3 – Substations and switching stations

System	Subsystem	Hazard cause for top-level hazard	Top-level hazard/accident	Groups at risk	Measure	Standards
S1 ... S4	Substations and switching stations	Insulation failure	A1, A4, A5	STAFF	Adequate design of compartment regarding pressure release Design according to the isokeraunic level	EN 50124 series, EN 50110 series, EN 62305 series
S1 ... S4	Substations and switching stations	Overheating of equipment	A4, A5, A6	PAX, PUB, STAFF	Adequate architecture and settings of protection Back up architecture for circuit breaking function	relevant equipment standards
S1 ... S4	Substations and switching stations	Voltage on equipment in substations and switching stations during work	A1, A4	STAFF	Implementation of earthing concept	EN 50110 series, EN 50122-1 Local rules, O&M manuals of equipment
S1 ... S4	Substations and switching stations	Arc faults in the switchgear	A1, A4	STAFF	Implementation of earthing concept Adequate design of compartment regarding pressure release	EN 50123 series (d.c.), EN 50124 series (insulation coordination), EN 50152 series (a.c.) and equipment standards

Table A.4 – Control and protection, hardware components

System	Subsystem	Hazard cause for top-level hazard	Top-level hazard/accident	Groups at risk	Measure	Standards
S1 … S4	Substations and switching stations, control and protection	Failure of electronic hardware in protection and interlocking NOTE The failure can put the protection system partially or totally out of service.	A1, A4, A5, A6	PAX, PUB, STAFF	Electronic hardware for protection shall comply with standards. Protection architecture shall ensure that a fault can be cleared even if one electronic hardware for protection fails (e.g. backup or reserve relay) to protect the installation. Electronic protection relays shall have built in self-test functions. Electronic protection relay failure to be transmitted to local control Optional: transmission of fault messages to central control Testing procedure and maintenance to be specified in accordance with EN 60255 series	EN 60255 series, EN 60664 series, EN 50122-1

Table A.4 – Control and protection, hardware components *(continued)*

System	Subsystem	Hazard cause for top-level hazard	Top-level hazard/accident	Groups at risk	Measure	Standards
S1 … S4	Substations and switching stations, control and protection	Tripping of fuses - in the protection of auxiliary power supply, - in the hard wired tripping signals, - in voltage measurement components for protection and interlocking system	A1, A4, A5, A6	PAX, PUB, STAFF	Protection architecture shall ensure that a single fault (in the power circuits) can be cleared even with one single fault present in the electronic hardware for protection (e.g. background or reserve relay, or background functions within the relay).	
S1 … S4	Substations and switching stations, control and protection	Failure of sensor (e.g. for the measuring of voltages and currents, position indicators for switchgears) for protection and interlocking system	A1, A4, A5, A6	PAX, PUB, STAFF	Protection architecture shall ensure that a single fault (in the power circuits) can be cleared even if one electronic hardware for protection fails (e.g. background or reserve relay or background functions within the relay). Detection of missing signals from measurement sensors (built-in monitoring or periodic tests or periodic inspections)	

Table A.4 – Control and protection, hardware components *(continued)*

System	Subsystem	Hazard cause for top-level hazard	Top-level hazard/accident	Groups at risk	Measure	Standards
S1 … S4	Substations and switching stations, control and protection	Failure of the connection between protection relay and circuit breaker	A1, A4, A5, A6	PAX, PUB, STAFF	Protection architecture shall ensure that a fault (in the power circuits) can be cleared even if one electronic hardware component for protection fails (e.g. background or reserve relay or background functions within the relay). Mechanical protection for the tripping wire If no hard-wired connection is used, the bus communication shall continuously be monitored.	EN 60255 series, EN 61010 series, EN 61850 series

