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NR/L3/ELP/29987

Module 1

General Requirements

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1 Purpose

This module supports a consistent understanding of 25 kV a.c. electrification and working on or about 25 kV a.c. electrified lines.

NOTE: Further requirements for working on or about the electrified lines and for communication are contained in the Rule Book Modules AC, HB16 and G1 (GE/RT8000/AC, GE/RT8000/HB16 and GE/RT8000/G1).

2 Scope

This module states the general requirements for working on or about 25 kV a.c. electrified lines including responsibilities, a description of the electrification systems, the danger that can arise from live overhead line equipment and how to communicate with the Electrical Control Operator (ECO).

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 a 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 Management of Staff Training and Competence

3.1 Employers

Employers are responsible for arranging that persons under their supervision who are required to work on electrified lines, or so near that danger could arise, are supplied with, trained and where required certificated in meeting the requirements contained within the Rule Book (GE/RT8000), the relevant modules forming this standard and that all such persons:

a) understand the requirements relating to their personal safety;

b) understand the requirements relating to obtaining an emergency switch-off;

c) understand the requirements which apply specifically to them and that they should make themselves acquainted with, and will be held responsible for the observance of, all such requirements.

Employers shall arrange for their staff who are required to operate overhead line disconnectors to be trained and authorised for this purpose in meeting the requirements provided within Network Rail standard NR/L2/CTM/014.

Employers shall arrange for their staff who are required to use voltage testing devices, live line tools, live line measuring devices and portable earthing equipment to be trained, assessed as competent and authorised for this purpose in meeting the requirements provided within Network Rail standard NR/L2/CTM/014.

3.2 Persons Working on or about the Electrified Lines

All persons required to work on or about the electrified lines should make themselves familiar with the work activity and electrical risks found in this standard.

3.3 Electrical Control Operators

The Electrical Control Operator is responsible for the safe operation of the electric traction system and, in conjunction with others, for:

a) maintaining the continuity of the electrical supply;

b) the operation of switching station equipment;

c) the operation of overhead line disconnectors.

4 Description of the Electrification System

4.1 System of Electrification

The system of electrification employs overhead conductors carrying electricity at 25,000 volts (25 kV), 50 hertz, alternating current (a.c.).

4.2 Supply of Electricity

Electricity is supplied to Network Rail feeder stations at 25 kV by the electricity supply industry by means of transformers connected to its high-voltage distribution network.

All +25kV -25kV grid supply point for Autotransformer Electrification System, the transformer secondary voltage is at 50 kV, centre tapped to earth. The autotransformer +25kV terminal is connected to the overhead line equipment (OLE) and the –25kV terminal is connected to the along track autotransformer feeder cable. The earthed centre tapping is connected to the traction return circuit.

4.3 The Electric Circuit

From the feeder stations, electrical supplies are taken to the overhead line equipment by means of feeders which are either bare overhead conductors or insulated cables. Bare overhead conductors from the feeder stations are terminated on or adjacent to feeder disconnectors mounted on the OLE supporting structures. Cables from the feeder stations are generally buried in the ground or laid in

troughing at ground level, run to the OLE supporting structures and then continue up the structures and terminate in sealing ends adjacent to the overhead line feeder disconnectors.

Short jumpers are usually installed between the termination of the bare conductors or the sealing ends of the cables and the disconnectors and also between the disconnectors and the OLE. In some cases, however, a cable terminates in a sealing end mounted on a structure and the sealing end is connected to a bare feeder which is supported on the overhead line structures and terminates adjacent to a feeder disconnector.

At feeder stations equipped with Structure Mounted Outdoor Switchgear (SMOS), the principle is similar except that the circuit breakers are not located within a building or enclosure.

Where an autotransformer feeding system is provided, the autotransformer feeders are similarly installed except that an autotransformer might be included in the circuit prior to the final connection to the OLE.

The current is collected from the OLE by the train pantograph and taken to the train equipment. Having passed through the equipment on the train, the current passes through the axles and wheels of the traction unit to the running rails. The current is returned to the feeder station by the traction return running rails which are connected to the feeder station with cables, by return conductors or by autotransformer feeders as explained below. In addition, a part of the current is returned to the feeder station through the general mass of earth.

In some areas, return conductors, connected to the rails at regular intervals, are electrically connected to the masts on which they are supported and can also fulfil the function of an earth wire. However in areas where electrical interference with telecommunications cables and other circuits is likely and there is no autotransformer system installed, return conductors electrically insulated from the masts, normally with booster transformers, are provided to control stray return current and voltage induction in neighbouring circuits.

Where booster transformers and return conductors electrically insulated from structures are provided, the return conductors are connected to the traction return running rails at approximately the mid-point between booster transformers. The current taken by any train situated between a booster transformer and the nearest mid-point connection flows in the traction return running rails to the mid-point connection and from that point on is forced by the booster transformers to flow in the return conductor, the proportion of the current remaining in the rails and earth being very small.

Where the autotransformer feeding system is used, the autotransformer feeders control the effects of electrical interference by taking return current from the running rails at the connections to the autotransformers.

Also, in areas where the autotransformer feeding system is used, and elsewhere, a return screening conductor is installed close to vulnerable telecommunications cables or other circuits. The return screening conductor is connected to the rails at regular intervals and mitigates the adverse effects of the traction current.

4.4 Switching Stations

Switching stations are situated at intervals alongside the electrified lines. They include feeder stations, where the electricity from the electricity supply industry is provided to the railway system, track sectioning cabins and track sectioning locations, which perform the function of Disconnection, sectioning, paralleling and electrical protection.

In areas equipped with an autotransformer feeding system, autotransformer feeder stations and autotransformer sites are provided, which can combine the functions of electrical supply, Disconnection, sectioning, paralleling and electrical protection of the OLE with that of connecting autotransformers to the system.

Switching stations are unattended and are kept closed, locked and alarmed for security. The switchgear is remotely controlled by supervisory control from the electrical control concerned, and is contained within buildings or outdoor housings, or is structure mounted.

4.5 System of Electrical Control

Apparatus for the remote control of the electrical equipment in the switching stations, known as Supervisory Control and Data Acquisition (SCADA), is located in electrical control. Each electrical control is continuously staffed by one or more ECO, who has control of the power supply to the electric traction system and who is responsible for all Disconnection operations of its electrical equipment.

4.6 Overhead Line Equipment

The OLE comprises a catenary wire and a contact wire, with an auxiliary catenary wire or stitch wire or supplementary conductor in some places, supported over each track by steel or other structures. The catenary wire is carried on insulators or insulated supports attached to the structures and the contact wire is suspended from the catenary wire by means of droppers.

Where an auxiliary catenary wire is used, it is suspended from the catenary wire by means of droppers and the contact wire is supported by droppers from the auxiliary catenary wire. On lines where stitch wires are used, the contact wire is supported by droppers from the catenary wire except in the immediate vicinity of the structures where the contact wire is supported by the stitch wire which is connected at its two ends to the catenary wire.

On some minor lines, and in sidings and depots, a construction is used where no supporting catenary wire is provided and only a contact wire is employed, supported by insulators or insulated supports attached to the structures. This is known as ‘tramway’ type equipment.

In areas equipped with an autotransformer feeding system, additional autotransformer feeder conductors are installed, normally replacing the return conductors. These feeders are classed as overhead line equipment for the purpose of these instructions.

The main conductors (catenary wire, auxiliary catenary wire and contact wire) of the overhead line equipment are pulled to a required tension. On main lines the tension is usually kept constant throughout the design temperature range by means of weights and pulleys, springs, pneumatic or hydraulic systems, and this equipment is said to be 'automatically tensioned'. Other conductors, and the main conductors on lines other than main lines, are fixed at their terminations, and hence the tension will vary with temperature. This equipment is said to be 'fixed termination'.

The nominal height of the contact wire above rail level is 4.7 metres (15 feet 5 inches) or 4.9 metres (16 feet) according to the design of the OLE. The nominal minimum height at public road level crossings (for road vehicles of 16 feet 6 inches maximum height) is 5.6 metres (18 feet 6 inches). For new overhead line equipment, the nominal contact wire height is 5.8 metres (19 feet and 11/32 inch) where possible.

The contact wire is staggered (i.e. offset from the track centre line) at structures: on straight track on alternate sides of the centre line of the track so as to maintain a smooth surface on, and prevent grooving of, the contact surface of the pantograph; on curved track generally to the outside of the curve to maintain the contact wire within the geometrical tolerances of its position on the pantograph head.

Booster transformers and return conductors (as previously described) are installed where necessary to minimise electrical interference with telecommunications cables and other circuits.

A supplementary conductor is installed where necessary to achieve suitable impedance levels. On lines where supplementary conductors are used, these are connected to, and in parallel with, the contact and catenary wire arrangement.

In areas equipped with an autotransformer feeding system, autotransformer feeder conductors are installed. These minimise electrical interference with telecommunication cables and other circuits and, together with their associated autotransformers, provide a means of improving voltage regulation.

4.7 Sectioning of the Overhead Line Equipment

Normally, discrete sections of the OLE are kept electrically separate from each other. There are usually separate sections for each track. Each section of OLE is fed through remotely controlled switchgear at the feeder station, track sectioning cabin, track sectioning location or autotransformer site. The remotely controlled switchgear is under the control of the ECO, who can open and close it remotely. The switchgear is arranged to open automatically ('trip') in the event of an electrical fault or an overload on the section concerned.

The OLE is further divided into subsections by section disconnectors which are mounted on the OLE structures and are generally arranged for manual operation from ground level. In consequence, a subsection of the OLE can be isolated and earthed in case of fault, or for maintenance purposes, whilst the electricity supply to other sections and subsections is maintained.

Each disconnector has a unique identifying number and is provided with a unique locking device, the key of which is kept in the box provided for that purpose. Some

section disconnectors can also be operated remotely by the ECO. These are known as motorised disconnectors.

At each point where the OLE can be sectioned, provision is made for electrical separation by means of an insulated overlap span, insulated knuckle, section insulator or neutral section as is required.

Arrangements are made by means of alternative feed disconnectors for certain sidings or terminal lines to be fed from either of two other sections of overhead line. In addition, some sidings or groups of sidings or terminal lines are fed by means of siding disconnectors by which the siding equipment can be made 'live' or 'isolated' and in certain cases 'earthed'.

Details of the sectioning arrangements (including alternative feed disconnectors) are given in the appropriate isolation diagrams and isolation instructions.

The overhead line disconnectors are operated only by staff who have been trained for this purpose and then only on the instructions of the ECO. The ECO specifies by identifying number which disconnectors are to be operated and how they are to be operated.

4.8 Isolation Diagrams and Isolation Instructions

The complete sectioning is shown on Isolation Diagrams. These are published on the Network Rail standards website together with Isolation Instructions. Local copies are taken by persons involved in the Isolation process as necessary.

4.9 Locations of Neutral Sections

Neutral sections are situated at intervals along the electrified lines, usually at feeder stations and certain track sectioning cabins, track sectioning locations or autotransformer sites. These are designed to maintain electrical separation between adjacent sections of the catenary system conductors, usually because they are normally, or can be, fed from different electrical phases.

Due to the interruption to the continuity of current collection so caused, trains switch off power when passing through a neutral section.

This is achieved by using an Automatic Power Control (APC) inductor which control the electric power circuits on the train automatically switching off power before entering the neutral section and automatically switching on the power after the train leaves a neutral section.

The locations of neutral sections are shown in the appropriate Sectional Appendix. On certain lines, signs are displayed on the approach to neutral sections.

NOTE: The procedure to be followed for any defective APC inductors is stated in Module 4, clause 9.

4.10 Remotely Controlled Earthing Devices

At strategic locations, remotely controlled earthing devices are installed to enable the ECO to earth the overhead line equipment and thereby reduce the extent of an emergency switch-off.

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4.11 Identification of Electrified Areas

Lines where overhead line electrification is installed are identified in Sectional Appendices and the extent of the installation is shown on the appropriate isolation diagrams. Signs are erected at certain locations to warn drivers and other persons that they are about to enter an electrified area.

Where new OLE is being installed, or an electrified area is being extended, warning of the impending energisation of the equipment will be given by the publication of an energisation notice. Such notifications will appear in weekly and periodical operating notices, and on posters at all necessary locations, and, where appropriate, personal notices will be issued to individual employees in accordance with Network Rail standard NR/L2/ELP/24013.

5 Danger from Live Overhead Line Equipment

5.1 General

The OLE incorporates parts, such as wires, insulators, conductors, etc. which are live, and these are bare (i.e. not having an insulated covering).

All persons who are required to work on, or about, the electrified lines shall make themselves familiar with the construction of the OLE.

Treat all exposed parts of the OLE as live at all times and consequently dangerous to life, unless:

a) an overhead line permit has been issued in accordance with Rule Book Module AC (GE/RT8000/AC) and Handbook HB16 (GE/RT8000/HB16); or

b) where local isolation is allowed, the OLE has been isolated and earthed and an assurance has been received in accordance with local instructions (*see Module 8)*; or

c) the OLE has been made safe in an emergency and an assurance has been received from the ECO. *See Rule Book Module AC (GE/RT8000/AC) and Handbook HB16 (GE/RT8000/HB16)*.

5.2 Train Equipment

The pantographs and other roof-mounted electrical equipment on trains have no insulating covering and shall be treated as live at all times and consequently dangerous to life unless this equipment has been made safe to approach and the provisions of 5.1 have been met.

5.3 Minimum Safe Clearance

No part of a person's body or clothing shall come within 600 millimetres (2 feet) of any live part of the OLE or live pantographs or other roof-mounted electrical equipment on trains.

Except for voltage testing devices, live line tools and live line measuring devices conforming to the relevant Network Rail standards and used in accordance with the relevant Network Rail standards, no part of anything which a person is using or carrying shall come within 600 millimetres (2 feet) of any live part of the OLE or live pantographs and other roof-mounted electrical equipment on trains.

Further details on voltage testing devices, live line tools and live line measuring devices with respect to the 600 millimetre rule are found in Module 2.

5.4 Broken or Displaced Equipment

Broken or displaced wires connected with the OLE shall not be approached. They shall be treated as live and consequently dangerous to life. Immediately report any broken or displaced wires to the ECO.

No attempt shall be made to remove anything from the OLE or from its vicinity nor shall it be approached. Immediately report the incident to the ECO.

No attempt shall be made to approach or re-secure any equipment detached or out of gauge from any rolling stock if there is a likelihood of it coming within 1 metre (3 feet) of the live parts of the OLE, nor shall it be approached. Immediately report the incident to the ECO.

5.5 Return Conductors

Return conductors carried on insulators shall be treated as live at all times and consequently dangerous to life unless they have been earthed and an overhead line permit issued or the OLE has been made safe in an emergency. The isolation and earthing of the adjacent OLE does not necessarily render the return conductors safe.

The arrangement for work on return conductors on insulators with or without booster transformers between successive earths are set out in Module 7 clause 12.

However at places where return conductors carried on insulators pass close to positions where persons might normally stand or work, these return conductors are provided with a protective insulating covering. Provided that the Return Conductor remains electrically continuous with an unbroken protective insulating covering, then the Return Conductor are consequently not dangerous to life.

5.6 Autotransformer Feeders

In areas equipped with an autotransformer feeding system, autotransformer feeders are provided, normally replacing the return conductor system.

These feeders are carried on insulators and classed as parts of the overhead line equipment and shall be treated as such for the purpose of these instructions.

The isolation and earthing of the adjacent OLE does not render the autotransformer conductors safe.

In addition, under worst case conditions a clearance of not less than 600 mm (2 feet) is provided between catenary and autotransformer feeder conductors.

Do not compromise the 600mm (2 feet) clearance when using portable earthing equipment, temporary continuity jumpers, live line tools, live line measuring devices, voltage testing devices, etc.

5.7 Rail Return Circuits

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, a dangerous voltage could be present and they shall not be touched until a documented safe system of work has been produced by a Competent Person in accordance with Module 4, clause 5.

Bonds found to be broken or defective shall be reported immediately to the ECO.

5.8 Signals

An assessment shall be made for each signal working place, ladder and platform to enable staff to carry out their normal duties in safety.

Some signals are fitted with fixed protective screens for this purpose.

All other work (e.g. painting or rewiring) are subject to the requirements stated in Modules 2 and 3.

5.9 Other Equipment

If there is any doubt as to whether any feature of the OLE or associated equipment is live or not, it shall be treated as live, and if necessary, further advice shall be sought from the Delivery Unit Electrification and Plant Maintenance Engineer (DUE&PME) or other competent authority appointed in writing by the DUE&PME.

6 Communication with the Electrical Control Operator

6.1 General

The ECO can be contacted directly by radio or telephone on the numbers shown in Appendix A. Contact can also be made using driver only or cab secure radio routed via signal boxes.

All conversations shall be in accordance with Rule Book Module G1 (GE/RT8000/G1).

Employers shall equip their staff, as necessary, with suitable radios and/or telephones and make them aware of how the ECO can be contacted promptly.

6.2 Numbering of Formal Communications to and from the Electrical Control Operator

Each formal communication to and from the ECO shall be numbered and shall take the form of the time of its despatch expressed as a four figure number in terms of the 24 hour clock in the electrical control, where 00:00 is midnight and 00:01 is one minute past midnight. Thus a message despatched at 18:15 hours would be identified as message number:

1	8	1	5

Employers shall make their staff aware of the method of numbering messages.

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Appendix A
Contact Numbers for Electrical Control Operators

ETD telephone numbers				
Electrical control	**NRN band III radio***	**Short code§**	**ETD++**	**PSTN phone numbers#**
Ashford for Network Rail (High Speed 1 Ltd)	N/A GSM-R 71000103	170	085 39450	01233 739450 01233 739300 (emergency)
RFLI Romford RCC for (Rail For London Infrastructure) (RFLI) (Elizabeth Line)	N/A	N/A	N/A	0300 215 1023 0300 215 1018
Cathcart (to be migrated to Glasgow ROC)	2 176	176	04 53989 04 53990 04 56399 04 62695	0141 632 3688 0141 632 5724
Crewe (to be migrated to Manchester ROC)	2 175	175	05 32841 05 32842 05 32843 05 32844	01270 255582
Didcot ECR (Thames Valley Signalling Centre)		170	085 41051 085 41050 (emergency)	0330 854 1051 0330 854 1050 (emergency)
Paddock Wood (to be migrated to Gillingham ROC)		172	01 34700	01892 833018
Romford	2 175	175	00 57980 00 57981 00 57982	01708 730292 01708 730314
Rugby	2 177 2 172	177 172	054 6422 054 6533 054 6546 054 6547	01788 553057 01788 555422

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ETD telephone numbers				
Electrical control	**NRN band III radio***	**Short code§**	**ETD++**	**PSTN phone numbers#**
York North desk	2 173	173	037 4691 037 4962 037 4963 037 4872	01904 525622
York South desk	2 174	174	037 5836 037 5837 037 4902 037 4906	01904 525952

Numbers subject to change on migration into ROCs.

NOTES:

* If busy use "P" button to obtain priority call

§ The ECO is able to identify calls coming in on short code emergency numbers; therefore these shall only be used for emergencies

++ Railway Extension Trunk Dialling

Public Subscriber Telephone Network

GSM-R Global System for Mobile Communications – Railway