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NR/L3/ELP/29987

Module 4

Maintaining the Integrity and Safe Operation of 25 kV A.C. Electrified Lines

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1 Purpose

Compliance with this module will preserve the integrity of the 25 kV a.c. electrification system and promote its safe and efficient operation through requirements and controls for its physical condition, electrical continuity and relationship with other infrastructure systems.

NOTE: Further requirements for working on or about the electrified lines are contained in the Rule Book Module AC (GE/RT8000/AC) and Handbook HB16 (GE/RT8000/HB16).

2 Scope

This module states the requirements for maintaining the integrity and safe and efficient operation of the 25 kV a.c. electrification system, through attention to the position of the overhead line equipment relative to the track, to traction bonding, and to automatic power control inductors.

It is applicable to Network Rail personnel and to Network Rail's contractors.

To provide a consistent approach to working on or about 25 kV a.c. electrified lines, Train Operating Companies may, as best practice, apply this standard to infrastructure they control.

This Standard also includes:

- Work on or about any future sections of electrification on Network Rail controlled infrastructure and areas required to adopt a process for securing points of disconnection to form points of isolation to use the Supplementary Isolation Process (Module X).
- Planning of isolations, testing and earthing of overhead line equipment on Network Rail controlled infrastructure equipped with 750V d.c. overhead line system (Sheffield Tram Train - Module Y).
- Planning of isolations, testing and earthing of overhead line equipment on Network Rail controlled infrastructure equipped with 1500V d.c. overhead line system (Sunderland Metro Systems Operating Area – Module Z).

3 25 kV A.C. Electrification Equipment

3.1 Overhead Line Equipment Masts and Structures

Nothing shall be fixed or attached to overhead line equipment or overhead line equipment structures without the permission of the Delivery Unit Electrification and Plant Engineer (DUE&PME).

Excavation or other work which is likely to affect the 25 kV a.c. electrification equipment, in particular structures, cables or their supports or covers, shall not be carried out without the permission of the relevant DUE&PME.

3.2 Overhead Line Conductors

If objects are observed to have been thrown onto, or are hanging from, the overhead line equipment, the circumstances shall be reported immediately to the ECO.

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Do not approach broken or displaced overhead line conductors, either on the ground or touching other infrastructure equipment, and treat as live and consequently dangerous to life. Immediately report any damage to the ECO.

If smoking, excessive flashing, fusing or other damage is observed, the ECO may implement a block to electric trains in accordance with electrical control instructions.

4 Traction Bonding – Description

4.1 General

Electric trains draw power from the OLE with current returning to the feeder stations via the running rails, earth wires, return conductors depending upon the specific location design. Each OLE structure is bonded to the traction return system.

Electrically conductive structures and services, where there is a risk of exposed metalwork becoming electrically connected to live OLE (by flashover, breakage of conductors, etc.), are bonded to the traction return system, thus providing a means of detection of a fault by the protection and disconnection of the traction power supply in the event of a fault. Additionally, equipotential bonding is provided where it is possible to simultaneously touch exposed metalwork and the running rails, trains or other conductive objects connected to the traction return system. This is necessary to limit accessible and touch voltages to values within acceptable limits.

The traction return current passing through the running rails and the bonding system is not dangerous to life.

However, if the rails are broken or separated, or the bonds become detached, they shall not be touched until the requirements of clause 7.3 and Module 7 clause 14 have been met.

This is because a dangerous voltage might be present.

Network Rail standard NR/L2/ELP/21085 states the requirements for the design of earthing and bonding for 25 kV a.c. electrified lines.

4.2 'Red' Bonds

Certain bonds connected to the running rails, such as those from switching stations, return conductors, auxiliary supplies transformers, earthing devices, harmonic dampers, etc. are marked in red. If disconnected at either end this could result in a dangerous voltage arising and a consequent risk of injury.

Red bonds shall be disturbed only by competent staff and shall work to a method of work authorised as in table 1.

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Work type	Authorised by
Maintenance	Delivery Unit Electrification and Plant Maintenance Engineer
Projects	Designated Project Engineer

Table 1 – Authorisers of methods of work

Where the DPE is not competent in assessment of electrical risks, they shall seek the advice of an identified competent engineer. Competent engineers are those identified as competent in writing by the Route Asset Manager (E&P).

4.3 'Yellow' Bonds

In certain circumstances, traction bonds which are required for traction return continuity are also essential to provide integrity for track circuits. In other cases, additional bonds are required to provide this facility, but are of a similar type to traction bonds because they might also carry traction current. Both types of bonds are identified by yellow markings and are indicated as such on the master bonding plan.

4.4 'Green' Bonds

Connections between the main earthing terminal (MET) of an LV network and the traction return circuit are designated as 'green bonds'.

If disconnected, the LV equipment or LV circuit might no longer be earthed. As a consequence: a fault on the LV system, or a broken overhead contact line coming into contact with the LV equipment, might not be detected.

Green bonds shall only be disconnected by competent staff and shall work to a method of work authorised as in table 1.

Where the DPE is not competent in assessment of electrical risks, they shall follow the advice of an identified competent engineer.

5 Bonds Found Broken or Disconnected

5.1 General

The reporting and repair of defective bonds found during the course of planned electrification maintenance activities shall be in accordance with the relevant Network Rail instructions.

Bonds found to be broken or defective under any other circumstances shall be reported immediately to the ECO identifying the type of bond, location and a description of the defect. The ECO shall initiate arrangements for corrective action to be taken in accordance with electrical control instructions.

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5.2 'Red' Bonds Broken or Disconnected

5.2.1 General

The previous clause states the general requirements for the reporting of any broken or defective bonds. However, damage to certain arrangements of red bonds, as detailed below, shall be immediately reported to the ECO.

5.2.2 Between Return Conductors Carried on Insulators and Rail or a Return Current Busbar

If the red bonds between a return conductor carried on insulators and rail or a return current busbar are broken or disconnected, the bonds could be at a dangerous voltage and shall not be touched.

Modules 7 and 11 state the requirements for earthing and working on connections between return conductors carried on insulators and rail or a return current busbar.

5.2.3 Between a Return Current Busbar and Rail

If all red bonds between a return current busbar and rail are broken or disconnected, the switching station enclosure, its fencing, the equipment within it and the bonds could be at a dangerous voltage and shall not be touched.

The ECO shall arrange for the de-energisation of the switching station and of the OLE in accordance with electrical control instructions; and for repairs to be undertaken by authorised staff.

Modules 7 and 11 state the requirements for earthing and working on connections between a return current busbar and rail.

5.2.4 Between Structures Carrying 25 kV Auxiliary Supplies Transformers and Rail

At certain locations, the neutral of the primary winding of a 25 kV single phase auxiliary supplies transformer is connected directly to the OLE structure on which it is mounted. This structure is then bonded to the traction return circuit by two separate bonds to two separate rails. One of these connections might be aerial. Both of these bonds are red bonds.

If both of these red bonds are broken, the structure and any overhead line disconnector mounted on it and the bonds could be at a dangerous voltage and shall not be touched.

The ECO shall arrange for the isolation of the transformer and, where necessary, the isolation and earthing of the section of the overhead line feeding the transformer in accordance with electrical control instructions.

Modules 7 and 11 state the requirements for earthing and working on connections between structures carrying 25 kV auxiliary supplies transformers and rail.

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5.2.5 Between Structures Carrying Earthing Devices or Harmonic Dampers and Rail

The earth terminal of earthing devices and the neutral terminal of harmonic dampers are connected directly to the OLE structure on which they are mounted. The structures are bonded to the traction return circuit by two separate bonds to two separate rails. One of these connections might be aerial. Both of these bonds are red bonds.

If both of the red bonds between the structure and the rail are broken, the structure and equipment mounted on it could be at a dangerous voltage and shall not be touched.

The ECO shall arrange for the isolation and earthing of the section of the overhead line to which the earthing device or harmonic damper is connected. In those cases where a harmonic damper is not connected directly to OLE, the ECO shall arrange for the isolation and earthing of the equipment to which it is connected in accordance with the electrical control instructions.

Modules 7 and 11 state the requirements for earthing and working on connections between structures carrying earthing devices or harmonic dampers and rail.

5.2.6 Other Red Bonds

Other broken or disconnected red bonds could still be at a dangerous voltage and shall not be touched. The ECO shall initiate arrangements for corrective action to be taken in accordance with electrical control instructions.

5.3 'Yellow' Bonds Broken or Disconnected

Clause 5.1 states the requirements for the reporting of any broken or defective yellow bonds.

The arrangements for the repair of yellow bonds shall be in accordance with the relevant Network Rail standard.

5.4 'Green' Bonds Broken or Disconnected

Clause 5.1 states the requirements for the reporting of any broken or defective green bonds.

The arrangements for the repair of green bonds shall be in accordance with the relevant Network Rail standard.

6 Bonding Installation

6.1 Application of Requirements

The requirements of this clause and clauses 7 and 8 apply to all bonds including those installed on a temporary basis prior to installation of a permanent bond.

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6.2 Master Bonding Plan

All bonds shall be installed in accordance with the relevant Network Rail standard and as indicated on the master bonding plan.

Prior to final commissioning for service, a thorough check shall be made that all bonds indicated on the master bonding plan have been correctly installed.

7 Bonding Alterations

7.1 Permanent Bonding

Any proposed changes to the continuity of any bonds or any part of the traction return circuit shall be planned so that the integrity of the traction return circuit is not compromised. Where necessary, the appropriate parties shall be in attendance to undertake the appropriate precautions. The planning process shall meet the requirements of this standard.

Redundant bonds shall either be totally removed at the time of disconnection or dealt with in accordance with the relevant Network Rail standard and arrangements made for their early removal.

7.2 Temporary Bonding

Temporary bonds installed for track renewals, repairs, or temporary bonding requirements, shall be in accordance with the relevant Network Rail standard.

7.3 Interrupted Continuity of Running Rails

If the electrical continuity of the traction return running rail is interrupted as a result of a defect, i.e. a completely broken and/or parted rail, this shall be reported immediately to the ECO.

A dangerous voltage might be present across the rail break.

When clamping a broken and/or parted traction return rail is undertaken a temporary bond shall first be applied across the break in the rail.

Temporary bonds shall be applied only by authorised staff and both ends of the bond shall not be touched simultaneously.

The DUE&PME, or delegate, shall assess the appropriate safe method of working for applying the temporary bond based on the following criteria:

- a) A temporary bond shall be applied without a switch-off (de-energisation) provided that:
 - 1) the integrity of the traction return system including adjacent track to track and/or rail to rail bonding arrangements have been visually verified against an approved bonding plan or schedule 400m either side of the broken and/or parted rail; or,
 - 2) an aerial earth wire is installed, and the integrity of these electrical connections have been visually verified either side of the parted rail.

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- b) Where the bonding arrangement or electrical connections cannot be verified, the ECO shall arrange for a block to electric trains (BTET) or a switch-off (de-energisation) of the complete electrical section for the affected track in accordance with Electric Control Instructions whilst the temporary bond is installed.

Single track areas without an aerial earth wire and with single rail traction return shall meet the requirements of clause 7.3 b).

Task risk control sheet NR/L3/MTC/RCS0216/OLE11 states the requirements for the application of temporary bonds.

A switch-off of the OLE is referred to as 'de-energisation' and shall be implemented by the ECO. This does not constitute an isolation or emergency switch-off and the overhead line equipment shall be treated as live.

As part of planned works where a traction return rail is to be cut, a temporary bond shall first be applied across the position where the cut is to be made. The bond shall be in accordance with Network Rail instructions. The bond shall be left in position until the continuity of the traction return rail is again continuous.

7.4 Alterations to Permanent Way

7.4.1 General

Work on the running rails, involving the breaking of any bonds or connections fixed thereto or compromising continuity of the return circuit through the rails, may be carried out by an Infrastructure Maintainer having a safe system of work.

Where such work is to be carried out by an Infrastructure Maintainer, the safe system of work shall be approved by Network Rail.

Temporary bonds shall be in accordance with the relevant Network Rail standards.

7.4.2 Removal or Loosening of Fishplates for Oiling, Adjustment, etc.

If the rail joint concerned is bonded, temporary bonding need not be applied unless the normal bonding has to be broken.

If the rail joint is insulated, temporary bonding shall not be applied.

If the rail joint is neither bonded nor insulated, a temporary bond shall be applied across the joint before the fishplates are loosened.

7.4.3 Removal of Rails

If the rail to be removed does not have an insulated joint at either end, a temporary bond shall be applied between each end of the rail to be removed and its abutting rails, before the joints are loosened. Each temporary bond shall be of sufficient length to bridge the gap after the rail is removed. When the rail has been removed, the bonds attached to it shall be kept intact until the new rail has been installed and correctly bonded.

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Once the new rail is installed and correctly bonded, the old rail may be taken away and the associated bonds detached.

Alternatively, except in jointless track circuit areas, the abutting rails may first be cross-bonded to another traction return rail.

If such cross-bonding is carried out, the temporary bonds shall be left in position until the rail has been replaced and normal bonding, if any, restored.

If, however, any bonds other than rail joint bonds are attached to the rail to be removed, or if more than one rail is to be removed at locations where Red Bonds, Return Current Busbar and Mid Point Connections etc, are installed and local instructions do not cover the situation, a temporary bonding plan shall be produced, agreed and issued prior to the commencement of the work.

7.5 Laying Out Rails Alongside the Track

When rails greater than 250 metres long are laid out, or left, alongside the running rails, bonding shall be provided to the traction return rail or earth wire at intervals of not more than 400 metres.

Where separate lengths of rail are to be jointed into a continuous length of more than 250 metres (e.g. for a track laying gantry or in preparation for installation as running rails), bonds shall be installed.

- i. Before jointing commences, both ends of each separate length of rail to be jointed shall be bonded to the adjacent traction return rail or earth wire as appropriate.
- ii. A bond shall then be installed across the joint position and the two bonds to the traction return rail or earth wire at the joint position may then be removed.
- iii. This process shall be repeated until the full length of rail has been jointed.
- iv. When joints have been welded, the bonds across the joints may then be removed.
- v. Where the jointed rail is to be installed as running rail and the joints are other than welded joints, the bonds across the joints shall be left in situ until the passage of the normal train service after which the appropriate permanent bonding shall be installed.
- vi. Once permanent bonding is installed, temporary bonds across the joints may be removed.

Any temporary bonding shall not bridge out any insulated rail joints.

7.6 The Use of On-track Machines Necessitating Bonding Alterations

Where an on-track machine is to work beneath live OLE, special arrangements for the removal or alterations to bonds shall be specified in a written method of work and authorised as shown in Table 1, clause 4.2.

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7.7 Bonding of Cables, Pipes, Signal Rods and Wires

Network Rail standard NR/L2/ELP/21085 states the requirements for the design of earthing and bonding systems for 25 kV a.c. electrified lines.

The requirements of this clause protect the integrity of the traction return circuit when work is carried out on lineside cables and services.

Some signalling and telecommunications lineside cables are provided with metallic sheaths for screening purposes. These sheaths are connected at intervals to low resistance earthing systems by means of bolted earth links or other connectors.

The connections shall be maintained at all times and before work of any nature is carried out on the cable, the person carrying out the work shall verify that the connections on both sides of the work are intact.

Before the continuity of a metallic sheath on a lineside cable, or any screening conductor is broken (e.g. before removing a joint sleeve), a temporary bond shall be connected across the proposed break.

In certain cases the levers in signal boxes and ground frames, rods and wires are bonded to the traction return circuit. In other cases, insulation is inserted in rods and wires.

Nothing shall be done which would affect the operation of any signalling equipment.

When cutting, renewing or repairing metallic gas, water, or other pipes, either above ground or buried alongside electrified lines, a temporary electrical continuity jumper cable shall be connected across any proposed gap in the pipe before the pipe is cut. The jumper cable shall be left in position until the permanent continuity of the pipe is re-established.

In some situations insulated joints are deliberately introduced.

Do not short circuit these by a temporary continuity jumper or metallic tools, etc.

In other situations pipes are bonded to earth and these connections shall not be removed unless they have previously been replaced by a temporary connection. In those situations where nominal insulation is provided between pipes and their supports, this shall not be short-circuited or removed.

When a metallic pipe in the vicinity of an electrified line is to be replaced with a pipe made of plastic or any other insulating material, the work shall be specified in a written method of work and agreed with the DUE&PME.

The above requirements are in addition to the requirements of Modules 2 and 3 concerning the assessment and management of electrical risks.

8 Permanent Way

8.1 General

The development of the track layout design shall be designed to accommodate the full range of movement of the pantograph gauge in accordance with Network Rail standard NR/L2/ELP/27715.

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The design of the overhead line equipment is based on the assumption that the geometrical relationship between the contact wire and the pantograph will be maintained at all times within agreed tolerances in accordance with the Network Rail standard NR/L2/ELP/21088.

Assuming that the relationship between the contact wire and its supporting structure is fixed, the correct pantograph and contact wire relationship shall be maintained by establishing and monitoring the relative positions of the supporting structure and the track.

NOTE: For this purpose, in some areas markers are provided on the fixed structure to indicate the design position of the track.

8.2 Sluicing and Lifting Running Rails

The running rails shall not be sluiced or raised or the super-elevation altered, except for such slight movements within the agreed limits of tolerance that are required to maintain the existing agreed line and level, without agreement between representatives of the relevant Route Asset Managers and, when applicable, the Network Rail (High Speed 1 Ltd) E&P Engineer, Rail For London Infrastructure Limited (Elizabeth Line) Discipline Engineer or South Yorkshire Supertram Limited (Sheffield Supertram) Discipline Engineer.

If, in an emergency, it is necessary to slue a line beyond the agreed limit of tolerance, the section of line affected shall be blocked to electric trains until the Infrastructure Maintainer's representative is satisfied that electric train working may be resumed.

The above requirements are in addition to the requirements of Modules 2 and 3 concerning the assessment and management of electrical risks.

NOTE: Network Rail standard NR/L3/TRK/2049 states the requirements for the design of track alignment and layouts on existing and new track assets.

9 Automatic Power Control Inductor

This clause sets requirements for the reporting of defective trackside APC equipment and arrangements to avoid repeated flashover and electrical damage to neutral sections.

Any APC track inductor found to be loose, damaged or defective shall be reported immediately to the ECO who shall initiate arrangements for it to be replaced or repaired in accordance with electrical control instructions.

If the defective inductor is on the approach side of the neutral section, the ECO shall notify the appropriate Network Rail Route Control, signal box Supervisor or Signaller so that arrangements can be made for all electric trains passing over that inductor to be warned that the APC track inductor is defective and that they shall shut off power immediately before entering the neutral section.