

**Detailed Requirements Document (DRD)
Rail Engineering Advanced Technician Level 4
Electrification Knowledge & Skills Content**

Purpose

The purpose of this Detailed Requirements Document (DRD) is to provide employers, colleges and training providers and those developing qualifications with an additional level of detail behind the Standard. The DRD should be used to support the delivery of the Railway Engineering Advanced Technician Apprenticeship

This document sets out the Knowledge and Skills required for anyone following the Signalling pathway. These requirements are in addition to the Rail Engineering Advanced Technician core knowledge and skills.

Once complete this document this document will form part of the Employer Occupational Brief (EOB).

Development process and sources

The detail within this document has been developed from Rail Engineering Technician DRDS which in turn was developed from existing National Occupational Standards (NOS) to which additional requirements were added or items that were deemed no longer necessary (very few) were removed.

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The Standard: Electrification Specialism

Core Knowledge. Within a Railway context all Rail Engineering Advanced Technicians need an in-depth knowledge and understanding of:

1. Safe and Professional working practices including legislation, regulation, industry procedures, safety requirements, risk management and environmental impact together with an understanding of human factors and techniques to address these.

2. The scientific, technical, engineering, mathematical and design principles (some of them complex) that are required in undertaking and directing maintenance, renewal and construction of and across The Railway.

3. How to work effectively to design and develop engineering solutions and innovation including understanding of failure modes and their causes; advanced problem solving, diagnostic systems and development of preventative maintenance; asset management and whole life asset costs.

4. How to deliver engineering solutions effectively including project management principles and systems to manage, time, resource, asset and quality management and assurance systems; business improvement and innovation systems, processes and techniques.

5. How the Railway works as a system and their role within it. The critical interfaces across the Railway system and how those interfaces are managed.

6. The importance of 3rd party and internal business requirements and operational interfaces. The need for and understanding of client confidentiality and compliance with corporate policies including ethics, equality and diversity and sustainability.

7. How the Railway works commercially including contractual principles and financial systems, forecasts and budgets, and performance implications and performance management techniques.

8. How the Railway is evolving. Awareness and understanding of new technological developments across the Railway and how these will impact the future operation of The Railway.

The above to include the Electrification specific Knowledge requirements of the Standard:

Electrification Advanced Technicians will have the following specific knowledge regarding different techniques and methods used to construct, install, maintain and renew The Railway and to avoid Railway asset, equipment, process and systems failures:

In-depth understanding of and experience of working with high and low voltage power rules, isolation and earthing of AC/DC electrical systems at different voltages and frequencies, reinstating power supplies by local and manual switching and working on live battery and inverter systems (this includes live working for TfL).

Knowledge of HV and LV cable systems, jointing techniques and electrical testing processes.

Understand, manage and maintain harmonic and power quality systems, transformer rectifiers, motor generators and transformers, DC traction breakers, protection and SCADA control systems, compressed air systems, power generation and other sub-station plant

Knowledge of compressed air systems and power generation.

Understand the physical and systems interfaces between Electrification assets and systems and other aspects of The Railway and the operating requirements, implications and constraints of these.

Core Skills. Within a Railway context all Rail Engineering Advanced Technicians need to be able to:

9. Keep themselves and others safe by leading and demonstrating safe working practices. Understand, reinforce and comply with statutory regulations and organisational safety requirements, including competence and safe access to work locations.

10. Produce a work plan based on safe systems of work that is informed by technical drawings, schematics and programmes of work needed for the development of rail engineering activity. Prepare contingency arrangements to manage change and risk as appropriate.

11. Undertake and direct a high standard of technical work. Take responsibility for the efficient and effective delivery of technical work activities and projects. Undertake and supervise the operation of equipment & systems. Complete integrity & compliance checks on own work and that of others and ensure appropriate testing is undertaken. Transfer responsibility of assets once work has been completed. Be responsible and accountable for their own work and that of others.