Table A.5 – Control and protection, software

System	Subsystem	Hazard cause for top-level hazard	Top-level hazard/accident	Groups at risk	Measure	Standards
S1 … S4	Substations and switching stations, control and protection	All software functions of a single protection relay out of work in protection or in interlocking system	A1, A4, A5, A6	PAX, PUB, STAFF	Software for protection shall comply with standards. Software failure detection during run time, e.g. time out monitoring, shadow RAM, code memory monitoring Protection system architecture shall ensure that a single fault (in the power circuits) can be cleared even if one protection relay fails (e.g. background or reserve relay). Transmission of failure information to the control centre (e.g. time out monitoring failure etc.)	EN 60255-27 NOTE Software developed and certified according to standards like EN 61508 could be cross accepted for the generic safety case. Accepted/established testing methods of manufacturers and operators for functions including failure modes

Table A.5 – Control and protection, software *(continued)*

System	Subsystem	Hazard cause for top-level hazard	Top-level hazard/accident	Groups at risk	Measure	Standards
S1 … S4	Substations and switching stations, control and protection	One ore more (not all) software functions out of work in protection or in interlocking system	A1, A4, A5, A6	PAX, PUB, STAFF	Software for protection shall comply with standards. Software failure detection during run time, e.g. time out monitoring, shadow RAM, code memory monitoring Protection system architecture shall ensure that a single fault (in the power circuits) can be cleared even if one protection function fails (e.g. background or reserve relay or background functions within the relay). Transmission of failure information to the control centre (e.g. time out monitoring failure etc.)	EN 60255-27 NOTE Software developed and certified according to standards like EN 61508 could be cross accepted for the generic safety case. Accepted/established testing methods of manufacturers and operators for functions including failure modes

Table A.6 – Contact system

System	Subsystem	Hazard cause for top-level hazard	Top-level hazard/accident	Groups at risk	Measure	Standards
S1 ... S4	Contact line system	Collision or contact with components of the overhead contact line system infringing the dynamic envelope of trains or road profile	A1, A2, A4, A5	PAX STAFF PUB	Design with respect to the dynamic envelope of trains Assumption: Design standards for rolling stock, e.g. for windscreens, have to be applied	design standard EN 50119 EN 50122-1 (to increase the probability of detecting a fault) NOTE For S3 and S4 sufficient mechanic stability of conductor rails is anticipated. EN 50388, EN 50367, EN 50153 (to increase the probability of detecting a fault)
S1, S2	Contact line system	Collision of road vehicles with overhead wires, e.g. at level crossings or on roads (tramways), either due to mechanical failures of the overhead contact system, or because of excess road vehicle size.	A1, A2, A4, A5	PAX STAFF PUB	Installing of contact line out of road profile (e.g. sufficient contact wire height at level crossings) If road profile cannot be maintained, barriers or suitable signs indicating the maximum height have to be installed	

Table A.6 – Contact system *(continued)*

System	Subsystem	Hazard cause for top-level hazard	Top-level hazard/accident	Groups at risk	Measure	Standards
S3 and S4	Contact line system	Live current rails on open sections and near level crossings could electrocute persons touching a conductor rail	A1	PUB, STAFF		Measures according to EN 50122-1
S1 ... S4	Contact line system	Flashover from contact line system to earth could cause fire, e.g. in tunnels, or on vehicles.	A4, A5	PAX STAFF	For high-voltage systems: limits of short circuit duration	EN 62305 series, CLC/TR / EN 50526 series (d.c.), EN 60099 series (a.c.), EN 50124 series, EN 50388, TSI Energy for interoperable lines
S1 ... S4	Contact line system	Insulation failure or thermal overload of feeder cables, measuring transformers, surge arresters etc.	A4, A5, A6	PAX STAFF PUB	Design of insulation coordination	EN 50124 series, EN 50119, EN 50123 series (d.c.), EN 50152 series (a.c.)
S1 ... S4	Contact line system	Voltage in the contact line system during work Negligence of safety rules	A1, A4, A5	STAFF		EN 50122-1, EN 50110 series, CLC/TR 50488 General requirement Exception: Intended live working under special conditions permissible.

