

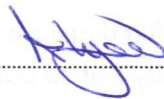
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Specification

Specification for the design of earthing and bonding systems for 25 kV a.c. electrified lines

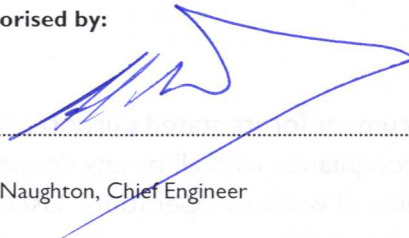
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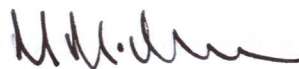
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Issue record

Issue	Date	Comments
E3	April 2007	Re-issued to reconcile temporary non-compliances, which have been agreed and were due to expire.

Implementation

7 April 2007

Compliance

This Network Rail specification is mandatory and must be complied with by Network Rail and its contractors from 7 April 2007.

When this specification is implemented, it is permissible for all projects, which have formally completed GRIP Level 4, to continue to comply with the Issue of any relevant Network Rail standards current when GRIP Level 4 was reached and not to comply with requirements contained herein unless the head of electrification and fixed plant has stipulated otherwise in the accompanying briefing note.

Where the head of electrification and fixed plant has specified that all projects will comply with the requirements, specific authority not to comply can be sought in the usual manner using the appropriate non-compliance authority processes described in Network Rail standard, [NR/SP/STP/045](#) Managing the process for non-compliance authority (formerly RT/LS/P/045).

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1 Purpose

This specification states the requirements for the design of earthing and bonding systems for 25kV a.c. electrified lines to ensure a continuous return circuit for traction load current and a continuous return path for fault current, and to ensure that accessible and touch voltages in excess of the values quoted in Appendix A do not occur.

The document is to be read in conjunction with the relevant project design remit.

2 Scope

This specification applies to earthing and bonding systems installed on Network Rail 25kV a.c. electrified lines.

Bonding required exclusively for signalling purposes is outside the scope of this specification.

3 Reference documentation

[NR/GN/ELP/27233](#) Network Rail guidance note for the characteristics of railway electrification traction power supplies

[NR/SP/ELP/21131](#) Network Rail specification for warning and other signs for a.c. and d.c. electrified lines

[NR/SP/ELP/40045](#) Network Rail specification for electric points heating

[BS EN 50122-1](#) Railway applications - Fixed Installations Part 1. Protective provisions relating to electrical safety and earthing

[BS 7671](#) Requirements for Electrical Installations

4 Definitions and abbreviations

For the purpose of this specification the following definitions and abbreviations shall apply:

Accessible voltage	That part of the rail potential under operating conditions which can be bridged by persons, the conductive path being conventionally from hand to both feet through the body or from hand to hand.
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Autotransformer	A transformer with a single winding that is centre tapped to provide a zero potential traction return connection. The +25kV terminal is connected to the catenary and the –25kV terminal is connected to the autotransformer feeder.
Autotransformer electrification system	A system of electrification in which the supply transformer secondary voltage is 50kV, centre tapped to earth. Two live 25kV secondary connections are made to the catenary and autotransformer feeder wires respectively. The earthed centre tapping is connected to the traction return circuit.
Autotransformer feeder	A bare live conductor provided in an autotransformer electrification system connecting the –25kV terminals of adjacent autotransformers. The autotransformer feeder is normally mounted upon 25kV insulators directly above the mast on cantilever and headspan structures, or directly above the uprights of a portal structure.
Autotransformer Site	The site of lineside equipment including autotransformers arranged together for the purpose of providing immunisation to signalling and telecommunications equipment and remote switching of the power supply to the overhead line equipment. Some autotransformer sites may also be track sectioning sites.
Bonding	The electrical connection of two or more conductive parts to ensure a continuous path for electric current, or, to maintain the connected parts at substantially the same potential.
Bonding Plan	A common plan which records the bonding necessary for both signalling and electrification purposes.
Bond	A suitably designed conductor electrically connecting together conductive parts.
Continuity bond (traction)	A bond across an electrical discontinuity in the traction return rails, e.g. at points and crossings, trap points and expansion points.
Cross bond (traction)	A bond between the traction return rails of the same track or adjacent tracks.