12. Solve problems: Design and develop a structured and/or innovative approach to problem solving and diagnosis. Apply appropriate methods and business improvement techniques. Predict and prevent failures through the analysis of data and the ability to provide feedback on these.

13. Make informed and considered decisions and complex critical judgements as appropriate.

14. Supervise and manage resources including the efficient utilisation of individuals, teams, tools, materials and equipment. Monitor and manage individual and team performance and development.

15. Work collaboratively maintaining effective relationships with colleagues, clients, suppliers and the public. Support the development of others through coaching and mentoring.

16. Communicate effectively across all management levels. Use oral, written, electronic and IT based methods and systems for the accurate communication, technical reporting & recording of information and management reporting.

The above to include the Electrification specific Skills requirements of the Standard:

Electrification Advanced Technicians will have the following specific skills regarding different techniques and methods used to construct, install, maintain and renew The Railway and to avoid Railway asset, equipment, process and systems failures

Able to undertake maintenance from first principles including modern techniques e.g. thermal imaging, partial discharge monitoring and trending.

Able to install, test commission and put Power Distribution Systems to work.

Knowledge

1. Safe and Professional working practices

1. Safe and Professional working practices including legislation, regulation, industry procedures, safety requirements, risk management and environmental impact together with an understanding of human factors and techniques to address these.

In-depth knowledge of electrical hazards and the legislation, regulations and standards related to working with electrical apparatus

- Identify and understand the management of the hazards that may exist when working with different pieces of electrical apparatus/systems
- Describe the control measures that should be used to reduce the risk of harm to self and others when working electrical apparatus/systems
- Describe the aspects of legislation, regulations and standards that relate to electrical apparatus/systems

2. The scientific, technical, engineering, mathematical and design principles

The scientific, technical, engineering, mathematical and design principles (some of them complex) that are required in undertaking and directing maintenance, renewal and construction of and across The Railway.

The Level 4 Rail Engineering Technician knowledge qualification for the Electrification pathway is made up of the following 2 units:

1. Features and Application of Electrical Machines
2. Rail Electrification Technologies

For further guidance please see the knowledge qualification structure at annex A.

These have been updated below to include Level 4 content / wording

Features and Application of Electrical Machines

Understand alternating current (AC) machines

- Explain the features, characteristics and application of AC motors
- Explain the features, characteristics and applications of AC generators
- Explain the features, characteristics and applications of transformers

Understand direct current (DC) machines

- Explain the features, characteristics and applications of DC motors
- Explain the features, characteristics and applications of DC generators

Know how electrical machine control circuits and systems operate

- Describe the operation and use of stop/start/retain relay control circuits for AC or DC machines

Rail Electrification Technologies

Describe the purpose and application of:

- Thermal imaging
- Partial discharge
- Trending
- Condition monitoring

- Harmonics
- Power quality systems

Understanding of the physical and system interfaces of the electrifications systems and the wider rail network e.g.

- Overhead line
- Electricity supplier DNO, electricity supplier
- Switchgear AC and DC
- Transformers
- Rectifiers
- Cabling HV and LV
- SCADA
- T&RS
- Signalling
- Control and communications

Describe the impacts, implications and constraints of these

Understand materials in the rail environment

- Describe mechanical, physical, thermal, electrical and magnetic properties of materials used in rail engineering
- Describe the effects of processing on the properties and behaviour of materials used in rail engineering
- Describe the principles of the modes of failure.

Understand the function of High Voltage and Low Voltage Switchgear, transformers, rectifiers and protection.

- Explain the purpose, operation and application of switchgear AC and DC
- Explain the importance of switchgear to plant safety and the requirement to use specialist tools
- Identify hazards associated with installation and maintenance activities on switchgear
- Identify switchgear component failure modes and causes

Switchgear components failures modes:

- Application
- Identifying hazards associated

Understand the function of High Voltage and Low Voltage cabling

- Explain the purposes of cabling and jointing
- Explain the types of and application and operation of different jointing techniques
- Identify hazards associated with jointing techniques
- Identify cable and joint failure modes and causes

Including the different types of cabling including their application and compliance (such as multi-core cables, single-core cables, steel wire armoured (SWA), data cables, screened cables, fibre cables) their fittings and their application.