Table A.6 – Contact system *(continued)*

System	Subsystem	Hazard cause for top-level hazard	Top-level hazard/accident	Groups at risk	Measure	Standards
S1, S2	Contact line system	Fall of weights or unintended release of springs etc. of tensioning equipment in case of mechanical failure	A2, A8	PAX STAFF PUB	Obstacles or protective covering to prevent access to falling weights in public areas Fall-arrest wheels or other measures shall be installed to prevent counter-weights from falling down	EN 50119

Table A.7 – Return circuit

System	Subsystem	Hazard cause for top-level hazard	Top-level hazard/accident	Groups at risk	Measure	Standards
S1 … S4	Return circuit	Return conductors (AC) or earth wires (DC) infringe with the dynamic envelope or road profile.	A2	PAX STAFF PUB	Sufficient laying depth for laid conductors and wires (e.g. mechanical tamper) that are laid in ground Inspection after track work The construction for return conductors on masts shall respect the dynamic envelope of trains e.g. EN 50119, EN 50367 and TSI Energy for interoperable lines Additional return conductors shall be installed out of the road profile according to the local regulations	
S1 … S4	Return circuit	Interruptions of the return circuit (e.g. broken running rails, return cables or connections) can cause impermissible touch voltages	A1	PAX STAFF PUB	Sufficient laying depth for laid conductors and wires (e.g. mechanical tamper) that are laid in ground Inspection after track work The construction for return conductors on masts shall respect the dynamic envelope of trains e.g. EN 50119, EN 50367 and TSI Energy for interoperable lines Additional return conductors shall be installed out of the road profile according to the local regulations	EN 50122-1

A.3.2 Standards explicitly referenced in hazard log

For the application of the hazard log as reference, it may be useful to know the version of the standards used for the generic hazard analysis. In general, the actual versions valid in July 2010 were taken into account. The versions explicitly referenced in the hazard log are as follows.

Table A.8 – Standards referenced in hazard log

Identification	Title
2008/284/EC - TSI ENE Energy	Commission Decision 2008/284/EC of 6 March 2008 concerning a technical specification for interoperability relating to the energy sub-system of the trans-European high-speed rail system, OJ L 104, 14.4.2008, p. 1-79
EN 50110-1:2004	Operation of electrical installations
EN 50110-2:1996 [1)] + corr. Feb. 2001	Operation of electrical installations – Part 2: National annexes
EN 50119:2009	Railway applications – Fixed installations – Electric traction overhead contact lines
EN 50122-1:2011	Railway applications – Fixed installations – Electrical safety, earthing and the return circuit – Part 1: Protective provisions against electric shock
EN 50123-1:2003	Railway applications – Fixed installations – D.C. switchgear – Part 1: General
EN 50123-2:2003	Railway applications – Fixed installations – D.C. switchgear – Part 2: D.C. circuit breakers
EN 50123-3:2003	Railway applications – Fixed installations – D.C. switchgear – Part 3: Indoor d.c. disconnectors, switch-disconnectors and earthing switches
EN 50123-4:2003	Railway applications – Fixed installations – D.C. switchgear – Part 4: Outdoor d.c. disconnectors, switch-disconnectors and earthing switches
EN 50123-7-1:2003	Railway applications – Fixed installations – D.C. switchgear – Part 7-1: Measurement, control and protection devices for specific use in d.c. traction systems – Application guide
EN 50123-7-2:2003	Railway applications – Fixed installations – D.C. switchgear – Part 7-2: Measurement, control and protection devices for specific use in d.c. traction systems – Isolating current transducers and other current measuring devices
EN 50123-7-3:2003	Railway applications – Fixed installations – D.C. switchgear – Part 7-3: Measurement, control and protection devices for specific use in d.c. traction systems – Isolating voltage transducers and other voltage measuring devices
EN 50124-1:2001 + A1:2003 + A2:2005 + corr. May 2010	Railway applications – Insulation coordination – Part 1: Basic requirements – Clearances and creepage distances for all electrical and electronic equipment

[1)] Superseded by EN 50110-2:2010, *Operation of electrical installations – Part 2: National annexes*.