Impedance bond	A device which, whilst allowing the traction return current to flow freely, so impedes the flow of track circuit current as virtually to isolate two track circuits one from another.
Rail joint bond	A bond across a joint in the running rails.
Red bond	A bond which if disconnected could result in either the bond or the equipment to which it is connected rising to a voltage in excess of the accessible or touch voltage values quoted in Appendix A.
Return conductor-to-rail bond	A bond from the traction return rail to the return conductor, often called a 'mid point connection'. These will usually be 'Red bonds'.
Structure bond	A bond connecting the steelwork of an overhead line equipment structure, or bridge, or other metal structure, to the traction return circuit.
Transposition bond (traction)	A bond connecting two traction return rails where the traction return rail changes from one side of the track to the other.
Yellow bond	A bond which is required for track circuit integrity and normally also for traction return purposes.
Booster transformer	A device to induce into the return conductors, virtually the whole of the traction return current, in order to reduce to a minimum electrical interference with communication circuits.
British Standard	A standard published by the British Standards Institution. Its alphanumeric identity is prefixed by BS.
CCTV	Closed circuit television
Circuit protective conductors	A protective conductor connecting exposed conductive parts to the main earthing terminal.
Classic electrification system	The traditional electrification system in which the supply transformer secondary voltage is 25kV and which generally uses a high level return conductor and booster transformers to minimise interference to lineside equipment.
Conductive part	A part of a building or other fixed plant and equipment which is capable of conducting electricity.

Contact line	A conductor system for supplying electric energy to vehicles through current collecting equipment.
Diversely routed bonds	Bonds which are independently routed via undertrack crossings, hollow bearers or aerial routes to ensure that the two bonds are not surface routed through the same cess or track.
Earth	The conductive mass of the Earth, whose electric potential at any point is conventionally taken as equal to zero.
Earth electrode	A conductor in intimate contact with and providing an electrical connection with earth.
Earth wire	A conductor electrically connecting together the steelwork of two or more overhead line structures or a number of overhead line small part steelwork assemblies and bonded to a traction return rail or to the centre tap of an impedance bond.
Equipotential bonding	Electrical connections ensuring that various conductive parts and extraneous conductive parts are maintained at substantially equal potential.
European Standard	A standard published by the European Committee for Standardisation or by the European Committee for Electrotechnical Standardisation. Its alphanumeric identity is prefixed by EN.
Exposed conductive part	A conductive part which can be touched and which is not normally live, but which may become live under fault conditions, such as exposed metalwork, exposed metal parts, exposed metal surfaces or exposed metal services and is within the overhead contact line zone or the pantograph zone. Excludes speed restriction signs, drain covers, metal stakes securing troughing and sections of fencing shorter than 3m.
Extraneous conductive part	A conductive part liable to introduce a potential, generally earth potential, such as bridge metalwork and metal services.
Fault current	The current which flows as a result of a non-intentional electrical fault on the electrification system, e.g. a short circuit or flashover.

Feeder Station	A building or compound containing electrical switchgear and equipment to which the main supplies from the Electricity Supply Industry are brought and from which the overhead line equipment is supplied.
Flammable gases and liquids	Those products which are dangerous goods with a flash point not exceeding 61 °C.
Hazardous zone	Those areas in which there exists a risk of explosion because flammable atmospheres exist.
Live	At a voltage by being connected to a source of electricity.
Metallic service	A service having an exposed metallic surface e.g. a gas pipe, water pipe, conduit, or metal sheathed cable.
Network Rail controlled infrastructure	As defined in the Network Rail Railway Safety Case.
Overhead contact line	A contact line placed above the roof of vehicles and supplying vehicles with electric energy through roof mounted current collection equipment.
Overhead contact line zone and pantograph zone	The zones whose limits are not exceeded in general, by a live, broken overhead line conductor or by a live, broken or dewired pantograph respectively.
Overhead line equipment	An arrangement of wires, suspended over the railway line, for supplying electricity to electric trains, together with associated fittings, insulators and other attachments including feeders, autotransformer feeders, overhead line switches, jumpers and return conductors.
Rail potential	The voltage occurring between the traction return rails and earth under operating conditions or under fault conditions.
Return conductor	A conductor provided in a classic electrification system to carry traction return current back to a feeder station for the purpose of suppressing electromagnetic interference in telecommunication and signalling circuits.

With booster transformers	A return conductor carried on insulators and connected in series with the secondary windings of booster transformers and bonded to the traction return rails.
Without booster transformers	A return conductor in electrical contact with the overhead line structures on which it is supported. It also fulfils the function of an earth wire and is bonded to the traction return rails.
Separately fed track	An electrical section from a neutral section or overlap to the next neutral section or overlap separately fed by a circuit breaker at each end or an electrical section from a neutral section or overlap to a terminal end or stub end separately fed by a single circuit breaker.
Simultaneous touching distance	The distance which can be bridged by a person. In general a minimum horizontal dimension of 2m and a minimum vertical dimension of 2.5m are adopted. Notes: 1. 'Can be touched simultaneously' – a simultaneous touching distance less than 2m in a horizontal direction and/or less than 2.5m in a vertical direction. 2. 'Can not be touched simultaneously' – a simultaneous touching distance greater than 2m in a horizontal direction and greater than 2.5m in a vertical direction.
SMOS	Structure mounted outdoor switchgear
Spider plate	A metal plate used as a point of common connection where a number of bonds from different connection points require to be commonly connected.
Stray current	The current which follows paths other than intended paths.
Switching station	The site of lineside equipment arranged together for the purpose of providing remote switching of the power supply to the overhead line equipment including Classic and Autotransformer Feeder Stations, Track Sectioning Cabins, Track Sectioning Locations and Autotransformer Sites.