Data Analysis

Principles and theories associated with power equipment (such as cascading and truth tables, logic/ladder diagrams, sequential charts/tables or functional diagrams)

System appreciation of the following

An appreciation of the following:

- The effects of short circuit and load flow on the performance of the system
- The principles of how communication-electronic or associated systems function and interact e.g. SCADA
- Knowledge of compressed air systems
- Knowledge of power generation systems as used in the Railway industry

- The principles of how Heating Ventilation Air Conditioning (HVAC) units/modules function

Assets & Equipment

The identification of different assets and Equipment:

- The different types of electrical component (such as plugs, sockets, switches, lighting and fittings, junction boxes, relays, protection devices)
- Compressors (such as screw piston, rotary vane)
- Hydraulic motors (such as piston, gear, vane)
- Pipework, fittings and manifolds, and their application
- Application, function and operation of different types of valves (such as poppet, spool, piston, disc and slide)
- Application function and operation of different types of sensors and actuators (such as rotary, linear, mechanical, electrical)
- Application of different types of pumps (positive, gear vane and piston) (Not in-depth for Siemens)

3. How to work effectively to design and develop engineering solutions and innovation

How to work effectively to design and develop engineering solutions and innovation including understanding of failure modes and their causes; advanced problem solving' diagnostic systems and development of preventative maintenance; asset management and whole life asset

The types of conditions and activities that would impact on the functional integrity and safety of the operational system

How to source and interpret information relating to the contact system, including operational activity, if applicable

How to source and interpret information relating to the switches, including maintenance reports, if applicable

How to source and interpret information relating to Distribution Switchgear, protection relays, transformers and testing procedures including installation reports and test results

4. How to deliver engineering solutions effectively

How to deliver engineering solutions effectively including project management principles and systems to manage, time, resource, asset and quality management and assurance systems; business improvement and innovation systems, processes and techniques.

Understand the impact of project Management and management of time within a project including quality, environmental and innovation for the future.

See Trailblazer document – no Electrification specific content

5. How the Railway works as a system and their role within it

How the Railway works as a system and their role within it. The critical interfaces across the Railway system and how those interfaces are managed.

Understand the interfaces between different engineering disciplines and the need for effective management and coordination including the role you play in the delivery

See Trailblazer document – no Electrification specific content

6. The importance of 3rd party and internal business requirements and operational interfaces

The importance of 3rd party and internal business requirements and operational interfaces. The need for and understanding of client confidentiality and compliance with corporate policies including ethics, equality and diversity and sustainability.

See Trailblazer document – no Electrification specific content

7. How the Railway works commercially

How the Railway works commercially including contractual principles and financial systems, forecasts and budgets, and performance implications and performance management techniques.

See Trailblazer document – no Electrification specific content

8. How the Railway is evolving

How the Railway is evolving. Awareness and understanding of new technological developments across the Railway and how these will impact the future operation of The Railway.

See Trailblazer document – no Electrification specific content

Skills

9. Keep themselves and others safe by adhering to safe working practices

Keep themselves and others safe by leading and demonstrating safe working practices. Understand, reinforce and comply with statutory regulations and organisational safety requirements, including competence and safe access to work locations.

Understand the requirements for a safe system of work and how this impacts on everyone working on the Railway, including compliance

In-depth knowledge of the Health, Safety and Environmental regulations and competence

10. Produce a work plan based on safe systems of work

Produce a work plan based on safe systems of work that is informed by technical drawings, schematics and programmes of work needed for the development of rail engineering activity. Prepare contingency arrangements to manage change and risk as appropriate.

Plan Electrification and Plant Activities

Plan electrification and plant engineering activities

- This element is about planning electrification and plant engineering activities, which may include considering the availability of:
 - technical documentation
 - equipment
 - tools
 - materials
 - components
 - personnel
- At all times you must take into account the time the system will be available for the task when planning activities and considering resources.
- The type of activities to be planned may relate to:
 - Contact systems (OLE, Conductor rails)
 - Power supply equipment (Switchgear, Transformers etc)

Prepare resources for electrification and plant engineering activities

- Conduct Maintenance, installation and repairs from first principles, following Work Instructions, Risk Assessments, Method Statements and or direct/give instruction. Identify electromechanical load flows before conducting switching so as to maintain supply to the railway via alternative feeds (where applicable). Arrange to switch Plant ON/OFF by remote (SCADA), Local or manual control via the correct authority. Identify any safety hazards present at the location of the work. Identify individual competencies needed for the task.
- Ensure that there are sufficient resources available for the activities to be undertaken and that the resources are used safely, appropriately and in a timely manner.
- Prepare and work to a plan and ensure the required resources are available and fit for purpose, including obtaining all the necessary documentation and reporting to your line manager.
- Activities may include:
 - Maintenance
 - Fault finding and/or installation work on electrification and plant equipment, assets and components

11. Under take and direct a high standard of technical work.

Undertake and direct a high standard of technical work. Take responsibility or the efficient and effective delivery of technical work activities and projects. Undertake and supervise the operation of equipment & systems. Complete integrity & compliance checks on own work and that of others and ensure appropriate testing is undertaken. Transfer responsibility of assets once work has been completed. Be responsible and accountable for their own work and that of others.

Lead and Carry out installation of electrification and plant assets

Lead and Carry out installation of electrification and plant assets

- Supervise and perform multistage processes ensuring any interference with other systems and assets is kept to a minimum.
- Where interference with other systems and assets has to take place, the correct approvals will be obtained.

The types of assets may include:

- Contact systems (OLE, Conductor rails)
- Power supply equipment (Switchgear, Transformers etc)

These may also be in one or more of the following areas:

- Structural
- Mechanical
- Electrical

Lead and carry out installation of electrification and plant equipment and components

Install, position and secure electrification and plant equipment and components correctly and making the necessary connections in accordance with policies and procedures.

The types of equipment and components may include:

- Contact and catenary wire
- Insulators
- Droppers
- Switchgear AC and DC
- Auto Transformers
- Protection
- Rectifiers
- Cabling

These may also be in one or more of the following areas:

- Structural
- Mechanical
- Electrical

The equipment and components will be sub-sets of the following assets

- Contact Systems (OLE, Conductor rails)
- Power Supply Equipment (Switchgear, Transformers etc)

Types of installation activities may include:

- AC/DC switchgear
- Transformers
- Other associated sub-station equipment

Lead and Carry out maintenance on electrification and plant equipment and components

- The activities may be routine and include preventative and corrective maintenance activities, the types of maintenance activities may include:

- Locating and diagnosing defects
- Fault finding
- Adjustments
- Replacements
- Renewals
- Restorations
- Removals
- Could also involve adjusting, replacing and dismantling electrification and plant equipment and components
- This element is about carrying out maintenance on electrification and plant equipment and components and may also include inter-connections, which may include preventative and corrective maintenance activities
- The activities will be routine and may involve adjusting, replacing and dismantling electrification and plant equipment and components
- The types of maintenance activities will be both planned and unplanned. The maintenance activities may be single stage or multi stage processes.
- Any interference with other systems and assets must be kept to a minimum.
- Where interference with other systems and assets has to take place, you will ensure the correct approvals are obtained.
- The types of assets may include:
 - Contact systems (OLE, Conductor rails)
 - Power supply equipment (Switchgear, Transformers etc)
- The types of equipment, components and inter-connections may include:
 - conductors (overhead wires and rails)
 - support and registration assemblies
 - Earthing and bonding cables and connectors
 - Insulators
 - Emergency Lighting
 - Maintenance Lighting
- These may also be in one or more of the following areas:
 - Structural
 - Mechanical
 - Electrical
- The equipment, components and interconnections will be sub-sets of the following assets:
 - AC/DC switchgear
 - Transformers
 - Other associated sub-station equipment
- Examples of maintenance activities may include:
 - Lubrication
 - Cleaning and security of equipment such as, insulation, signage, guarding
- Examples of replacement techniques may include:
 - Crimping
 - Fastening
 - Rail drilling
 - Using tensioning rigs

Establish the operational condition of electrification and plant assets

Establish the operational condition of electrification and plant assets

- Including intrusive or non-intrusive inspection or other methods appropriate for the asset.
- At all times the inspection or other methods must be approved by your organisation.

- The types activities could vary and will generally be multi stage processes.
Operational Control - Remote, Local and Manual Switching (SCADA)

The assets may include:

- Contact systems (OLE, Conductor rails)
- Power supply equipment (Switchgear, Transformers etc)

The assets may also include one or more components in the following areas:

- Structural
- Mechanical
- Electrical

Identify and assess switching programmes for any errors or variations that may be required for operational reasons

Undertake technical assessment of electrification and plant

- Undertake technical assessments of contact systems (OHLE, Conductor rails) or Distribution assets in the rail engineering industry. i.e. Switchgear both AC and DC, Auto Transformers, Rectifiers and protection systems for both intrusive and Non-intrusive.
- Including intrusive or non-intrusive inspection or other methods appropriate for the asset type, which may be routine.
- At all times the inspection or other methods must be approved by your organisation.
- Contact systems will include all aspects of overhead line electrification equipment and conductor rails, such as substation electrification equipment.
 - Assets are mainly electrical but the activity could include one or more structural and/or mechanical components.

Lead preventative and corrective maintenance of traction cabling systems and maintenance of traction cabling

- The maintenance may be routine and could involve replacing, locating, diagnosing, restoring and testing earthing and bonding equipment.
- This element may also include working on one or more electrical components associated with power supply systems.
- The types of activities will be both planned and unplanned but will generally be single stage processes

The types of systems may include:

- Contact Systems (OLE, Conductor rails)
- Power Supply Equipment (Switchgear AC and DC, Transformers)

Types of maintenance activities may include:

- Routine and preventative maintenance
- Replacement
- Faultfinding
- Restoration
- Testing

Switching
<p>Manually switch the electrical supply to contact systems to meet defined requirements in the rail engineering industry</p> <ul style="list-style-type: none"> • Confirm the requirements for switching prior to undertaking the switching on and off of the electrical supply. • Follow local Low Voltage and High Voltage procedures for Switching. • Record and document all activities and agree any switching activities beforehand. • Follow verbal communication procedures. • Source and interpret the relevant information relating to the switches and their location • The different types and mechanisms of switches and their correct mode of operation • How to identify and analyse the sequence of switching activities to be undertaken • Carry out the switching activity within the limits of your own authority • Carry out the switching activities in the specified sequence and in an agreed timescale • How and when switching activities cannot be completed • Identify and confirm the required position of the switches prior to the activity • Establish and confirm the correct positioning of the switches upon completion of the activity • Report any instances where the switching activities cannot be fully met or where there are identified defects outside the planned activities • The implications of not reporting instances of where the switching activities cannot be fully met.
Isolation and Earthing
<ul style="list-style-type: none"> • Source and interpret the relevant information relating to the Distribution/contact system and the location of the isolation and earthing activity switching • Carry out the required isolation and earthing activities in the specified sequence and in agreed timescales • Identify and confirm the required isolation and earthing methods and procedures • Confirm the isolating and earthing activities have been completed within the limits of your own authority
<p>Isolate and earth the Distribution/contact systems to meet defined isolation requirements in the rail engineering industry</p> <ul style="list-style-type: none"> • Confirm the requirements for isolating and earthing prior to undertaking the activity. • The types of isolations may include: pre-arranged, urgent, short notice. • Establish the operational condition of the Distribution/contact system • Identify where the operational condition of the Distribution/contact system may affect the functional integrity and safety of the operational system
Restore contact systems
<p>Restore the Distribution/contact systems to operational condition in the rail engineering industry</p> <ul style="list-style-type: none"> • Assess the condition of the Distribution/contact system and mode of failure to restore the contact system to full operational capability. • The Distribution/contact systems could include all aspects of electrification equipment and conductors • The assets are mainly electrical but the restoration activity could include one or more structural and/or mechanical components.
Thermal imaging and partial discharge
<p>Thermal imaging and partial discharge (from standard, preventive maintenance)</p> <ul style="list-style-type: none"> • Replacement • Faultfinding • Restoration • Testing • Commissioning • Use of varying Electrical and Mechanical Test Equipment
Planning for Testing

Under supervision for L3 and L4 but more in-depth knowledge for L4
Identify and analyse the sequence of testing and earthing activities to be undertaken
The types of tests and checks that can must be performed upon completion of the installation
Identify any special requirements (national grid, energy supplier) and incorporate them in the plan, for example, identifying when independent testing and additional communications equipment are required
Transfer responsibility of electrification and plant equipment and components
<ul style="list-style-type: none"> • Follow Low and High Voltage Rules and Permitting systems. Declare and Record Plant Equipment 'Fit' or 'Unfit' for Service and follow local procedures associated with these processes. Place Status Documentation on equipment that must be energized into service due to technical inefficiency or defect. Provide suitable and sufficient evidence to confirm the operational status of the equipment and/or components including recommending whether to : <ul style="list-style-type: none"> ○ Carry out and lead Test and Commissioning of the system ○ System is fit for entry into service ○ System is fit for entry into restricted service ○ System is not fit for entry into service • Communicate to the control room or necessary controlling authorities following appropriate standards • Ensure that the equipment and/or components are transferred back only after sufficient evidence exists to ensure safe working and the information supplied accurately and clearly identifies the operational status of the equipment and/or components.

12. Solve problems

Solve problems: Design and develop a structured and/or innovative approach to problem solving and diagnosis. Apply appropriate methods and business improvement techniques. Predict and prevent failures through the analysis of data and the ability to provide feedback on these.

13. Make informed and considered decisions and complex critical judgements

Make informed and considered decisions and complex critical judgements as appropriate

See Trailblazer document – no Electrification specific content

14. Supervise and manage resources

Supervise and manage resources including the efficient utilisation of individuals, teams, tools, materials and equipment. Monitor and manage individual and team performance and development.

Allocate and monitor resources for electrification and plant engineering activities

- Identify and allocate the resources required and source information regarding those resources. Procuring drawings, work instructions / method statements, tools, parts and testing equipment / other equipment necessary for the task. Identify correct level of staffing, for the task, to maintain a safe environment.
- Monitor the use of resources and ensure that there are sufficient resources available for the activities to be undertaken and that resources are used in a safe, appropriate and timely manner. Compile a report of any anomalies or unsafe practices so that improvements can be put in place.
- Where constraints in resources or activities occur the individual will be able to challenge when a plan or resource allocation may need amending.
- Make proposals for change
- Follow Change Control Policy where significant variances happen, liaising with Line Managers at all times.

15. Work collaboratively maintaining effective relationships with colleagues, clients, suppliers and the public

Work collaboratively maintaining effective relationships with colleagues, clients, suppliers and the public. Support the development of others through coaching and mentoring.

See Trailblazer document – no Electrification specific content

16. Communicate effectively

Communicate effectively across all management levels. Use oral, written, electronic and IT based methods and systems for the accurate communication, technical reporting & recording of information and management reporting.