Table A.8 – Standards referenced in hazard log *(continued)*

Identification	Title
EN 50124-2:2001 + corr. May 2010	Railway applications – Insulation coordination – Part 2: Overvoltages and related protection
EN 50152-3-1:2003	Railway applications – Fixed installations – Particular requirements for a.c. switchgear – Part 3-1: Measurement, control and protection devices for specific use in a.c. traction systems – Application guide
EN 50152-3-2:2001	Railway applications – Fixed installations – Particular requirements for a.c. switchgear – Part 3-2: Measurement, control and protection devices for specific use in a.c. traction systems – Single-phase current transformers
EN 50152-3-3:2001	Railway applications – Fixed installations – Particular requirements for a.c. switchgear – Part 3-3: Measurement, control and protection devices for specific use in a.c. traction systems – Single-phase inductive voltage transformers
EN 50153:2002	Railway applications – Rolling stock – Protective provisions relating to electrical hazards
EN 50367:2006 + corr. May 2010	Railway applications – Current collection systems – Technical criteria for the interaction between pantograph and overhead line (to achieve free access)
EN 50388:2005 + corr. May 2010	Railway applications – Power supply and rolling stock – Technical criteria for the coordination between power supply (substation) and rolling stock to achieve interoperability
CLC/TR 50488:2006	Railway applications – Safety measures for the personnel working on or near overhead contact lines
EN 50526-1 [2)]	Railway applications – Fixed installations – D.C. surge arresters and voltage limiting devices – Part 1: Surge arresters
EN 60099-1:1994 + A1:1999	Surge arresters – Part 1: Non-linear resistor type gapped surge arresters for a.c. systems (IEC 60099-1:1991 + A1:1999)
EN 60099-4:2004 + A1:2006 + A2:2009	Surge arresters – Part 4: Metal-oxide surge arresters without gaps for a.c. systems (IEC 60099-4:2004, mod. + A1:2006 + A2:2009)
EN 60099-5:1996 + A1:1999	Surge arresters – Part 5: Selection and application recommendations (IEC 60099-5:1996, mod. + A1:1999)
EN 60255-3:1998 + corr. Jan. 1998	Electrical relays – Part 3: Single input energizing quantity measuring relays with dependent or independent time (IEC 60255-3:1989, mod.)
EN 60255-5:2001	Electrical relays – Part 5: Insulation coordination for measuring relays and protection equipment – Requirements and tests (IEC 60255-5:2000)
EN 60255-6:1994 + corr. Feb. 1995	Electrical relays – Part 6: Measuring relays and protection equipment (IEC 60255-6:1988, mod.)
EN 60255-8:1998	Electrical relays – Part 8: Thermal electrical relays (IEC 60255-8:1990, mod.)

2) At draft stage.

Table A.8 – Standards referenced in hazard log *(continued)*

Identification	Title
EN 60255-21-1:1995	Electrical relays – Part 21: Vibration, shock, bump and seismic tests on measuring relays and protection equipment – Section 1: Vibration tests (sinusoidal) (IEC 60255-21-1:1988)
EN 60255-21-2:1995	Electrical relays – Part 21: Vibration, shock, bump and seismic tests on measuring relays and protection equipment – Section 2: Shock and bump tests (IEC 60255-21-2:1988)
EN 60255-21-3:1995	Electrical relays – Part 21: Vibration, shock, bump and seismic tests on measuring relays and protection equipment – Section 3: Seismic tests (IEC 60255-21-3:1993)
EN 60255-22-1:2008	Measuring relays and protection equipment – Part 22-1: Electrical disturbance tests – 1 MHz burst immunity tests (IEC 60255-22-1:2007)
EN 60255-22-2:2008	Measuring relays and protection equipment – Part 22-2: Electrical disturbance tests – Electrostatic discharge tests (IEC 60255-22-2:2008)
EN 60255-22-3:2008	Measuring relays and protection equipment – Part 22-3: Electrical disturbance tests – Radiated electromagnetic field immunity (IEC 60255-22-3:2007)
EN 60255-22-4:2008	Measuring relays and protection equipment – Part 22-4: Electrical disturbance tests – Electrical fast transient/burst immunity test (IEC 60255-22-4:2008)
EN 60255-22-5:2011	Measuring relays and protection equipment -- Part 22-5: Electrical disturbance tests - Surge immunity test (IEC 60255-22-5:2008)
EN 60255-22-6:2001	Electrical relays – Part 22-6: Electrical disturbance tests for measuring relays and protection equipment – Immunity to conducted disturbances induced by radio frequency fields (IEC 60255-22-6:2001)
EN 60255-22-7:2003	Electrical relays – Part 22-7: Electrical disturbance tests for measuring relays and protection equipment – Power frequency immunity tests (IEC 60255-22-7:2003)
EN 60255-24:2001	Electrical relays – Part 24: Common format for transient data exchange (COMTRADE) for power systems (IEC 60255-24:2001)
EN 60255-25:2000	Electrical relays – Part 25: Electromagnetic emission tests for measuring relays and protection equipment (IEC 60255-25:2000)
EN 60255-26:2009	Measuring relays and protection equipment – Part 26: Electromagnetic compatibility requirements (IEC 60255-26:2008)
EN 60255-27:2005	Measuring relays and protection equipment – Part 27: Product safety requirements (IEC 60255-27:2005)

Table A.8 – Standards referenced in hazard log *(continued)*

Identification	Title
EN 60664-1:2007	Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests (IEC 60664-1:2007)
EN 60664-3:2003 + A1:2010	Insulation coordination for equipment within low-voltage systems – Part 3: Use of coating, potting or moulding for protection against pollution (IEC 60064-3:2003 + A1:2010 + corr. Nov. 2010)
EN 60664-4:2006 + corr. Oct. 2006	Insulation coordination for equipment within low-voltage systems – Part 4: Considerations of high-frequency voltage stress (IEC 60664-4:2005) NOTE Applies in conjunction with EN 60664-1:2003, EN 60664-5:2003.
EN 60664-5:2007	Insulation coordination for equipment within low-voltage systems – Part 5: Comprehensive method for determining clearances and creepage distances equal to or less than 2 mm (IEC 60664-5:2007) NOTE Applies in conjunction with EN 60664-1:2007.
EN 61508-1:2001 [3)]	Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 1: General requirements (IEC 61508-1:1998 + corr. May 1999)
EN 61508-2:2001 [4)]	Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems (IEC 61508-2:2000)
EN 61508-3:2001 [5)]	Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 3: Software requirements (IEC 61508-3:1998 + corr. April 1999)
EN 61508-4:2001 [6)]	Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 4: Definitions and abbreviations (IEC 61508-4:1998 + corr. April 1999)
EN 61508-5:2001 [7)]	Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 5: Examples of methods for the determination of safety integrity levels (IEC 61508-5:1998 + corr. April 1999)
EN 61508-6:2001 [8)]	Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 6: Guidelines on the application of IEC 61508-2 and IEC 61508-3 (IEC 61508-6:2000)

[3)] Superseded by EN 61508-1:2010, *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 1: General requirements* (IEC 61508-1:2010).

[4)] Superseded by EN 61508-2:2010, *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems* (IEC 61508-2:2010).

[5)] Superseded by EN 61508-3:2010, *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 3: Software requirements* (IEC 61508-3:2010).

[6)] Superseded by EN 61508-4:2010, *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 4: Definitions and abbreviations* (IEC 61508-4:2010).

[7)] Superseded by EN 61508-5:2010, *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 5: Examples of methods for the determination of safety integrity levels* (IEC 61508-5:2010).

[8)] Superseded by EN 61508-6:2010, *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 6: Guidelines on the application of IEC 61508-2 and IEC 61508-3* (IEC 61508-6:2010).

Table A.8 – Standards referenced in hazard log *(continued)*

Identification	Title
EN 61508-7:2001 [9)]	Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 7: Overview of techniques and measures (IEC 61508-7:2000)
EN 61850-5:2003	Communication networks and systems in substations – Part 5: Communication requirements for functions and device models (IEC 61850-5:2003)
EN 62305-1:2011	Protection against lightning - Part 1: General principle (IEC 62305-1:2010 (mod.))
EN 62305-2:2006 + corr. Nov. 2006	Protection against lightning – Part 2: Risk management (IEC 62305-2:2006)
EN 62305-3:2011	Protection against lightning -- Part 3: Physical damage to structures and life hazard (IEC 62305-3:2010 (mod.))
EN 62305-4:2011	Protection against lightning -- Part 4: Electrical and electronic systems within structures (IEC 62305-4:2010 (mod.))

9) Superseded by EN 61508-7:2010, *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 7: Overview of techniques and measures* (IEC 61508-7:2010).

Annex B
(informative)

Abbreviations and acronyms

Table B.1 – Abbreviations and acronyms

Abbreviation and acronym	Explanation
AC	alternating current
CCZ	current collector zone
DC	direct current
EMC	electromagnetic compatibility
HMI	human machine interface
O&M	operation and maintenance
OCC	operation and control centre
OCLZ	overhead contact line zone
OTHERS	other groups of persons besides PAX, PUB and STAFF, such as trespasser, vandals etc. characteristic: knowing that there are residual risks when entering the vicinity of tracks, power lines and contact systems
PAX	passengers of the railway. characteristic: not expecting a risk
PUB	general public, e.g. neighbourhood, passer-by, but not passengers. characteristic: not expecting a risk
STAFF	competent persons having the permission for access to and work on railway assets, e.g. railway personnel, civil workers for railway construction, search and rescue etc. Characteristic: knowing that there are residual risks when entering electrical rooms or the vicinity of tracks, power lines and contact systems
TSI	technical specification interoperability
T&C	testing and commissioning
WHO	world health organisation of the United Nations

Annex C
(informative)

Documents and standards correlated to this document

Table C.1 – List of correlated documents and standards

Identification	Title
2002/730/EC - TSI MAI Maintenance	Commission Decision 2002/730/EC of 30 May 2002 concerning the technical specification for interoperability relating to the maintenance subsystem of the trans-European high-speed rail system referred to in Article 6(1) of Directive 96/48/EC, OJ L 245, 12.9.2002, p. 1-36
2004/108/EC	Directive 2004/108/EC of the European Parliament and of the Council of 15 December 2004 on the approximation of the laws of the Member States relating to electromagnetic compatibility and repealing Directive 89/336/EEC, OJ L 390, 31.12.2004, p. 24-37
2004/49/EC	Directive 2004/49/EC of the European Parliament and of the Council of 29 April 2004 on safety on the Community's railways and amending Council Directive 95/18/EC on the licensing of railway undertakings and Directive 2001/14/EC on the allocation of railway infrastructure capacity and the levying of charges for the use of railway infrastructure and safety certification (Railway Safety Directive), OJ L 164, 30.4.2004, p. 44-113
2006/42/EC	Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC (recast), OJ L 157, 9.6.2006, p. 24-86
2006/95/EC	Directive 2006/95/EC of the European Parliament and of the Council of 12 December 2006 on the harmonisation of the laws of Member States relating to electrical equipment designed for use within certain voltage limits, OJ L 374, 27.12.2006, p. 10-19
2008/232/EC - TSI RST Rolling Stock	Commission Decision 2008/232/EC of 21 February 2008 concerning a technical specification for interoperability relating to the rolling stock sub-system of the trans-European high-speed rail system, OJ L 84, 26.3.2008, p. 132-392
2008/284/EC - TSI ENE Energy	Commission Decision 2008/284/EC of 6 March 2008 concerning a technical specification for interoperability relating to the energy sub-system of the trans-European high-speed rail system, OJ L 104, 14.4.2008, p. 1-79
EN 50110-1	Operation of electrical installations
EN 50110-2	Operation of electrical installations – Part 2: National annexes
EN 50119	Railway applications – Fixed installations – Electric traction overhead contact lines
EN 50121 (all parts)	Railway applications – Electromagnetic compatibility
EN 50122 (all parts)	Railway applications – Fixed installations – Electrical safety, earthing and the return circuit
EN 50123 (all parts)	Railway applications – Fixed installations – D.C. switchgear
EN 50124-1	Railway applications – Insulation coordination – Part 1: Basic requirements – Clearances and creepage distances for all electrical and electronic equipment

Table C.1 – List of correlated documents and standards *(continued)*

Identification	Title
EN 50124-2	Railway applications – Insulation coordination – Part 2: Overvoltages and related protection
EN 50125-2	Railway applications – Environmental conditions for equipment – Part 2: Fixed electrical installations
EN 50126-1	Railway applications – The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS) – Part 1: Basic requirements and generic process
EN 50152-3-1	Railway applications – Fixed installations – Particular requirements for a.c. switchgear – Part 3-1: Measurement, control and protection devices for specific use in a.c. traction systems – Application guide
EN 50152-3-2	Railway applications – Fixed installations – Particular requirements for a.c. switchgear – Part 3-2: Measurement, control and protection devices for specific use in a.c. traction systems – Single-phase current transformers
EN 50152-3-3	Railway applications – Fixed installations – Particular requirements for a.c. switchgear – Part 3-3: Measurement, control and protection devices for specific use in a.c. traction systems – Single-phase inductive voltage transformers
EN 50153	Railway applications – Rolling stock – Protective provisions relating to electrical hazards
EN 50163	Railway applications – Supply voltages of traction systems
EN 50238	Railway applications – Compatibility between rolling stock and train detection systems
EN 50317	Railway applications – Current collection systems – Requirements for and validation of measurements of the dynamic interaction between pantograph and overhead contact line
EN 50318	Railway applications – Current collection systems – Validation of simulation of the dynamic interaction between pantograph and overhead contact line
EN 50328	Railway applications – Fixed installations – Electronic power converters for substations
EN 50329	Railway applications – Fixed installations – Traction transformers
EN 50367	Railway applications – Current collection systems – Technical criteria for the interaction between pantograph and overhead line (to achieve free access)
EN 50388	Railway applications – Power supply and rolling stock – Technical criteria for the coordination between power supply (substation) and rolling stock to achieve interoperability
CLC/TR 50488	Railway applications – Safety measures for the personnel working on or near overhead contact lines
EN 50526-1 [10)]	Railway applications – Fixed installations – D.C. surge arresters and voltage limiting devices – Part 1: Surge arresters

[10)] At draft stage.

Table C.1 – List of correlated documents and standards *(continued)*

Identification	Title
EN 60071-1	Insulation co-ordination – Part 1: Definitions, principles and rules (IEC 60071-1)
EN 60071-2	Insulation co-ordination – Part 2: Application guide (IEC 60071-2)
EN 60255-3	Electrical relays – Part 3: Single input energizing quantity measuring relays with dependent or independent time (IEC 60255-3, mod.)
EN 60255-5	Electrical relays – Part 5: Insulation coordination for measuring relays and protection equipment – Requirements and tests (IEC 60255-5)
EN 60255-6	Electrical relays – Part 6: Measuring relays and protection equipment (IEC 60255-6, mod.)
EN 60255-8	Electrical relays – Part 8: Thermal electrical relays (IEC 60255-8, mod.)
EN 60255-21-1	Electrical relays – Part 21: Vibration, shock, bump and seismic tests on measuring relays and protection equipment – Section 1: Vibration tests (sinusoidal) (IEC 60255-21-1)
EN 60255-21-2	Electrical relays – Part 21: Vibration, shock, bump and seismic tests on measuring relays and protection equipment – Section 2: Shock and bump tests (IEC 60255-21-2)
EN 60255-21-3	Electrical relays – Part 21: Vibration, shock, bump and seismic tests on measuring relays and protection equipment – Section 3: Seismic tests (IEC 60255-21-3)
EN 60255-22-1	Measuring relays and protection equipment – Part 22-1: Electrical disturbance tests – 1 MHz burst immunity tests (IEC 60255-22-1)
EN 60255-22-2	Measuring relays and protection equipment – Part 22-2: Electrical disturbance tests – Electrostatic discharge tests (IEC 60255-22-2)
EN 60255-22-3	Measuring relays and protection equipment – Part 22-3: Electrical disturbance tests – Radiated electromagnetic field immunity (IEC 60255-22-3)
EN 60255-22-4	Measuring relays and protection equipment – Part 22-4: Electrical disturbance tests – Electrical fast transient/burst immunity test (IEC 60255-22-4)
EN 60255-22-5	Measuring relays and protection equipment – Part 22-5: Electrical disturbance tests – Surge immunity test (IEC 60255-22-5)
EN 60255-22-6	Electrical relays – Part 22-6: Electrical disturbance tests for measuring relays and protection equipment – Immunity to conducted disturbances induced by radio frequency fields (IEC 60255-22-6)
EN 60255-22-7	Electrical relays – Part 22-7: Electrical disturbance tests for measuring relays and protection equipment – Power frequency immunity tests (IEC 60255-22-7)
EN 60255-24	Electrical relays – Part 24: Common format for transient data exchange (COMTRADE) for power systems (IEC 60255-24)
EN 60255-25	Electrical relays – Part 25: Electromagnetic emission tests for measuring relays and protection equipment (IEC 60255-25)

Table C.1 – List of correlated documents and standards *(continued)*

Identification	Title
EN 60255-26	Measuring relays and protection equipment – Part 26: Electromagnetic compatibility requirements (IEC 60255-26)
EN 60255-27	Measuring relays and protection equipment – Part 27: Product safety requirements (IEC 60255-27)
EN 60529	Degrees of protection provided by enclosures (IP code) (IEC 60529)
EN 60664-1	Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests (IEC 60664-1)
EN 60664-3	Insulation coordination for equipment within low-voltage systems – Part 3: Use of coating, potting or moulding for protection against pollution (IEC 60064-3)
EN 60664-4:2006 + corr. Oct. 2006	Insulation coordination for equipment within low-voltage systems – Part 4: Considerations of high-frequency voltage stress (IEC 60664-4:2005) NOTE Applies in conjunction with EN 60664-1, EN 60664-5.
EN 60664-5	Insulation coordination for equipment within low-voltage systems – Part 5: Comprehensive method for determining clearances and creepage distances equal to or less than 2 mm (IEC 60664-5) NOTE Applies in conjunction with EN 60664-1.
EN 61508 (all parts)	Functional safety of electrical/electronic/programmable electronic safety-related systems (IEC 61508, all parts)
EN 61850 (all parts)	Communication networks and systems in substations (IEC 61850, all parts)
EN 62305 (all parts)	Protection against lightning (IEC 62305, all parts)
HD 637	Power installations exceeding 1 kV a.c.
IEC/TS 60479-1	Effects of current on human beings and livestock – Part 1: General aspects
IEC/TS 60479-2	Effects of current on human beings and livestock – Part 2: Special aspects
UIC 791	Quality assurance of overhead line equipment
UIC 791-1	Maintenance guidelines for overhead contact lines

Bibliography

NOTE See also Table A.8 and Table C.1.

EN 50238, *Railway applications – Compatibility between rolling stock and train detection systems*

EN 60870-5-104, *Telecontrol equipment and systems – Part 5-104: Transmission protocols – Network access for IEC 60870-5-101 using standard transport profiles* (IEC 60870-5-104)

EN 61010 (all parts), *Safety requirements for electrical equipment for measurement, control, and laboratory use* (IEC 61010, all parts)

EN 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety-related systems* (IEC 61508, all parts)

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

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

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