Touch voltage	The voltage occurring under fault conditions between parts when touched simultaneously.
Track Sectioning Cabin	A building containing enclosed electrical switchgear and equipment which is arranged to connect together a number of sections of overhead line equipment.
Track Sectioning Location	A compound containing outdoor electrical switchgear and equipment which is arranged to connect together a number of sections of overhead line equipment.
Traction earth	The distributed earth system formed by the traction return rails intentionally connected to the general mass of earth by the foundations of the overhead line structures.
Traction load current	The current which flows as a result of the operation of electric trains.
Traction return rail	A running rail used to carry traction return current.
Traction return circuit	The path by which traction load current returns from a traction unit to a Feeder Station, incorporating the traction return rails, bonding connections, return conductors and booster transformers as appropriate.
Voltage limiting device	A protective device against the existence of an inadmissibly high voltage.

5 Performance requirements

The earthing and bonding system design shall be fit for purpose when installed as part of the 25kV a.c. electrification system specified in the project design remit.

NR/GN/ELP/27233 describes the types of 25kV a.c. electrification systems forming part of Network Rail's railway infrastructure.

The earthing and bonding system shall:

- provide a reliable, adequately rated, continuous return circuit for the return of traction load current;
- provide a reliable, adequately rated, continuous return circuit for fault current including that arising at any structure or at any conductive part bonded to traction earth so as to ensure the proper operation of protective equipment and the disconnection of the supply;

- c) provide permanent multiple connections between the traction return circuit and the general mass of earth by way of the overhead line structure foundations, supplemented where necessary, by other earthing when the presence of foundations alone is inadequate;
- d) ensure that accessible voltages and touch voltages do not rise above the values quoted in Appendix A, including those associated with metal objects connected to remote earth;
- e) ensure that capacitive or electromagnetic potentials are not present on metallic services, earth electrodes and other metallic objects in excess of the values quoted in Appendix A;
- f) prevent, so far as practicable, traction return current and fault current from flowing in non-electrified lines, metallic services, earth electrodes and other metallic objects which may be affected and ensure that such currents do not exceed safe levels;
- g) prevent arcing in the vicinity of Flammable Gas and Liquid or Oxygen Installations when transfer is taking place;
- h) at interfaces with other electrified lines, non-electrified lines and other administrations' railways, be coordinated with the earthing and bonding and return current arrangements of such other lines, so that the above performance requirements are complied with across the interfaces, and the risks from stray current are limited to acceptable levels.

Notes:

- 1. Stray a.c. or d.c. current may cause hazards to signalling and telecommunications circuits.
- 2. Stray d.c. current will damage buried metallic assets by electrolytic corrosion.

6 Input design data

The following design data will be provided in the project design remit.

6.1 Route data

- a) Details of the lines to be electrified and interfaces with existing a.c. or d.c. electrified lines.
- b) Details of those locations where provision is to be made for future electrification.
- c) Details of the types of 25kV a.c. electrification systems to be utilised.
- d) Details of the existing and proposed signalling systems.
- e) Details and location of any new a.c. / d.c. interfaces.
- f) Details and locations of nearby other administration's electrification systems.

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- g) Details and locations of stations, tunnels, viaducts, bridges, metal pipes crossing over the track, metal pipes or conduits running in parallel with the track for more than 200m and cables installed above ground level.
- h) Details and locations of any Flammable Gas and Liquid or Oxygen Installations.

6.2 Electrification system design data

- a) Base track plan showing running rails, overhead line structures, bridges etc.
- b) Preliminary traction power supply system design.
- c) Preliminary overhead line equipment system design including as appropriate the preliminary system design for return conductors or autotransformer feeders and details of any earth wires or necessary supplementary earths.
- d) Locations of switching stations.
- e) Locations of and preliminary designs for any new interfaces with existing d.c. electrified Lines.
- f) The magnitude and duration of fault current.
- g) The required electrical rating of bonds.
- h) The policy to be followed with regard to the bonding of extraneous parts and services.

7 Overhead contact line zone and pantograph zone

7.1 Dimensions

The overhead contact line zone dimensions for a specific location on Network Rail controlled infrastructure shall be determined from the positions of the 25kV overhead line conductors, including the position of out of running and terminating contact lines and 25kV feeder wires, but not from the positions of return conductors or earth wires.

Note: The term '25kV feeder wires' includes bare feeder wires and autotransformer feeder wires.

The dimensions of the overhead contact line zone and pantograph zone for a specific location shall be determined as follows: