LIGHT RAIL
Safety and Standards Board

Overhead Line Systems Training and Competency Guidance

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DESCRIPTION:

THIS DOCUMENT PROVIDES GUIDANCE ON TRAINING AND COMPETENCY FOR MAINTENANCE ACTIVITIES ON LIGHT RAIL OVERHEAD LINE SYSTEMS

EXPLANATORY NOTE:

LRSSB is not a regulatory body and compliance with this guidance document is not mandatory. This document reflects good practice and is advisory only. Users are recommended to evaluate this guidance against their own arrangements in a structured and systematic way, noting that parts of this guidance may not be appropriate to their operations. It is recommended that this process of evaluation and any subsequent decision to adopt (or not adopt) elements of this guidance should be documented. Compliance with any or all of the contents herein, is entirely at an organisation's own discretion.

SOURCE / RELATED DOCUMENTS:

LRG 1.0 Tramway Principles and Guidance (TPG) (LRSSB)
LRG 6.0 Fatigue Management Guidance (LRSSB)
LRG 15.0 Stray Current Management Guidance (LRSSB)
LRG 21.0 OLE Reference and Maintenance Manual (LRSSB)
LRG 27.0 Weather and Climate Resilience Guidance (LRSSB)
LRG 32.0 Testing and Commissioning Guidance (LRSSB)
LRG 37.0 Weather and Climate Resilience Guidance (LRSSB)

RELATED TRAINING COURSES:	RELATED LEGISLATION:
NTSAR (National Transport Safety Authority Rail): OLE Competency Board-based Skills	Health and Safety at Work Act etc. 1974 Management of Health and Safety at Work Regulations 1999 Railways and Other Guided Transport Systems (Safety) Regulations 2006 (ROGS) (as amended) Electricity at Work Regulations 1989 Construction (Design and Management) Regulations 2015 (CDM) Working at Height Regulations 2005 New Roads and Street Works Act 1999 Control of Substances Hazardous to Health 2002 (COSHH) Lifting Operations and Lifting Equipment Regulations 1998 (LOLER) Provision and Use of Work Equipment Regulations 1998 (PUWER)

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LIGHT RAIL OVERHEAD LINE SYSTEMS TRAINING AND COMPETENCY GUIDANCE

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TERMS AND ABBREVIATIONS

Table A – Terms

Term	Definition
Adopted (or Legacy) Tramways	Systems converted from Heavy Rail to Light Rail that retain a portion of a Heavy Rail OLE system.
Authorised Isolating Person	A person undertaking switching either locally or with remote operations by the OCC and using a switching programme to complete designated actions for an OLE isolation.
Bonding	A protective normally non- energised set of cables used to provide a path between unintentionally energised structures and a safety earth.
Catenary	A series of structures and components that support the contact wire along its length. Also, non-UK definition for overhead contact system.
Competent Person	Competence is the ability to work to an agreed standard on a regular basis. It involves practical and thinking skills, experience and knowledge, and may include a willingness to follow agreed standards, rules and procedures. The combination required depends on what needs to be done, in what circumstances and how well.
Contact wire	Electric conductor of an overhead contact line with which the current collectors makes contact.
Double Insulated system	An electrical system whereby two or more insulators are fitted in series between live and earthed components and structures.
First Generation Tramways	UK tramways from the Victorian era until the middle of the Twentieth Century. Often referred to as heritage tramways.
Isolation	The de-energisation of the OLE system in part or whole from the traction power source for emergency or maintenance activity and having protective earth(s) applied either automatically or manually to remove the risk of any residual voltage being present and a danger to staff or a third party.
Overhead Line System	An energised contact line placed above (or beside) the upper limit of the rail vehicle gauge and supplying vehicles with continuous electric energy through roof-mounted current collection equipment. This includes, in addition to all current-collecting conductors, the following elements: reinforcing feeders; cross-track feeders; section insulators; overvoltage and surge protection devices; insulators connected to live parts; conductors or equipment connected permanently to the contact line for supply of other electrical equipment; bonding wires and return conductors.
Permit To Work	A document issued by the isolating authorised person which states a specific system and its location to be worked on is de-

	energised, earthed, locked out of service, and proven so by testing.
Radial Load	The physical loading found in contact and catenary wires when they are subject to a change in direction.
Term	**Definition**
Rake	The setting of a pole or mast whereby when the load is applied it looks uniformly vertical. Positive rake is away from the load, negative rake is towards the load.
Rig	The use of mechanical devices consisting of pull-lifts, clamps[1] and slings to allow controlled movement, reduction in tension and safe disassembly of OLE components whilst the rest of the system is maintained in tension.
Second Generation Tramways	UK tramways and Light Rail systems that have been in operation from the 1990's.

1 A common name for spring loaded come along clamps or wedge clamps used to hold contact or catenary wire during installation.

Table B – Abbreviations

Abbreviation	Definition
BS	British Standard
CDM	Construction (Design and Management) Regulations 2015
CMS	Competency Management System
COSHH	The Control of Substances Hazardous to Health Regulations 2002
DC	Direct Current
EN	European Norm
HASAW	The Health and Safety at Work Act 1974
HGV	Heavy Goods Vehicle
HV	High Voltage
IET	Institution of Engineering and Technology
IPAF	International Powered Access Federation
ISO	International Organisation for Standardisation
kg	Kilograms
kV	kilovolt
LOLER	Lifting Operations and Lifting Equipment Regulations 1998
LRSSB	Light Rail Safety and Standards Board
LVL	Low Voltage Limiter
m	Metre(s)
MEWP	Mobile Elevating Work Platform
mm	Millimetres
mph	Miles per hour
NR	Network Rail
NRSWA	New Roads and Street Works Act 1991
OCC	Operations Control Centre
OEM	Original Equipment Manufacturer
OLE	Overhead Line Equipment
PPE	Personal Protection Equipment
PTW	Permit to Work
REFOS	Running Edge to Face Of Structure
ROGS	Railways and Other Guided Systems (Safety) Regulations 2006 (as amended)
ROL	Ratchet Operated Lever
RRV	Road Rail Vehicles
SI	Section Insulator
Abbreviation	**Definition**

SPS	Small Parts Steel
SWL	Safe Working Load
TPG	Tramway Principles and Guidance
UK	United Kingdom
VDC	Volts Direct Current
VLD	Voltage Limiting Device
WLL	Working Load Limits

1. Introduction

1.1. This guidance supports the high level principles set out in LRG 1.0 Tramway Principles and Guidance (TPG) published by the Light Rail Safety and Standards Board (LRSSB).

1.2. This document provides high level overhead line systems training and competency guidance for those delegated this responsibility in relation to UK Light Rail systems (tramways) based on 'line-of-sight' operations only. As with all guidance, this document is not prescriptive and is intended to give advice not to set a mandatory industry standard, and it is based upon goal setting principles as best practice.

1.3. Much of this guidance is based on the experience gained from existing UK Light Rail systems, related employers and published documents including the National Occupational Standards (NOS), the Overhead Line Equipment Construction (OLEC) 1 - 3[2] and NR/L2/CTM/028[3] Standards. It does not prescribe particular arrangements adopted by any existing UK Light Rail system and is intended to give guidance and advice to those involved in the overhead line systems training and competency.

1.4. This guidance is not intended to be applied retrospectively to existing Light Rail systems. However, owners and operators should consider and assess any implementation of this guidance and / or any subsequent revision, to ensure continual improvement in reducing risks related to the impacts of overhead line systems training and competency, so far as is reasonably practicable.

1.5. This guidance is intended to provide enough information in that OLE assets can be maintained, perform adequately, and reduce any risk to staff undertaking the task.

1.6. This guidance should be linked to a Competency Management System (CMS) in order that staff are regularly assessed on the minimum criteria and to the timescales suggested with retraining undertaken as required.

2 OLEC 1 - 3 is the heavy rail standard competency for a staff member to undertake OLE works in a construction environment safely.

3 Competence and Training in OLE Construction Engineering (Network Rail)

2. Scope

2.1. The purpose of this document is to assist Light Rail systems to adequately, appropriately, and sufficiently prepare maintenance staff to work safely on OLE systems. This includes items to be considered in the design and construction of Light Rail systems, that may later assist when the system is in operational.

2.2. The guidance in this document relates to the competency and skills required for the maintenance of Light Rail overhead line systems up to 1500 VDC and describes the core skills and specialisms required to be competent.

2.3. This guidance will support the delivery of the Light Railway engineering OLE competency in the planning and delivery of any apprenticeship or to existing or new staff including the conversion of existing skills.

2.4. The scope of training should apply best practice with sufficient theoretical and practical knowledge so that City and Guilds 6497-03 Level 3 Diploma in Rail Engineering Technician Knowledge (Overhead Line Equipment) or equivalent could be awarded.

2.5. Though infrequent, some aspects of maintenance will require works where the application of the Construction (Design and Management) Regulations 2015 (CDM) are required.

2.6. This guidance does not cover the aspects or methodology of undertaking traction isolations. However, to validate safety management systems some aspects of this will need to be included.

2.7. This guidance considers several factors that should be assessed with successful competence, such as the following:

- Whether the person is new to the job;
- Previous training and experience;
- Experience of any other types of equipment;
- Gathering and collating of observed evidence; and
- Risks due to incompetent performance.

2.8. This document also includes different functions and the hazards associated with maintenance of OLE encompassing many operations or functions in order that the asset remains in a serviceable condition.

2.9. This guidance will also support the systems that employers should already have in place to ensure a continued competency assessment is in place through the auditing of work including physical and written (work report etc.), or a CMS input. Reassessment should be undertaken within a maximum of 3 years to maintain or enhance the competency of staff. Any near misses, incidents or accidents that are a result of divergence from any competency scope will require the staff member to be fully assessed before being allowed to undertake future work on the OLE.

2.10. This guidance also encompasses, First Generation (heritage) and adopted (legacy) systems as well as those interfacing / with cross or dual access to mainline Heavy Rail systems. However, the competency for Light Rail OLE is not transferable to mainline due to Network Rail (NR) minimum requirements of OLEC competency as well as others.

3. Basic and First Principles

3.1. The basic and first principles of the maintenance of overhead line systems to be included when assessing competency and that should be provided when training include the following:

- Explanation of the requirements for safe working, complying with health and safety and other relevant regulations and guidelines. Additional competences are required, such as International Powered Access Federation (IPAF) or equivalent accreditation, New Roads and Streets Works Act (NSWRA), and the use of Road Rail Vehicles (RRV), Permits to Work (PTW) and isolation of OLE and the use of isolation diagrams;
- Identification and explanation of the hazards associated with OLE construction activities;
- Identification and explanation of the hazards associated with OLE maintenance activities;
- Basic OLE assemblies and their terms (including First and Second Generation tramways and mainline where appliable);
- Identification and explanation of the component parts of a Light Rail OLE system and their functions;
- Identification of the kit used to allow safe disassembly of OLE;
- Identification of the kit used in maintenance of OLE for gauges and digital era inspections including the use of drones;
- Understanding and demonstration of an ability to interpret general, renewal, installation, and enhancement documentation for the components that are being renewed or installed;
- Demonstration of their ability to complete basic OLE inspection activities using the correct tools and equipment whilst under the direction from competent personnel for ground and high-level working;
- Explanation of recording, reporting and escalation procedures;
- Explanation of the importance of producing accurate records of work undertaken; and
- Incident management including extreme weather (refer to LRG 37.0 Weather and Climate Resilience Guidance for further information).

3.2. Refer to Appendix A of this document for a suggested training scope / checklist of items against each competency being tested and Appendix B for a training an assessment cycle. In addition, Appendix C provides a suggested skills and competency matrix.

4. Prequalification Competency and Safety

4.1. The Health and Safety at Work Act (HASAW) 1974[4] and the Management of Health and Safety at Work Regulations 1999[5] and the Railways and Other Guided Transport Systems (Safety) Regulations 2006 (ROGS) (as amended)[6], combine to require all employers to ensure that staff are competent to carry out their tasks without risk to the health and safety of themselves and others. The HASAW states:

> *'It shall be the duty of every staff member whilst at work to take reasonable care for the health and safety of themselves and other persons who may be affected by their acts or omissions at work and to co-operate with the employer as far as is necessary for statutory obligations to be met.'*

4.2. Working on OLE systems requires a high degree of safety to prevent accident and incidents to staff, equipment and / or infrastructure that could lead to serious or fatal consequences and the loss of operations and revenue. In serious cases, prosecution of the maintenance company including those involved at the time may be sought by the Health and Safety Executive under the HASAW.

4.3. Under the visual inspection aspect of OLE maintenance, all staff should be in possession of current Personal Track Safety[7] competency and be certified medically fit before embarking on trackside activities.

4.4. Staff should be familiar with Lifting Operations and Lifting Equipment Regulations 1998[8] (LOLER) and Provision and Use of Work Equipment Regulations 1998[9] (PUWER) regarding the inspection and use of equipment supplied to allow safe and controlled disassembly of OLE systems.

4.5. In order that any risk of electrocution is minimised, all works on or adjacent to the system should only be undertaken on isolated and earthed OLE sections[10].

4.6. It is recommended that staff are familiar with a Light Rail system's OLE electrical sectioning and limits including the use of buffer sections to provide additional safety. This skill will require the interpretation of references on isolation diagrams compared to those at physical locations, usually referenced by a chainage identification label or plate on the mast / pole or spanwire. From this, staff should be able to identify the limit of an isolation on both diagrams, the physical location and issued permits.

4.7. Insulated equipment shall be used prior to any validated isolation[11].

4 https://www.legislation.gov.uk/ukpga/1974/37/data.pdf
5 https://www.legislation.gov.uk/uksi/1999/3242/made/data.pdf
6 https://www.legislation.gov.uk/uksi/2006/599/made/data.pdf
7 Scope and detail could be relevant to that system only and not transferable unless sentinel is in use.
8 https://www.legislation.gov.uk/uksi/1998/2307/made/data.pdf
9 https://www.legislation.gov.uk/uksi/1998/2306/made/data.pdf
10 EN 50488 Railway Applications, Fixed Installations, Electrical protection measures for working on or near an overhead contact line system and /or its associated return circuit
11 Items such as live line testers are specifically designed to operate on live equipment and to provide a clear and unambiguous status to the operator to show if the line is energised. Generally, live working on OLE using insulated tools is not common practice in the UK.

4.8. OLE section isolations should follow a robust methodology of possession management, including the following:

- Implementation of locked physical barriers or stop boards at the extremes of the isolation[12];
- Use of isolation diagrams and references;
- Switching and programmes;
- Lock out Tag Out (LOTO) procedures;
- Applying of earths;
- Testing; and
- Issue of PTWs that will prevent unambiguous and clear identification of locations and equipment, and unintentional re-energisation of the section(s) being worked on where more than one party may be employed.

4.9. Staff should be aware of additional preventative measures required where the overlapping of sections occurs, i.e. when fitting of insulated sleeves, signage, or additional localised isolation apparatus, etc.

4.10. Where staff are to undertake a combined role, for example, authorised isolating person, etc., they should be trained and competent in the planning and use of isolation diagrams and switching programmes, and the ability to identify sections and their limits, the sectioning isolators[13], and their use as part of the switching sequence to provide safe isolation from all traction power.

4.11. Staff should be trained and competent in the use of Live Line Tester and its limitations. The authorised isolating person should not be the sole user of this equipment with verification checks undertaken as necessary by OLE staff. This should include pre-use checks.

4.12. Staff should be trained and familiar with various portable earthing apparatus and its procedure for correct and safe application and removal. The location may determine additional measures are required for protection and visual acuity.

Access by Use of Vehicles or Other Means

4.13. The standard method for access is to use on track plant (OTP), an RRV Mobile Elevating Work Platform (MEWP- type 3B) or other means i.e. scaffold tower. Where use of these are required, staff must be familiar with the Working at Height Regulations 2005[14]. In particular this includes the use of ladders, as although the use of them has lessened, they are still used in some circumstances.

12 This is nearly impossible on a section of shared highway unless it is closed to road traffic. Therefore, other means of prevention or access to a potentially live section should be implemented as far as reasonably possible.

13 These could be automatically engaged using a SCADA (supervisory control and data acquisition) system or manually operated local to a site.

14 https://www.legislation.gov.uk/uksi/2005/735/made/data.pdf

4.14. Staff using a lorry based RRV MEWP (i.e. Unimog U400)[15], with an unladen gross vehicle weight (GVW) of 7.5 tonnes or above will require a Class C driving licence[16] to drive the vehicle on any road / street sections, including when it is being used for access under its own power and / or operated from the basket. The towing of any trailer attachment for cable drum transportation will require the additional competency to Class C+E.

4.15. Although segregated and separated alignments will not require a Class C driving licence, the operator of the vehicle should be sufficiently trained and competent to operate the vehicle correctly and safely within the possession and to the rules of the Light Rail system[17].

4.16. Where there are shared alignments with NR, it is likely that any vehicles used by an operator will not be allowed on NR infrastructure unless they have been certified to do so and under pre-arranged possession to NR requirements[18].

4.17. To note, under Driver and Vehicle Standards Agency Regulations, any RRV being operated on a highway and using tyres for traction, whether the rail guidance is employed or not, is classed as a road vehicle not a Light Rail vehicle so Highway Regulations must be adhered to.

4.18. In addition, the operation of a MEWP will require the operator to be sufficiently trained and certified competent[19] with continuous competence updates in a PAL logbook[20] from a certified training body, i.e. IPAF and to ISO 18878:2013[21]. As part of this training, competence in the use of harness is a mandatory requirement to operate a MEWP.

4.19. Any staff operating an MEWP should conform to The Road Vehicle Lighting Regulations 1989[22] to provide conspicuous marking and lighting, or be in a possession and protected by barrier / escort vehicles operating front and rear displaying regulatory amber warning lights. Under EN 15746-4[23], lighting will be compliant with rail requirements if in rail mode i.e. the front main beam may be replaced by marker lights. However, the lights will still be white to the front of the vehicle and red to rear, substituted by amber warning beacons if following conventional road traffic flow direction[24].

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15 There are some interpretations that this vehicle does not need a Class C licence to drive it if classed as plant equipment. However the staff using the vehicle should be sufficiently trained and have competence in operating it and the operator should comply with the law: https://www.gov.uk/government/publications/unimogs/unimogs

16 Driving licence categories: https://www.gov.uk/driving-licence-categories

17 External or internal assessor qualified to validate the competence and have certification to prove so.

18 OTP (On Track Plant) handbook and Network Rail Standard NR/PLANT/0200 – Infrastructure Plant Manual. OTP must meet the requirements of Rail Industry Standard RIS-1530-PLT: Rail industry standard for engineering acceptance of on-track plant and associated equipment.

19 The certification should be relevant to the model / type being operated, for example, a type 1b static boom is different to a type 3b mobile boom. In addition, RRV MEWPs may be type 2 special.

20 Performance Analysis of Logs logbook

21 ISO 18878:2013: Mobile elevating work platforms — Operator (driver) training

22 https://www.legislation.gov.uk/uksi/1989/1796/made/data.pdf

23 EN 15746-4: Railway applications - Track - Road-rail machines and associated equipment - Part 4: Technical requirements for running, travelling and working on urban rail

24 Under EN 15746-4 5.12.1 normal road lighting and amber warning beacons are disabled when rail lighting is used on the mainline railways. However it is a requirement that is is used when the vehicle is on a highway.

4.20. In order that maintainers comply with Regulations for works within a highway environment, staff should undertake training and then continuous assessment under NRSWA. There should be compliance with guidelines for either a stationary or rolling work site regarding adequate and correct warning signage including when debarking from the works site so other road users will be aware and minimising the risk of an incident.

Other Considerations

4.21. Staff should be familiar with the appropriate personal protection equipment (PPE) and this should be in efficient working order and in good repair and include the following as a minimum:

- Approved high visibility clothing to BS EN ISO 20471:2013+A1:2016[25] including trousers, jacket and garments for cold / wet weather working in orange or yellow colour as appropriate to the Light Rail system;
- Safety boots;
- Safety helmet to BS EN 397:2012 +A1:2012[26] (with head torch) and chin strap[27];
- Gloves;
- Safety glasses or goggles: staff requiring prescription glasses should seek to have safety glasses to EN 166[28] Class F. Alternatively, a helmet with integral visor to EN 166 A/B can be used when additional eye protection is required;
- Hearing protection as required: either plugs or helmet mounted;
- Safety harness: used for operation of MEWP or as part of retrieval system in confined spaces, chamber, or pits, etc.; and
- Gas monitor: used to detect oxygen depleting gases in pits or chambers.

4.22. Confined space working training and competency should be implemented to those staff likely to enter pits or chambers as part of OLE works that are deeper than 4 feet / 1.2 m[29] and where access to equipment is likely to place their head below the surface of the pit and free flowing non- ventilated air.

4.23. Staff should understand the Control of Substances Hazardous to Health Regulations 2002[30] (COSHH) where specific lubricants, oils or cleaning agents / methodologies are in use. This will prescribe any additional PPE or measures required during the application.

4.24. In addition, specific safety measures such as the registers of materials shall be implemented where materials are used that are deemed hazardous to health, for example, asbestos, mica, lead, cadmium, bitumen etc., especially in relation to First

25 BS EN ISO 20471:2013+A1:2016: High visibility clothing. Test methods and requirements
26 BS EN 397:2012 +A1:2012: Industrial safety helmets
27 Safety helmets should be clean and free of damage, and in date. It is recommended they are replaced every 5 years or if damaged.
28 EN 166: Personal Eye Protection European Standard
29 Although there is no defined depth for an open pit in HSE documentation, the United States Department of Labor document Confined Spaces in Construction (OSHA3788 05/2015) defines a measurement of 4 feet which is used as guidance to comply with HASAW 1974 and the Confined Spaces Regulations 1997.
30 https://www.legislation.gov.uk/uksi/2002/2677/regulation/7/made/data.pdf

Generation systems. These should be handled with care or replaced where possible, with alternatives and disposed of where required using specialist agents and methods.

5. Overhead Lines Construction Activity

5.1. To provide a basic overview, trainees should be aware of construction activities that may be encountered during OLE maintenance. Some OLE construction works are undertaken by specialist civil engineers who can validate their design against failure during operation of the Light Rail system.

Duct and Access Pit Routes

5.2. Light Rail systems require the installation of ducts and pits for OLE reinforcing cables, traction returns, injection points and any protective device installations along the length of the section in urban environments. This takes the place of any catenary and reduces the overall number of and mass of components in the air. This allows for balanced and efficient traction power supplies in a section. Injection points can be anything from 50 m to 500 m depending on the reinforcing cable and system design.

5.3. Even the catenary free or ground level power supply[31] systems and those implementing on board battery or energy source will still require duct installations for supervisory, signalling and communications. Once the ducts are installed the main cables are run.

5.4. Specific duct construction hazards include the following (not exclusively):

- Disruptive and deep excavations: requiring utilities to be moved or relocated and can lead to incidents or replacement;
- Noise;
- Concrete and waste including spoil;
- Disruptions for business, public and traffic: cost and value of project; and
- Access and egress.

Foundations

5.5. Pile foundations are usually constructed using continuous flight auger / open bore methods or tubular steel shell, vibrated or percussion hammered into the ground to EN 12794[32]. These contain a steel reinforcement cage / bolt frame for mast securing and to provide an earthing interface, conduits for cables and concrete infill. The pile cap is cast on top of the pile providing a bearing / support face for the mast or pole. In some cases, the mast or pole is mounted above the pile cap to allow for adjustment (rake) then infilled with grout once cables are installed.

5.6. Side bearing / open grab or gravity foundations are constructed by excavation and insertion of reinforcing cage, cables conduits and shuttered concrete infill. These are used where ground conditions will not allow piles or are shallow on bridge decks.

5.7. Pile construction hazards include the following (not exclusively):

- Numerous construction machines working in a tight envelope;

31 Alstom APS "Alimentation Par le Sol," Direct contact system, Ansaldo 'Tramwave', Bombardier 'Primove' induction system or CAF ACR "Acumulador de Carga Rápida

32 EN 12794: Precast concrete products. Foundation piles

- Storage of tubular steel shells and movement for use;
- Storage of steel reinforcements and movement for use;
- Ground conditions and environment;
- Noise from vibrators or percussion hammers;
- Liquefaction of ground near pile insertion;
- Undetected underground obstacles;
- Correct location;
- Concrete and waste / disposal;
- Disruption and restricted access for pedestrians; and
- Claims for damage: utility or service penetrations.

Wall, Bridge or Tunnel Fixings

5.8. Where the consideration of aesthetics is required, the Light Rail system is located within an area of historic and / or architectural importance in the urban environment, or where the OLE structure envelope is not sufficient for posts, wall anchors are utilised. These can be mounted in the following ways:

- Into an existing building internal structural steelwork;
- Designed into the construction phase of new builds; and / or
- Into buildings render or fascia material[33].

5.9. Bridge and tunnel fixings are employed to support the OLE. They are not exposed to the same forces as wall anchors and have multiple points of fixing.

5.10. Wall anchor, bridge and tunnel support construction hazards include the following:

- Working at height;
- Dust and noise from coring: water / dust suppression required, especially where asbestos, silica or quartzite materials are being released;
- Vibration from using power tools;
- Wrong location drilled due to inadequate survey;
- Epoxy resins and cements (COSHH);
- Failure of the anchor or supporting structure: usually apparent during a pull test and delays activities whilst it is being investigated and replacement installed. The result could be a material failure affecting numerous installations quality assurance, time and money; and / or
- Other people and access where an anchor requires access from within a building.

Pole or Mast Erection

5.11. Light Rail systems use a variety of mast or poles; the majority are steel tubular fabrications. However, I or H beam sectional structures can also be used. They are generally bolted to a foundation, and although they vary in weight and length, typical lengths are between 8 – 10.5 m with a weight usually between 1.5 – 2.5 tonnes. Some

33 Subject to it being assessed to be adequately robust to support the anchor and the loads imposed on it, especially if the building is of historic, architectural significance and / or importance. Planning powers and design approval may be required.

masts or poles have additional applications supporting or being supported by the OLE, for example, highways lighting assemblies.

5.12. Mast / pole construction hazards include the following:

- Lifting and manoeuvring an unbalanced load: working envelope of grab or crane;
- Foundations not constructed or set out correctly to the required design specification: includes wrong type or strength of concrete;
- Foundation failure: bolts fail or pull out upon tightening or when mast loaded. This can happen with offset or amended assemblies whereby welded components fail;
- Aligning and landing of mast / pole: trapping; and / or
- Environment: lifting under high voltage (HV) power lines: safeguards and mitigation.

Small Parts Steel (SPS) Assemblies

5.13. SPS usually consists of brackets and cantilever assemblies either in prefabricated multi-part complete assemblies or sub-assemblies and are generally manufactured from aluminium, brass, bronze, stainless steel, composites or galvanised steel. Such parts include the following:

- Headspan and radial pull off span wires;
- Tensioning devices:
- Midpoint components;
- Switches;
- Actuators;
- Feeder cables (injection); and
- Surge arrestors.

5.14. SPS hazards include the following:

- Trapping of limbs, strains and sprains when assembling small parts especially if being lifted in to place by crane etc.;
- Noise and dust if mounting into overbridge structures;
- Working at height and restricted access;
- Multivehicle use; and
- Cantilevers that are not secure.

Catenary and Contact Wire Installation

5.15. Catenary (if fitted) is run first and then the contact wire is usually undertaken mechanically due to the sheer weight of cable drums[34] and the assemblies are then tensioned when this is complete.

5.16. Catenary and contact wire installation hazards include the following:

- Multi vehicle machines: restricted movement and work site envelope / environment, especially in an urban environment;
- Wires in tension, weight and stiffness including radial loads;

34 An average of 2.5 tonnes

- Sprain and stains: moving wires to correct position;
- Trapping of limbs or bodies;
- Failure of assemblies: things unexpectedly move or collapse;
- Working at height: HV overhead lines;
- Unauthorised people on or near site;
- Tensioning assemblies; and / or
- Cutting of wire.

Registration and Panning

5.17. Registration is the penultimate set up of the OLE system and includes the registration and 'clipping in' of the contact wire into the steady arms or bridles, and set to the correct / designed height and stagger and other settings. Other cables can be fitted to the contact wire or catenary where required. The registration process is set out below.

5.18. Intermediate feed connections are made off with section isolators locked to earth. Temporary earths may be added as additional safety measures, that are essential if track bonds are not made off or within depot confines where some roads may be live.

5.19. Section insulators are cut in at their respective locations. Feed cables are fitted and droppers adjusted if in use.

5.20. A dummy pantograph is then run through on a RRV to check settings, clearances, overlaps and any fouling points. Final checks and confirmation of height and stagger and connections are then undertaken including torque settings for bolts etc. Running Edge to Face Of Structure (REFOS) / super elevation measurements are then taken and documented.

5.21. Following this, section insulators are panned through the locally to check the 'run through' is satisfactory and not likely to foul a passing pantograph. These settings are then documented.

5.22. Registration hazards include the following:

- Radial loads on curves and gradients whilst adjustments are made;
- Live sections where interfacing occurs;
- Getting caught up in cantilevers or crushed against a bridge / structure whilst observing the panning process from the RRV basket;
- Collision between RRV and ground staff undertaking height and stagger;
- Exposure to laser light; and / or
- HV overhead lines.

Bonding and Protective Devices

5.23. Bonding is the activity that checks and connects non-OLE earthed or metallic structures that could potentially become live during fault conditions to the OLE system. This includes over and under bridges, buildings and tramstop furniture and could involve the use of Low Voltage Limiters (LVLs) / Voltage Limiting Devices (VLDs) and rail connections.

5.24. Traction return bonds are connected to rails and identified. For on street running, traction returns or earthing are connected to the rails before encapsulation is undertaken or a track inspection box is made available.

5.25. Isolator to track bonds (earthing) are then checked and connected and construction earths are disconnected and removed, then energisation notices are posted.

5.26. Bonding hazards include the following:

- Working in tight, deep, and confined spaces / pits or at height;
- Water;
- Gas;
- Strain and sprain and cuts / abrasions;
- Traffic if adjacent an open road following construction completion;
- Unauthorised persons; and / or
- Tools: mechanical and hydraulic systems and failures of kit.

Testing and Commissioning

5.27. Once all construction activities have been completed satisfactorily, the system will be handed over for section by section energisation and testing and commissioning. Although this activity is not strictly OLE works, the testing of sections using line testers may be undertaken.

5.28. Further guidance on testing and commissioning can be found in LRG 32.0 Testing and Commissioning Guidance.

6. Maintenance of Overhead Lines – Hazards

6.1. Maintenance of OLE encompasses many operations or functions so that the asset remains in a serviceable condition. Within a training scope, staff and technicians should be able to identify the different functions and the hazards associated with the tasks, such as the following:

- Visual inspections;
- Data collection;
- Planned and unplanned works; and
- Incident management.

6.2. All the above inspections should follow the prescribed timeline of the Original Equipment Manufacturer (OEM). However, where sufficient resources are not available or the timelines are not achievable for the infrastructure, they may be extended to suit the Light Rail system, so long as there has been a documented risk assessment against failure. Nevertheless, critical elements, for example, section insulator checks and adjustment maintenance must be maintained within the scope.

Visual Inspections

6.3. Visual inspections are generally ground borne and on foot. Cab rides can supplement this for longer sections. However, observations are not as comprehensive.

6.4. Inspections can be planned or unplanned, and used to identify items such as the following:

- Damage to the asset that is easily identifiable using the naked eye or visual aids, for example, binoculars, camera (both manual or vehicle mounted), or drones for more intrusive, reactive and rectification works;
- Degradation of assets that are likely to cause problems for near or future running;
- Degradation due to weather influence;
- Degradation due to external influence, for example, vegetation;
- Degradation due to poor or inadequate construction or manufacture;
- Vandalism or theft; and / or
- Incidents[35].

6.5. Visual inspection hazards include the following:

- Walking along a live open alignment which can include ballast and track, overbridges, cuttings, embankments and limited and restricted access between structures and the track;
- Walking along a street running section with limited clearance areas;
- Lone working, environment, time scales and fatigue;

35 For example, dewirement and rip downs due to failure of OLE or pantograph or external influence i.e. catching the OLE with a crane / HIAB (Hydrauliska Industri AB) / MEWP/ excavator etc.

- Vandalised or degraded assets can pose a risk if the nature is not fully understood[36]; and
- Dewirements or rip downs can pose a risk to staff / passengers / emergency services etc. as not all the hazards are immediately evident.

Data Collection Hazards

6.6. Data collection can be undertaken manually or automatically. This can be undertaken using vernier callipers or similar test instruments, height and stagger gauges, tension gauges or using vehicle mounted apparatus for OLE condition monitoring. Hazards associated with this include the following:

- Contact wire wear: working at height 'on the wire' including vehicle movements and trapping of limbs between baskets and structures / OLE components;
- Unintentional but avoidable damage to infrastructure and vehicles: collision with structure or other vehicles;
- Exposure[37] or stray into energised sections;
- Fatigue: repeated and familiarisation of the work can lead to distraction and fatigue. This is dangerous when undertaking the work in open traffic corridors both on segregated and shared highway sections. See LRG 6.0 Fatigue Management Guidance for further information;
- Weather: exposure during cold and wet conditions are different from warm and dry;
- Exposure to laser light / emitted radiation: the height and stagger gauge uses a laser to pin point the datum point on the contact wire, giving risk of exposure to anyone working in a MEWP at the time;
- Road traffic: a hazard for staff when interacting with road traffic on shared alignments or the vehicles are using unauthorised routes[38]. This activity should be assessed and scheduled to a time when traffic is likely to be quieter. However, additional measures will be required where Light Rail systems cross busy roads with speeds greater than 30 mph with protective lane closures and / or barrier vehicles to allow data collection to be undertaken safely; and
- Unauthorised persons and members of the public under the influence of drink or drugs: often curiosity can lead to people interfering in the activity, whether getting in the way of the vehicle or wanting to look or have a go.

Planned and Unplanned Works

6.7. Planned and unplanned works are the physical and intrusive inspections required to check and maintain the OLE. This work exposes staff to different hazards which should be risk assessed and mitigated by thorough and comprehensive training / refresher schedules in order that the risks are minimised as far as possible.

36 For example, a cable fault within a pole is not obvious unless noise and arcing is evident and as such there is risk of staff being exposed to arcing, smoke, flames, or explosive components etc.

37 Where HV power lines (132 - 400 kV) pass over the overhead, under certain conditions there could be inducted voltages found within a dead OLE that is not adequately earthed. 25 – 66 kV powerlines maybe in proximity and may not induce any voltage. However, access at height may mean that the work strays into the safety envelope and risk of flashover, therefore, measures must be in place to avoid danger to staff from external influences.

38 Emergency vehicles will use a trambann for access.

6.8. Planned and unplanned works hazards include the following:

- Working at height 'on the wire': vehicle movements and trapping of limbs between baskets and structures / OLE components;
- Failure of rigging equipment;
- Failure of a support due to testing / checking integrity[39];
- Unintentional but avoidable damage to infrastructure and vehicles: collision with structure or other vehicles;
- Radial loads;
- Tensioned loads;
- Exposure or stray into energised sections including induced voltages from HV lines;
- Fatigue and timescales for the intended work;
- Weather, environmental conditions and exposure: can affect staff and / or operation of access equipment (refer to LRG 37.0 Weather and Climate Resilience Guidance for further guidance);
- Road traffic; and
- Unauthorised persons and members of the public under the influence of drink or drugs.

6.9. Incident Management is something that usually occurs in normal workings and can leave the OLE or vehicle in such a degraded state that hazards are present. This can expose staff to stored energy within components or systems, for example, a failed pantograph mechanism or wires entangled in structures or vehicle batteries. As there is high risk of danger to undertaking this activity, measures must be implemented to reduce any risk to safety.

6.10. In addition, incident management can include partial or whole failure of a component, resulting in unexpected discharge of electrical energy and arcing i.e. a failed feeder cable in a pole. Care is required when trying to locate the fault.

6.11. Incident management hazards include the following:

- Accessing site to determine the extent and nature of the incident, whether additional hazards are present to staff or passengers or emergency services, isolation of OLE lines open to traffic;
- Accessing to make the OLE mechanically and electrically safe to work on;
- Accessing and working at height on a vehicle roof: sudden vehicle component movements and trapping of limbs and the use of harnesses and restraining points. Access and security should be accessed before undertaking the work;
- Unintentional, unavoidable damage to infrastructure and vehicles to release failed components;
- Fatigue and time of day / night;
- Weather and exposure;
- Unauthorised persons and members of the public under the influence of drink or drugs;

39 Wall supports can fail if tested too frequently, as such, the frequency should be based on risk to avoid over testing and loading and system downtime.

- Failure of MEWP; and
- Staff become incapacitated when using an MEWP (see further guidance below).

6.12. An approved rescue plan should be available for the failure of MEWP or if a staff member becomes incapacitated. Should the MEWP fail for whatever reason, staff will need to be brought down in a safe and controlled manner so adequate familiarisation, training and instructions should be provided on emergency lowering procedures for the MEWP.

6.13. In terms of staff in an MEWP becoming incapacitated where there is no additional person in the basket, an approved process should be in place.

7. Maintenance of Overhead Lines - Basic Characteristics

7.1. Light Rail OLE systems can encompass all manner of designs and styles to support the contact wire. There are three categories outlined below that trainees should be made aware of, including the differences between them:

- First Generation tramways: with more decorative structures and fixed tensioning of contact wires;
- Second Generation tramways: usually lightweight in construction and structure with auto tensioning compensation; and
- Adopted (legacy) tramways.

7.2. Attributes of First Generation OLE can include the following:

- Cast fabricated and painted steel tubular poles usually sunk (planted) into a 6 foot / 1.82 m manually excavated deep concrete foundation, usually 31 feet / 6 - 8 m long. Two or three standard sizes are usually employed for light, medium or heavy loads. The rake of the pole should be 3° positive measured at 2 feet / 0.6 m from ground level. The poles will be decorative with stepped profiles, bolted fixed cantilevers of short (usually 2 feet / 0.6 m) or long length (usually up to 16 feet / 4.8 m) and flexible contact wire supports, lighting, and finials;
- Bolted cast iron wall fixings (rosettes) with galvanised steel span wires, cast contact wire hangers and porcelain block or globe type insulators to provide double / triple insulation, and spliced and wrapped joints;
- The contact wire is hard drawn profiled copper usually 0.4 inches - 0.1257 square inches / 80 mm², fixed tensioned and operating at 550 VDC. Average height above rail, usually at 19 feet 7 inches (minimum 17 feet / 5.8 - 6 m). Supports are approximately 120 feet / 36.5 m and a maximum electrical section of ½ mile. Contact wire is not staggered;
- Feeder sub stations and feeder pillars are usually spaced every ½ mile with no reinforcing cable unless heavily traffic is expected on the system;
- No crossover at switches and crossings, moving frog assembly, operated either by trolley pole or operator;
- Wooden / insulating material section insulators for electrical sectioning;
- System double / triple insulated by use of insulated bolts on hangers or inclusion of insulators in supports or span wires; and
- There may be materials hazardous to health used on the system which should be risk assessed and mitigation measures applied.

7.3. Attributes of Second Generation OLE can include the following:

- Fabricated, steel, galvanised and / or painted tubular poles with a stepped or linear / tapered profile usually 8 - 10.5 m long. Various profile sizes are used including H / I sectional universal beams or specific designed profiles. Poles are bolted onto piled or cast reinforced concrete foundations using 8 x M24 / M30 bolts and raked to suit the implied load. Highway lighting and pole caps can also be part of the poles and sometimes poles are profiled and / or decorative;
- Cantilevers are moveable at their axis, made from steel or aluminium tubes with diameters usually of 42 mm, 55 mm and 70 mm. Aluminium or stainless steel fixings. Cantilevers can be single or multi tube assemblies, single or twin track, back-to-back (umbrella), double tube assemblies using bolter or welded supports.

Mast / pole brackets are bolted or banded. Composite / synthetic single or triple shedding insulators are used and steel or parafil rope support wires;

- Catenary can be employed off street running, usually 150 mm² single or twin copper cable;
- Underground copper or aluminium reinforcing cable used on street sections is 300 - 500 - 630 mm². 150 - 300 mm² copper PVC injection cables are used every 50 - 500 m;
- Head spans made from stainless steel or parafil rope and aluminium fixings;
- Bolted or cemented (epoxy resin) stainless steel assembled and forged wall fixings with composite or resin insulators. Parafil / stainless steel wire rope is used to form headspans;
- Contact wire is profiled copper alloy of 107 mm² -120 mm²- 150 mm² with single or twin contact wires of 750 – 1500 VDC depending on the system design. Height above rail is usually 3.6 - 6.2 m. Contact wire is staggered every span except on curves where it follows a tangent or versine of the track curve and stagger -0 >±300 mm of track centreline;
- Composite or synthetic section insulators with continuity skids or uninsulated overlaps for electrical sectioning;
- Systems are auto tensioned using weights, springs, or gas tensioners (some short, fixed tensions sections are used); and
- System achieves double insulation properties at contact wire registration arm and again at the cantilever midpoint or foot. The use of multiple insulators in span wires or the use of parafil achieves the same characteristics.

7.4. Attributes of adopted / legacy systems can include the following:

- Steel galvanised I / H sectional universal beam profile mast used instead of tubular poles sunk (planted) or bolted to steel / reinforced concrete piled / foundations;
- BR Mk 1 and Mk 3 portals and stainless-steel wire headspans;
- Contact wire is profiled copper alloy 107 mm² single contact wires 750 VDC depending on system design. Height above rail is 4.7 m. Contact wire is staggered every span. 0 >±320 mm of track centreline;
- Converted insulators;
- Converted neutral sections;
- Catenary (19/2.1) 70 mm² single copper- magnesium (bronze II) cable;
- Systems are auto tensioned using weights; and
- Original 25 kV multi-shed porcelain insulation and registration assemblies may still be in use[40].

40 With these, the location of insulation on the registration is different to those found on Light Rail OLE. Therefore, care should be taken when assessing which parts are isolated or live.

8. Maintenance of Overhead Lines – Components

8.1. Trainees must be familiar with terminology and components. Guidance is provided in LRG 21 OLE Reference and Maintenance Manual in conjunction with physical interaction with equipment and components. Below are some of the terminology and components any trainee will need to be conversant with.

OLE Component Identification and Standards

8.2. To achieve and prove competence in this standard, the trainee shall need to demonstrate the ability to identify terms, items at component level and assemblies. This includes, but is not limited to the following:

- Foundation types;
- Poles;
- Masts;
- SPS including wall and bridge / tunnel fixings and registration;
- Cantilever types;
- Headspan types (wire and synthetic);
- Insulators;
- Catenary, contact wire and auxiliary wires / cables;
- Tensioning devices;
- Protective devices;
- Sectioning devices;
- Bonding and signage;
- Depot equipment and interlocking; and
- First Generation components (for example, switched frogs).

8.3. This knowledge will provide a good understanding of the Light Rail system through practical and theoretical demonstrations.

Materials

8.4. Trainees should be able to identify materials and their use including the more common elements listed below.

- Electrolytic copper (Cu-ETP) and copper alloys with silver and magnesium, primarily for contact wires and stranded wires, possibly identified as bronze (BZ);
- Copper-Magnesium alloy contact wires (CuMg) are characterised by their outstanding mechanical strength and high resistance to abrasion;
- Copper -Silver alloyed contact wires (CuAg) combine high strength and thermal stability and are especially well-suited for DC systems;
- Copper Cadmium (CuCd) can be found on older installations but not generally used nowadays due to health risks with manufacture;
- Copper alloys with magnesium or electrolytic copper are also used for catenary and dropper wires;
- Copper-Tin (CuSn) coated sheets are used for sleeves to prevent electrolytic corrosion between dissimilar materials;

- Electrolytic copper and copper alloys used for clamps having high current-carrying capacity are used to connect catenary and contact wires with droppers, feeder, and jumper cables;
- Aluminium (Al) and aluminium alloys. Aluminium is not only low in cost but also corrosion resistant, requiring little maintenance. It can be affected by polluting elements, for example, cement dust;
- Hot-dip galvanized steel and malleable cast iron. Hot-dip galvanized steel together with hot-dip galvanized malleable cast iron is used for the majority of SPS fittings;
- Plastics. Glass Reinforced Plastic / Polymer, resins and polyethene based for insulators and ropes. They provide a high level of safety, electrical insulation and come in economical or slim designs. Some manufacturers cover the base with a coating of silicon for added protection and durability;
- Silicone composites used for insulators. Components with composite insulators and silicone sheaths not only have hydrophobic properties for high electrical resistance but are also resistant to vandalism and environmental influences. They replace porcelain insulators; and
- Stainless steel and stainless-steel castings / forgings for high-strength standard parts and ropes. In addition to their great strength, connecting elements made of stainless steel and fittings made of stainless-steel castings also offer advantages in terms of dimensional precision and resistance to environmental influences.

OLE Component Identification: Terms

8.5. To achieve and prove competence in this standard, the trainee shall need to demonstrate the ability to identify terms used within an OLE system and environment. This includes the following:

- Trolley wire or catenary;
- System height or encumbrance;
- Tension length;
- Along track tension;
- Radial loads and span wire tension;
- Height and stagger (negative and positive stagger);
- Super elevation;
- REFOS;
- Low wire height;
- Contact wire grading (gradients);
- Pull off / push off;
- Registration;
- Static clearance;
- Dynamic clearance;
- Auto tensioning;
- Fixed tensioning;
- Mid-point anchor;
- Primary insulation;
- Secondary insulation;

- Out of running wire;
- Overlaps and crossing bars;
- In running wire; and
- Injection point / feeder.

OLE Component Identification: Terms and Tools for Data Collection

8.6. To achieve and prove competence in this standard, the trainee shall need to demonstrate the ability to identify the tools and their purpose to allow data to be collected in accordance with directions from a specified competent individual. See LRG 21 OLE Maintenance and Reference Manual for further information and illustrations of tools and other specialist equipment.

8.7. The trainee will understand the safety precautions required where working at height is required with associated tools and equipment.

8.8. Trainees will be required to demonstrate safe working practices and care of tools throughout and will need to understand the responsibility they owe to themselves and others.

Height and Stagger Gauge

8.9. This is a lightweight non-contact device that sits with the track gauge allowing the height and stagger of the contact wire (or catenary) to be determined using laser technology and recorded, relative to the track centre line. The collected data is compared to as built details during analysis.

8.10. The gauge is used to verify any reinstatement or following track works, that the contact wire is in the correct position relative to the track. The latest devices allow direct recording of data to Android and / or IOS (Apple) devices including global positioning satellite (GPS) location and dedicated spread sheet, thus reducing time and errors. Staff will need to understand of the basic principles and processes in the following:

- Assembly of the gauge on site, sighting it the correct way round;
- Height;
- Stagger;
- REFOS;
- Super elevation; and
- Errors due to original laser device change, lack of calibration or damage or miss reading from system datum. The gauge should be checked before use on a standard test area.

Thermograph Camera

8.11. A hand-held non-contact thermal camera can be used to determine non visible, potential failures in OLE under normal running conditions. Staff employed in this activity will need to understand the basic principles and processes in the following:

- Connections;
- Wires and cables (hotspots);
- Switching or disconnection apparatus (mainly pole mounted); and

- Be able to determine likely faults from images.

8.12. Where data indicates something is not correct, this should be escalated for isolation, physical inspection, and rectification as necessary.

Vernier Calliper

8.13. This is a hand-held device usually with digital readout that can be used to measure the remaining contact wire (usually in mm) and determine its wear at certain datum points, usually near a registration, change in gradient or interface.

8.14. This is very labour intensive, requires isolation and working at height. It is usually undertaken as part of a high-level inspection and not a specific standalone activity. Staff employed in this activity will need to understand the basic principles and processes:

- Determining or measuring ambient temperature;
- Setting of balance weights relative to temperature, drop on the mast and charts;
- Setting of spring tensioners relative to temperature and charts;
- Setting of fixed tension lengths relative to temperature and charts (both First and Second Generation); and
- Setting of cantilevers relative to temperature and position charts along track.

Insulation Tester

8.15. This device is used to determine if a section insulator, insulation component has been degraded by use, age, or contamination. Generally, many sections insulators are non-contact in passing and require cleaning to remove minor deposits of carbon / arcing from the insulator component. However, in some low-speed versions, the pantograph rubs and will leave a carbon trace.

8.16. In addition, lightning surge arrestors can be tested under routine maintenance using an insulation tester, VLD or LVL tester. See below for further information.

8.17. With Light Rail systems, failure of injection cables can occur through degradation of insulation either caused by construction, aging or damage. Although it is not standard practice to test these on a large-scale schedule, where suspect, the insulation tester can be used between ground, pole, and cable. For replacement cable, it is standard practice that before energising, testing should take place regarding the integrity of the cable insulation compared to earth, and that the cable is intact and has not been damaged during installation.

8.18. Staff employed in this activity will need to understand the basic principles and processes including the need to demonstrate safe working practices, PPE, and care of tools throughout, due to test voltage applied in insulation testing up to 1000 VDC for systems operating at 750 VDC and 2500 - 5000 VDC for 1500 VDC systems.

VLD / LVL Tester

8.19. This device is used to test the voltage limiting and protective devices located between metallic structures, for example, bridges, tramstop furniture etc., that could become live under fault conditions. There are three outcomes of this testing, as identified below:

- The device is working correctly triggering at the required non- adjustable setpoint;
- The device is failed open circuit (through fault or aging); and / or
- The device is failed through short circuit, potentially tripping a circuit breaker, or leaking stray current into localised earthed, metallic structures.

8.20. Staff employed in this activity will need to understand the basic principles and processes including the need to demonstrate any safe working practices, PPE, and care of tools throughout. The device shall be tested when disconnected from the feed and rail side, thus preventing false reading through the reinforcing or negative return system. The correct and multiple isolated electrical sections shall be instigated to prevent access to live or energised equipment. This is particularly relevant where electrical sections cross over in a single connection box.

8.21. Further guidance in relation to stray current is provided in LRG 15.0 Stray Current Management Guidance.

RRV and Pantograph

8.22. Many RRVs have a panning device or pantograph fitted. These are used to check the contact wire is within the operating tolerance, both plane line and curves, in and out of running wires and level at overlaps as well as crossovers or section insulators set up. Staff employed in this activity will need to understand the basic principles and processes including the need to demonstrate any safe working practices whilst panning.

Digital Era Maintenance Tools

8.23. Digital maintenance tools are now starting to be used on Light Rail systems due to expansion, reduced costs and technology advancements.

8.24. There is now equipment available on the market that can undertake maintenance works without the need of isolation or working at height, for example, a thermograph camera. They are designed to be more accurate than traditional equipment and can download data automatically onto a tablet or data storage device. Such digital data collection activities include those outlined below.

8.25. Non-contact contact wire gauge and digital cameras are fully compatible and designed to be mounted on existing approved live line working poles (LLWPs) as they are lightweight with non-conductive polymer materials with inbuilt instrumentation that enables an operator to record data from the ground via bluetooth providing instant readings at ground level. Interchangeable wire shims for different wire sizes are available and calibrated images can be taken as reference on some models.

8.26. Instrumented trams are standard or modified vehicles fitted with lighting, cameras, instrumented pantograph, data storage etc. They can be used in service to collect various data inputs including height, stagger, wire wear, anomalies, gauge, video etc. This can reduce the number of staff working at height or on the ground. However, the data will still need to be analysed.

8.27. The use of drones is becoming more viable and economical due to staff rationalisation and health and safety. They can be used to undertake some aspects of visual and / or thermographic inspections without the need to work at height or under isolation. They are restricted for use in segregated areas and not generally allowed in cities where the

public is present. The flying of a drone will require the appropriate certification and authorisation of the operator from the Civil Aviation Authority (CAA).

8.28. Remote condition monitoring asset maintenance involves the use of sensors and internet of things (IoT) devices allows the condition and status of assets to be monitored remotely and will initiate an alert when intervention is required. This can include balance weight position, temperature etc. Additional devices not directly connected to OLE but used as a preventative measure against dewirements include vehicle pantograph conditioning monitoring that can be located either on a mainline or depot.

OLE Component Identification: Tools

8.29. Trainees will need know the various tools employed in the safe disassembly of OLE, including the care, use and limitation of the tools. Trainees will need to understand the safety precautions required when working at height and with wire working on the right side of radial loads and be required to demonstrate safe working practices throughout. They will also need to understand the responsibility they owe to themselves and others when working on OLE.

Ratchet Operated Lever (ROL) Pull-lifts

8.30. ROL pull-lifts are mechanical devices that are used to support, allow disconnection and movement of OLE assemblies under a controlled manner for the purpose of replacing failed or worn items, or adjusting the OLE to restore it back into its operational condition and service tolerance.

8.31. The load hooks are drop-forged that yield when overloaded instead of breaking, are made from high tensile steel, are fitted with robust safety catches, and rotate 360 degrees. The chain stops are designed to withstand double the rated capacity to ensure that the chain does not unintentionally run free. The pressure brake parts are manufactured from high quality materials and are corrosion protected. The surface is zinc plated alloy steel link chain. The lever will have a forward, neutral, or reverse operation to allow ease of operation. The chain will allow up to 1.5 m of adjustment.

8.32. Pull-lifts are factory tested for overload and should be supplied with a certificate of Encumbrance Certificate (EC) declaration of conformity. Under LOLER, the trainees should be able to distinguish the following about the unit:

- Is fit for purpose;
- Not damaged;
- Able to identify faults and escalate its removal from service and repair / replacement;
- Able to identify that the unit has been inspected by an independent competent engineer;
- Able to identify that the unit is registered in the lifting equipment log; and
- Able to identify that the unit has a current in date service tag.

8.33. There are two distinct types of ROL pull-lifts that are employed in OLE maintenance: 1.5 tonne and 0.75 tonne. Their attributes include the following:

- Safe Working Load (SWL) 1.5 tonne: used on along track contact wire rigs to allow:
  - Introduction of spliced contact wire;
  - Removal of section insulators;

- Tension from the wire when maintaining or adjusting tensioning devices; and
- They can be used singularly or in pairs;

- SWL 0.75 tonne: used on across track contact wire rigs to allow:
  - Tension to be removed from a radially loaded contact wire;
  - Load from span wires / cantilevers when maintaining, adjusting, or removing registrations;
  - Supporting weights during adjustment; and
  - They can be used singularly.

3 Tonne Turfer Winch

8.34. Turfer winches are ratchet mechanical devices that are used to support or pull OLE assemblies contact and catenary cable under a controlled manner. The hooks are drop-forged, made from high tensile steel, are fitted with robust safety catches and the hooks rotate 360 degrees. Instead of a chain they have a galvanised steel rope some 20 m long providing a long range of pull. The other attributes are as below:

- SWL 3 tonnes;
- Remove tension from the wire when maintaining or adjusting tensioning devices;
- Combined with suitably rated shackles and clamps;
- Used as temporary mast or post guy assembly; and
- Require at least two persons to use.

Slings and Straps

8.35. Polyester webbing slings used should be manufactured, and colour coded in accordance with BS EN 1492-1:2000[41]. Endless polyester round slings should be manufactured and colour coded in accordance with BS EN 1492-2:2000[42]. The working load limits (WLL) are the maximum weights which slings are designed to carry in general lifting service according to the standard uniform load method of rating. This should never be exceeded.

8.36. Below are the general uses of the two types of round slings:

- SWL / WLL 1 tonne (1000 kgs), 1 m long- violet colouring or 1 stich for identification:
  - Used on across track rigs combined with 0.75 tonne ROL pull-lift;
  - Used to support pullies when re wiring;
  - Used in straight pull: full WLL;
  - Used in choke pull: WLL reduced to 800 kgs; and
  - Can be combined with shackles and clamps.
- 3 tonne (3000 kgs), 2 m long (can be longer if required) yellow colouring or 3 stiches for identification:
  - Used on along track rigs combined with 1.5 tonne ROL pull-lift or Turfer;
  - Used to support contact wire when splicing;
  - Used in straight pull – full WLL;

41 BS EN 1492-1:2000: Textile Slings - Safety - Part 1: Flat woven webbing slings, made of man-made fibres, for general purpose use

42 BS EN 1492-2:2000: Textile Slings - Safety roundslings made of man-made fibres for general purpose use

- Used in choke lift- WLL reduced to 2400 kgs; and
- Can be combined with shackles and clamps.

Clamps

8.37. Clamps are used to grip or hold wires and cables securely. They are usually made of cast or forged alloy steel. However, aluminium is used for lighter assemblies.

8.38. The main attributes and uses of wedge clamps are as follows:

- Correct clamps must be used for wire diameter to be held;
- Serrated jaw to grip contact wire;
- Uses a wedge action to apply clamping pressure (Beaufort clamp uses a sleeve on jaws);
- Requires checks for wear, slipping;
- Serrated jaw needs to go on unworn surface of contact wire for maximum grip;
- Wire can be deformed and require straightening;
- Come-a-long clamp;
- Spring loaded jaws with serrations (for parafil rope, smooth jaws used); and
- Come in various sizes, therefore correct item needs to be used for pulling the wire.

Other Tools

8.39. Wire hooks are made from steel and formed into a double leg hook. They sit over the contact wire and allow even tension to be applied when pulling or releasing.

8.40. A load link dynamometer is used to accurately measure the tension during installation of conductor cables.

8.41. A wire tension gauge allows checking of steel or parafil rope span wires tension without disconnection or insertion of a dynamometer.

8.42. A wire twister / twisting iron is used to twist the contact wire allowing easy insertion into a registration / dropper clamp or splice.

8.43. A podge spanner is used to align SPS and brackets prior to insertion of bolts. This is a common rigging tool.

8.44. Torque wrenches are used to apply a registered torque to fixtures and fittings in order they do not vibrate loose or are strained leading to failure.

8.45. SPS brackets are generally banded to the pole or mast on modern installations using stainless steel banding tool. This tool will apply the correct tension to the band and cut the tail to the required length for securing in the clamp / buckle.

8.46. The section insulator jig is usually supplied by the OEM and is used to level any continuity skid fitted. This can also be used to level the section insulator to the track below using the height and stagger gauge at 4 marked datums on the jig.

8.47. The contract wire roller (Rolls Royce) is used to progressively remove kinks and twists out of the contact wire. In a standalone mode it can be used to straighten a piece of contact

wire for insertion of a splice. However, appropriate training must be provided due to the use of the rollers.

8.48. Crimping pliers / jaws are used to apply crimped ferrule or connections to droppers, nose wires, some span assemblies, and cables and are mainly hand operated. However, powered versions are available with jaws to suit harder materials, larger diameter cables or to swage inserts for a rail bond connection. Some assemblies have an attachment that will cut contact wire efficiently.

8.49. Various hand tools including socket sets, saw, cable cutters, spirit level and pliers are used to remove or make off components. For First Generation systems, many of the span wires are splayed and wrapped joints / terminations.

Specialist Tools

8.50. Where rigs cannot be used it may be probable to use a RRV vehicle with a suitably rated HIAB (Hydrauliska Industri AB) crane to hold assemblies whilst components are removed and replaced or used to remove / lift components. Heavy components should not be lifted in a MEWP.

8.51. Where wall anchors are to be tested periodically, either as part of a percentage set scheme or suspected failure, pull test apparatus is employed to apply the designed load plus a factor of safety. A failed anchor will render a support out of service until repaired and retested before reloading. Care should be taken to avoid failing too many anchors in one section.

Working at Height

8.52. Trainees will need to understand the safety precautions required when working at height whilst moving materials and components. They will be required to demonstrate safe working practices throughout, and will need to understand the responsibility they owe to themselves and others on the worksite.

8.53. Trainees should be able to undertake the following:

- Know / obtain the weight components to apply correct lifting techniques;
- Select lifting method so weight is distributed and secure; and
- Communicate to other staff operating lifting apparatus including formally, informally and hand signals or by radio / mobile phone.

OLE Documentation

8.54. Trainees will need to know and have an appropriate level of understanding of the various documents used in the maintenance of OLE, the recordings required and data analysis. These include the following:

- OEM manual: a set of documents that contain all the information on the design, construction, maintenance and schedules and renewals of the OLE system;
- General assembly drawings: showing the assumed assembly of a group of components for a cantilever. All parts and quantities will be listed with any notes being relevant to type, position etc.;

- Component level drawings: showing individual components with part number, dimensions, material, torque settings etc.;
- Layout drawings: showing the OLE alignment indicating system heights, wire heights, staggers, pull-off tensions (span wires) and loads, mast, or pole types;
- As-built drawings: showing the system to as built details which may have amendments to original designs or proposals implemented during construction. These are the drawings will be used when reinstatement is required;
- Single line and isolation drawings: showing the electrical sections and isolating points of the OLE;
- Materials and tolerance tables: listing all materials used at specific locations throughout the system; and
- Maintenance schedules: providing the frequency and type of maintenance to be undertaken on the system. They can revolve around a specific time or for an unspecified event.

9. Demonstrable Skills Validation

9.1. In order that a trainee can accomplish the required basic skill set, they should undertake a set of physical and written tasks under direction of a competent person using the correct tools and equipment. They should then apply this knowledge to at least two attempts with instruction provided and then a further two solely on their own before undertaking work on an in-service OLE system. See suggested training scope and demonstrable skills tables in Appendix A.

9.2. Trainees must demonstrably be able to:

- Work safely, complying with health and safety and other relevant Regulations, directives, and guidelines;
- Show understanding, follow, and use the relevant documentation for the overhead line components to be maintained as directed;
- Undertake and carry out the installation and adjustment activities using approved tools, components, processes, and procedures, both with and without direction; and
- Complete tasks showing an understanding of recording, reporting and escalation procedures as necessary.

9.3. Although experience is gained through working on Light Rail systems, trainees should not be tasked to undertake some aspects of work on their own until fully confident and competent.

9.4. A refresh of demonstrable skills should be timetabled as below:

- 3 years if regularly engaged in the work at least once a week annually;
- 2 years if the work is infrequent but undertaken with competent OLE staff; and
- 1 year for new staff or where the work is infrequent and no competent staff exist, or if an incident occurred as the result of malpractice.

APPENDIX A SUGGESTED TRAINING SCOPE AND DEMONSTRABLE SKILLS

The tables below provide a checklist of items that the trainee should be able to demonstrate to show competency in each element. Some aspects can be applied to both First and Second

Task and Training Scope	1	2	3	4	5
Ground Borne Visual Inspection					
Select appropriate PPE and tools					
Identify and describe possible hazards before task undertaken (2 - 3 items):					
Urban Inspection					
Segregated Inspection					
Identify degraded but serviceable components					
Identify failed components for escalation and possible mitigation measures required					
Identify OLE encroachment and escalate as required					

Generation systems.

Height and Stagger					
Select appropriate PPE and tools and documents					
Identify and describe possible hazards before task undertaken (2 - 3 items):					
Urban Inspection					
Segregated Inspection					
Check calibration and condition					
Determine height of contact wire and document reference to as built documentation					
Determine stagger of contact wire and document reference to as built documentation					
Determine super elevation					
Thermography					
Select appropriate PPE tools and materials for the task					
Identify OLE hazards correctly and required documentation prior to accessing location					
Determine likely faults with thermograph images, store them and escalate as required					
VLD/ LVL Inspection					
Select appropriate PPE tools and materials for the task					
Identify OLE and / or hazards correctly and required documentation prior to accessing location					
Identify device and disconnect for testing					
As per OEM documentation, test the apparatus for correct operation and using safe methods of work and record keeping					
Demonstrate refitting to the correct standard and checks required prior to closing					
Bonding Cembré					
Select appropriate PPE tools and materials for the task					

Identify OLE hazards correctly and required documentation prior to accessing location					
Demonstrate use of rail drill					
Demonstrate insert fixing using swaging tool					
Demonstrate cable fixing and security					
Task and Training Scope	**1**	**2**	**3**	**4**	**5**
Inspection and Testing of Wall Anchors					
Select appropriate PPE tools and materials for the task					
Identify OLE hazards correctly and required documentation prior to accessing location					
Use OEM manuals and locate wall anchor details for load test					
Apply pull test apparatus to simulate a test with span wire and damping device already removed					
Discuss failure mode and escalation process					
Applying an Along Track Rig for Splice Insertion					
Select appropriate PPE and tools for the task					
Identify OLE hazards correctly and required documentation prior to assessing location					
Access OLE correctly and assess location for splice insertion					
Apply clamp 1 to contact wire and secure					
Apply clamp 2 to contact wire and secure					
Set up rig using pull-lift, slings D links / shackles					
Apply tension to the rig and monitor itself and surrounding components					
Describe procedure and precautions for splice insertion					
Safely remove tension from rig and monitor surrounding components					
Applying an Along Track Rig for Tension Device Removal or Adjustment					
Select appropriate PPE and tools / drawings / diagrams for the task					
Identify OLE hazards correctly and required documentation prior to assessing location					
Access OLE correctly and assess locations for rig fitting					
Apply clamp 1 to contact wire and secure					
Fit slings and pull-lift to mast / pole and contact wire					
Apply clamp 2 to contact wire and secure					
Set up rig ('rig 1') using pull-lift, slings D links / shackles between contact wire and tensioning device ropes and assess the length of pull that is going to be required beforehand					
Apply tension to rig 1 and monitor itself and surrounding components and describe interactions - different tension devices					
Apply a weight support at the mast securing it in place (for branded weight anchor (BWA))					

Use rig 2 to move the weights / tension wheel and / or allow disconnection of the tensioning device					
Describe procedure and precautions for adjustment and temperature compensation					
Safely remove tension from rig and monitor surrounding components especially rope on guides and pullies					

Task and Training Scope	**1**	**2**	**3**	**4**	**5**
Applying an Across Track Rig for Registration or Component Removal on a Cantilever					
Select appropriate PPE and tools for the task					
Identify OLE hazards correctly and required documentation prior to assessing location					
Access OLE correctly and assess location for rigging and work on correct side of wire					
Apply hook to contact wire and secure					
Set up rig using pull-lift, slings D links / shackles on cantilever or mast					
Apply tension to the rig and monitor itself and surrounding components					
Describe procedure and precautions for registration adjustment and demonstrate accordingly					
Describe procedure and precautions for registration arm removal and demonstrate accordingly					
Describe rigging procedure and precautions for cantilever component / tube removal and demonstrate accordingly. Refit assembly					
Safely apply tension from rig and monitor surrounding components					
Applying an Across Track Rig for Registration or Component Removal on a Headspan					
Select appropriate PPE and tools for the task					
Identify OLE hazards correctly and required documentation prior to assessing location					
Access OLE correctly and assess location for rigging and work on correct side of wire					
Apply hook to contact wire and secure					
Set up rig using pull-lift, slings D links / shackles and clamps on span wire (steel)					
Apply tension to the rig and monitor itself and surrounding components					
Describe procedure and precautions for registration adjustment and demonstrate accordingly					
Safely remove tension from rig and monitor surrounding components					
Splice Insertion					
Select appropriate PPE tools and materials for the task					
Identify OLE hazards correctly and required documentation prior to accessing location					

Able to fit:					
Standard contact wire splice (for example, Siemens 8WL4534-0)					
Adjustable splice (for example, Arthur Flurry SKR)					
Tapered splice (for example, Cembré FTWG)					
Contact splice for First Generation trolley wire (BICC)					
Dressing of contact wire where required					

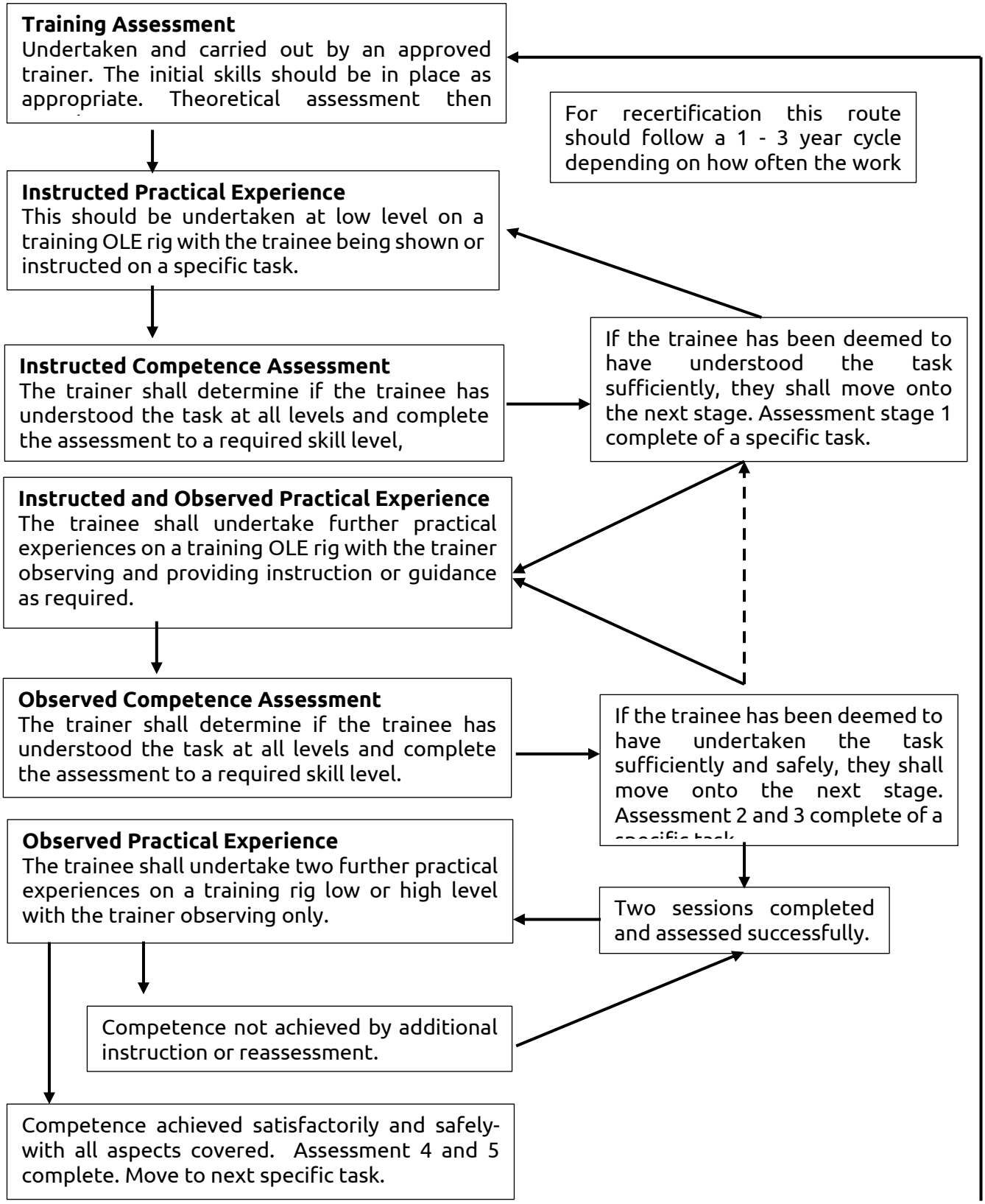
Task and Training Scope	**1**	**2**	**3**	**4**	**5**
Applying an Across Track Rig for Registration or Component Removal on a Spanwire					
Select appropriate PPE and tools for the task					
Identify OLE hazards correctly and required documentation prior to assessing location					
Access OLE correctly and assess location for rigging and work on correct side of wire					
Apply hook to contact wire and secure					
Set up rig using pull-lift, slings D links / shackles and clamps on span wire (parafil)					
Apply tension to the rig and monitor itself and surrounding components					
Describe procedure and precautions for registration adjustment and demonstrate accordingly					
Safely remove tension from rig and monitor surrounding components					
Component Manufacture Steel and Parafil Span Wire and Ends					
Select appropriate PPE tools and materials for the task					
Make up steel span wire assembly using wedge clamp, crimped or bolted connectors					
Describe limitations					
Make up parafil span wire assembly using compression connectors					
Describe limitations including load test					
Using Section Insulator Jig Line and Level Setup					
Select appropriate PPE tools and materials for the task					
Identify OLE hazards correctly and required documentation prior to accessing location					
Fit appropriate jig to a Section Insulator (SI)					
Demonstrate adjustment of live skids and level of assembly relative to the rack (spirit level or height and stagger gauge)					
Demonstrate final checks including panning					
Using Section Insulator Jig Removal					
Select appropriate PPE tools and materials for the task					

Identify OLE hazards correctly and required documentation prior to accessing location					
Where applicable and the unit is available, fit appropriate removal jig to a SI					
Where applicable and the unit is available, set up rig using pull-lift, slings D links / shackles and clamps on contact wire					
Demonstrate removal of section insulator					
Demonstrate final checks including panning					
Measurement of Contact Wire					
Select appropriate PPE tools and materials for the task					
Identify OLE hazards correctly and required documentation prior to accessing location					
Demonstrate contact wire measurement and identify errors					

Task and Training Scope	**1**	**2**	**3**	**4**	**5**
Checking Overlaps, Crossovers and Assemblies					
Select appropriate PPE tools and materials for the task					
Identify OLE hazards correctly and required documentation prior to accessing location					
Demonstrate overlap level					
Demonstrate crossing bar for free movement					
Surge Arrestor Inspection and Test					
Select appropriate PPE, equipment, tools, and materials for the task					
Identify OLE hazards correctly and required documentation prior to accessing location					
Demonstrate a test and validate the result					
Identify replacement component					
Using Banding Tape to Fix SPS to a Pole					
Select appropriate PPE tools and materials for the task					
Identify OLE hazards correctly and required documentation prior to accessing location					
Select tape and cut enough without waste for correct application of part					
Fix SPS correctly using band and tool.					
Complete and check installation					
Assembly of a Cantilever Selecting Components from Inventory					
Select appropriate PPE tools and materials for the task					
Identify OLE hazards correctly and required documentation prior to accessing location					
Select components and using geometry diagrams assemble a cantilever					
Fix to SPS correctly and adjust to suit					
Complete and check installation and document					

Maintain and Adjust a Manual Disconnector Switch / Isolator (Non-powered or Instrumented)					
Select appropriate PPE tools and materials for the task					
Identify OLE hazards correctly and required documentation prior to accessing location					
Demonstrate operation and areas of maintenance					
Demonstrate adjustment of throw and precautions required					

APPENDIX B SUGGESTED TRAINING AND ASSESSMENT CYCLE



APPENDIX C SUGGESTED SKILLS AND COMPETENCY MATRIX

Competency	Achieved	Notes
Poles and Cantilever		
Replace a pole / mast and set rake		May need additional resource
Replace banded SPS on a pole / mast		
Replace bolted SPS a pole / mast		
Replace or adjust cantilever tube, insulator or fitting under radial loading or catenary (along track and temperature compensation)		High radial loads may require additional resource
Replace or adjust cantilever tube, insulator or fitting non radial loading (along track and temperature compensation)		
Replace or adjust push-off registration / steady arm		
Replace or adjust pull-off registration / steady arm		
Replace insulated end contact wire clamp of a steady arm		If system employs them
Replace or adjust nose dropper or cantilever tether wire(s): compression, crimped or dead end / wedge clamp fastening		
Replace dropper assembly, where fitted		
Headspan		
Replace a steel or parafil span wire		
Adjust or replace a headspan box spring, where fitted		
Adjust or replace a headspan turnbuckle		
Replace a dropper		
Replace or adjust a headspan registration or steady arm		
Replace or adjust a headspan bridle or delta		
Replace or adjust a headspan clamped contact wire support (line hanger or microphone) single contact wire		Need to assess radial loads
Replace or adjust a headspan clamped contact wire support (line hanger or microphone) twin contact wire		Need to assess radial loads
Wall Support		
Replace damping device, turnbuckle, and span wire		
Maintain (inspect), replace and test fixing with pull test		May require specialist assistance
Replace a loop insulator on a steel span wire		
Bridge or Tunnel Support		

Adjust or replace components including steady arms or pulley assemblies		Full replacement if bridge drilling is required that may require specialist assistance

Competency	Achieved	Notes
Tensioning		
Adjust a tension wheel and weights relative to temperature		
Adjust a spring tensioner (Tensorex-C) relative to temperature		
Adjust a spring tensioner (box or linear) relative to temperature		
Maintain a tension wheel by grease and oil application		
Replace tension assembly parts		Replacement of whole assemblies may require assistance
Adjust a fixed tensioned contact wire		
Contact Wire		
Determine remaining wire measurement for correct wire type		
Insertion of splice, replacement wire and dressing wire		Does not include running long sections or tension lengths of wire
Remove deformation or kink from wire using rollers		
Replace clamp (registration)		
Replace or adjust a jumper wire		
Replace or adjust a Z dropper wire for mid-point anchor		
Replace or adjust T clamp for injection point cable		
Replace or adjust crossover bar / guide		
Replace or adjust section insulator setup with skids (runners) using jig.		Runners or skids can be replaced separately
Replace or adjust section insulator setup without skids		Note some systems may not use this type
Catenary Wire		
Insertion of splice, replacement wire and continuity connections		Some systems may not have this, and it may require specialist work. Does not include running

		long sections or tension lengths of wire
Replace or adjust continuity or jumper wires: catenary to contact and catenary to catenary across track		

Competency	Achieved	Notes
Feeding		
Maintain, replace, and adjust a manual pole mounted disconnector switch / isolator and components (depot or mainline where fitted)		
Replace or maintain the operating mechanism in line with an interlocking system		Depot only
Maintain or replace a voltage detection unit (depot) and visual indications		Depot only
Replace cables from a take-off pit or chamber to injection point on the wire		This may require specialisms to undertake works under BS 7671:2018 IET[43] Wiring Regulations
Replace or fit cable hangers / supports on a cantilever or headspan		
Maintain or replace a lightning surge arrestor		
Maintain or replace a VLD or LVL		
Maintain or replace a take-off point connection box		This may require specialisms to undertake works under BS 7671:2018 IET Wiring Regulations
Replace or maintain a track bonding connection		This may require specialisms to undertake works under BS 7671:2018 IET Wiring Regulations
Replace or maintain a track return cable connection		This may require specialisms to undertake works under BS 7671:2018 IET Wiring Regulations
Maintain, replace, and adjust a trackside disconnector switch / isolator (mainline)		Depends on if this competency is under OLE or Traction Power System

43 BS 7671:2018 IET: Requirements for Electrical Installations. IET Wiring Regulations

		Maintenance and linked to substations.
(Add additional competencies as required)		

APPENDIX D SUGGESTED FIRST GENERATION (HERITAGE) COMPETENCY MATRIX

Competency Heritage	Achieved	Notes
Poles and Arms		
Replace a pole		May need additional resource
Replace bolted assemblies on a pole		
Replace or adjust bracket arm and tie rod		
Replace or adjust trolley wire flexible suspension components and insulators		
Headspan and Span Wires		
Replace a steel span wire radial load		
Adjust or replace a headspan turnbuckle		
Replace a porcelain loop insulator		
Replace or adjust a headspan clamped trolley wire support hanger straight track and 'hockey stick' support where fitted		
Replace or adjust a headspan clamped trolley wire support hanger straight track		
Replace or adjust a headspan clamped trolley wire support hanger curved track		Need to assess radial loads
Wall Support		
Replace insulator and span wire		
Replace or adjust a turn buckle		
Trolley Wire		
Determine remaining wire measurement for correct wire type		Only used on systems with collectors and not trolley poles
Insertion of splice, replacement wire and dressing of wire		Does not include running long sections or tension lengths of wire
Remove deformation or kink from wire using rollers		
Replace trolley wire hanger		
Replace or adjust T clamp for injection point cable		
Replace or adjust frog switch including operating wire		
Replace or adjust section insulator setup		
Adjust fixed tension for temperature compensation over 1 span		

Competency Heritage	Achieved	Notes
Feeding		
Maintain, replace, and adjust a manual pole mounted disconnector switch / isolator and components (depot where fitted)		
Replace or maintain the operating mechanism in line with an interlocking system		Depot only
Maintain or replace a voltage detection unit (depot) and visual indications		Depot only
Replace cables from a feeder pillar to injection point on the wire		This may require specialisms to undertake works under BS 7671:2018 IET Wiring Regulations
Adjust or replace cable hangers / supports		