Detailed Requirements Document (DRD)
Rail Engineering Advanced Technician Level 4
Signalling 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: Signaling 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 signaling specific Knowledge requirements of the Standard:

Signalling Specific Knowledge: Signalling 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 and application of safety integrity, signalling principles and the varying types of signal control as applied to train control systems.
Understand (and be able to undertake) rudimentary signalling system design.
Understand the physical and systems interfaces between Signalling 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 signaling specific Skills requirements of the Standard:

Signalling Specific Skills: Signalling 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:
Ensure the application of installation & maintenance techniques and processes.
Undertake in depth and complex integrity checks and testing of components and equipment.
Be able to undertake rudimentary signalling system design.

Knowledge

1. Safe and Professional working practices

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.
Health, Safety & Environment
Specific hazards associated with carrying out signal maintenance, component replacement and diagnostic activities (such as stored energy, radio frequency radiation, electrical supplies, electrical/electronic interfaces, using damaged or badly maintained tools and equipment, not following laid-down procedures), and how to minimise these and reduce any risks
The safe working practices for the release of stored energy, including electrical, pneumatic, hydraulic, mechanical
Your organisation's procedures for the recording and control of modifications
Understand the range of own authority and processes / documentation to be followed / completed (L4 has the authority to sign off maintenance installations)
Protection
The relevant railway possession and protection arrangements for the work site and equipment to provide a safe system of work and how to check these have been implemented
Safe working practices
The implications of not following the methods and techniques for safe component handling
The implications of not following the procedures for the installation activities
Your organisation’s procedures for the transfer of responsibility of signalling assets

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 Rail Engineering Technician (L3) knowledge qualification for the Signalling pathway is made up of the following two units: 1. Function and Characteristics of Railway Signalling Systems and 2. Signalling Technologies. These have been reviewed and updated for Level 4 content and workding in line with the contributors views For more information re the L3 qualification see Annex A

Function and Characteristics of Railway Signalling Systems
Understand the role of rail signalling within the railway system • Describe the historical development of signalling systems • Explain the purpose and scope of a signalling system within the rail system • Explain the man-machine interfaces, their problems and how they are addressed • Describe a signalling system lifecycle from design to decommissioning
The principles of modern rail traffic management systems including • Signals - concepts, how they inform the driver (including cab signalling), reading and interpreting. • Interface - signaller and driver. • Control. • Signalling diagrams. • Interlocking - route trains correctly and keep them apart. • The headway principle. • Train protection systems. • Protection systems for staff working on the line. • Level crossings - legal and technical aspects. (these are governed by a special set of rules though Highways) • Management and passenger information systems. • Interfaces with other infrastructure companies
Understand the principles of safety and high integrity systems as applied to a railway signalling system • Explain the principles of high integrity engineering with reference to the components of a signalling system • The need to ensure adequate separation of trains including accidents & incidents • Time interval v space interval • The need for block systems and interlocking • Preventing signalers and drivers errors • Single line operation • Technical advances in systems and equipment • Know which operation / company standards to loom at, how to interpret them and when to ask questions regarding their understanding and application • The need for verification and quality assurance. o How it can be achieved. o Legal requirements. o What else is advisable? o Safety authorities and railway administrations.
Know the function and characteristics of line-side signalling elements • Describe the application of principles throughout the signalling lifecycle • Explain the function of elements, consequences of failure and risk mitigation for a given signalling application • Describe the main line-side elements of a typical railway signalling system
Know the major sources and categories of controlled documentation, signalling information, notation and terminology • Describe how information is obtained and the importance of documentation control • Describe signalling abbreviations, symbols and definitions.

How to interpret the conventions, symbols, terminology and abbreviations used in site and equipment diagrams, engineering drawings and specifications including an understanding of signalling terminology

Communications principles

Understanding of communication principles to include:

- Characteristics of information; bandwidth requirements; introduction to communication protocols.
- Information theory.
- Interference - caused and suffered by signalling and communications systems.

Transmission Media

Understanding of transmission media and their propagation characteristics for e.g.:

- Twisted pair.
- Multicore cable.
- Coaxial cable.
- Optical fibre.
- Microwave link.
- Rails, inductors etc

Communication Systems

Awareness of:

- Radio systems:
- Principles of AM & FM, propagation, performance, frequency spectrum, security, noise.
- Power requirements.
- System performance and measurements.
- Secure (including cab-secure) and other radio-based systems.
- Fixed systems.
- Other business telecomms requirements.

Underlying electrical and electronic principles:

- Relays characteristic and constraints
- Serial and parallel logic ideas.
- Logic using switches and relays applied to signal equipment.
- Microprocessor systems, hardware and software, in the SSI context.
- Interfacing to the real world e.g speed of response , timing
- Tuned circuits in the signalling situation - transmission and track circuits

Signalling Technologies

Train detection:

- Track circuits.
- Axle counters.
- Treadles.

Point operation and detection

- Electric motor operated.
- Hydraulically operated.

Signals

- Information to driver.
- Semaphore signals.
- Colour-light signals.
- Cab signalling.

System hardware

- Block instruments.
- Relay arrangements.
- Solid-state interlockings.
- The signaller interface - lever frames, panels and VDU-based systems.
- TDM and FDM links.
- Combating interference.
- Automatic Warning System (AWS), Train Protection Warning System (TPWS), Automatic Train Protection (ATP).
- New developments.

Level crossing equipment

- Types of crossing.
- Gates, barriers, lights, alarms.
- Surveillance and traffic detection.

Understand the function and operation of diodes, transistors and logic gates

- Explain the purpose of two different types of diode, each in a different electronic circuit application
- Explain the operation of two different types of transistor, one in an analogue and one in a digital circuit
- Explain the operation of three different logic gates with appropriate gate symbols, truth tables and Boolean expressions

Be able to build and test operational amplifier-based analogue circuits

- Build and test two different types of analogue circuit using operational amplifiers

Be able to build and test combinational and sequential logic circuits

- Build and test a combinational logic circuit that has three input variables using different technologies e.g. relays, programmable logic controllers (plc), transistors, hydraulics and pneumatics
- Build and test a sequential circuit using integrated circuit(s)

Know about system monitoring and reliability

- Describe a condition monitoring method and technique related to a given engineering system
- Use given data to calculate failure rates for a range of components and equipment
- Describe the factors affecting reliability for a given engineering system

Data Analysis

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

Systems

The effects of pressure and flow on the performance of the system

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

The principles of how communication-electronic or associated systems function and interact e.g. SCADA

Assets and Equipment All of this section (Assets & Equipment) is expected as prior knowledge for those progressing to or entering L4

Understanding of safety integrity and fundamental signalling principles as applied to train control systems, the varying types of signal control and the signalling symbols and alphabet used in signalling design drawings *(This is the knowledge requirement of the "signaling specific" content in the Standard)*
Introduction to Signalling Design
Understand and be able to undertake rudimentary signalling system design. *(This is the knowledge & skills requirement of the "signaling specific" content in the Standard)*
Basic Signalling Design - Introduction to Signalling Design Outline Project Specification(OPS), Signalling Design Specification (SDS) and Scheme Plan
Basic Signalling Design Design Handbook Module Presentations Colour convention modifications
Basic Signalling Design Signalling Alphabet Tests CAD Practice
Basic Signalling Design - CAD Analysis sheets Location Activity Plan (LAP) Extracts (where available)
Interlocking system Appreciation Binary Exercise
Interlocking systems signal equipment housing design
Interlocking systems points equipment housing design
Project lifecycle process associated with Outline Design/Detailed Design and the associated moves from optioneering to single option selection/Approval in Principle
Production of Design Hazard/Risk log and possible brief on the Common Safety Method of Risk Assessment
Production of an early Interface Specification and Operating Specification and draft Signal Sighting Forms
An appreciation of signalling Control Tables and how these coupled with the signalling scheme plan & signaling design specification are the main building blocks in order to commence detailed circuit designs.
The existence of Typical Design Circuits
The need for independent design checking and verification and processes used

The Approval process for design and the associated notifications process leading to approval for construction and handover to
Understanding of principle of designing out risk and achieving safety through design
Parallel/Overlapping design issues and dangers associated with non-sequential working/Stage-Works
Production of on-going design log / explanation sheets to record all design decisions
Issue of Design for Installation/ Issue of Design for Test & Commissioning/issue of Design To maintainer and 'As-Built' record copies back into records custodian
Analysis
How defects and variations can affect the safety and performance of signalling system
The types of defects or variations that could occur in signalling equipment, products and assets
What constitutes a signalling component/equipment defect and the implication on safety and performance of the operational railway
Technical leadership of a small team undertaking signal engineering activities for the following types of signalling equipment: • Points • Train control (such as signals or other method of authorising train movements) • Train detection (such as track circuits or axle counters) • Power supplies
Knowledge of and uses of the following types of signaling equipment and the related engineering activities, e.g.: • Balises • ETCS Other industry specific signalling equipment
The types of defects or variations that could occur in maintained or newly installed signalling systems
The correct mode of operation of signalling asset to be adjusted
Understanding and appreciation of the implications of a signaling design with regard to the system and infrastructure interfaces and potential impacts in order to be able to take a holistic view and consider the knock on effects on the operative Railway and the context in which they are working.

3. How to work effectively and contribute to 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

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.
See Trailblazer document – no signalling 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 physical and systems interfaces between Signalling assets and systems and other aspects of The Railway and the operating requirements, implications and constraints of these. Including Track and 3rd rail, OLE, T&RS, telecoms, Signalling Systems, Control Systems and Rail Systems

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 signalling 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 signalling 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 signalling specific content

9. Keep themselves and others safe by leading and demonstrating 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.
Statutory Regulations
Ensure that any stored energy or substances are released safely and correctly
Work Area
Identify and analyse any necessary changes to safety requirements on arriving at site, including the prompt reporting to the relevant person(s)

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.
Resources
Ensure that the following resources are considered during the planning as applicable to the signal equipment being tested: • Documentation (current and appropriate) • Tools, plant and test equipment (calibrated and serviceable) • Materials, replacement equipment and consumables • Communications equipment • Personnel (total required and competence) • Access arrangements
Use of Information
Establish the required installation technical information for the following types of signalling equipment: • Points • Train control (such as signals or other method of authorising train movements) • Train detection (such as track circuits or axle counters) • Power supplies • Balises • ETCS • Other industry specific signalling equipment
Establish the required maintenance and/or testing technical information for the following types of signalling equipment: • Points • Train control (such as signals or other method of authorising train movements) • Train detection (such as track circuits or axle counters) • Power supplies • Balises • ETCS • Other industry specific signalling equipment

Activity Planning
The relevant methods and techniques covering maintenance and/or fault finding of signalling equipment and how to interpret them
What constitutes a fault and/or defect in signalling assets
Plan maintenance testing for the following types of signalling equipment: • Points • Train control (such as signals or other method of authorising train movements) • Train detection (such as track circuits or axle counters) • Power supplies • Balises • ETCS • Other industry specific signalling equipment

11. Undertake and direct a high standard of technical work

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..
Maintenance
The methods, techniques and procedures for the maintenance of signalling systems and equipment
Lead and / or direct /control the planned maintenance of the following types of signalling equipment, for example: • Points • Train control (such as signals or other method of authorising train movements) • Train detection (such as track circuits or axle counters) • Power supplies • Balises • ETCS • Other industry specific signalling equipment
Ensure that interference with other systems is minimised, and equipment and systems other than those being maintained are not disturbed without authority
The types of operational constraints that could occur when carrying out signalling maintenance activities
Replacement
Lead and / or direct / control the replacement of components from the following types of signalling equipment, for example: • Points • Train control (such as signals or other method of authorising train movements) • Train detection (such as track circuits or axle counters)

• Power supplies • Balises • ETCS • Other industry specific signalling equipment
Integrity Checks
Ensure the application of installation & maintenance techniques and processes.
Installation
Able to direct the installation of the following types of signalling equipment Mandatory: • Points • Train control (such as signals or other method of authorising train movements) • Train detection (such as track circuits or axle counters) • Power supplies Optional: • Balises • ETCS Other industry specific signalling equipment
The protection and disconnection requirements or permit to work procedure that apply to the system (such as electrical isolation, locking off switchgear, placing of warning notices, proving the isolation has been achieved and secured)
The relevant methods and techniques covering the installation of signalling equipment and how to interpret them
Hazards associated with carrying out signalling installation activities (such as stored energy, radio frequency radiation, electrical supplies, electrical/electronic interfaces, using damaged or badly maintained tools and equipment, not following laid-down procedures), and how to minimise these and reduce any risks
Confirm the operational status of signalling equipment that is: • Fit for entry into service • Fit for entry into restricted service Not fit for entry into service
Transfer responsibility for the following types of signalling equipment: Mandatory: • Points • Train control (such as signals or other method of authorising train movements) • Train detection (such as track circuits or axle counters) • Power supplies Optional: • Balises • ETCS Other industry specific signalling equipment

Ensure the application of installation & maintenance techniques and processes.:

Apply installation & maintenance techniques and processes including wiring, cable access requirements & terminations, adjustment of signalling assets, locate and replace components and methods for signal component handling working on isolated and live signalling equipment

(This is a skill requirement of the "signaling specific" content in the Standard)

Maintenance

Run, secure and terminate wires and cables correctly

The correct mode of operation of signalling assets to be maintained

Fault Diagnosis

Collect fault diagnosis evidence from:

- The person or operator who reported the fault
- Equipment self-diagnosis
- Test instrument measurements
- Recording devices
- Sensory input (such as sight, sound, smell, touch)
- Equipment records
- Circuit meters

Equipment outputs

Use a range of fault diagnostic techniques including:

- Understanding of when to use which technique and their limitations
- Understand and direct others to use appropriate techniques and processes
- Instruct others in the application of fault finding techniques

The techniques must include the following:

- Half-split technique
- Input/output technique
- Injection and sampling
- Emergent sequence
- Unit substitution
- Function/performance testing

Equipment self-diagnostics

Undertake in depth and complex integrity checks and testing of components and equipment.

(This is a skill requirement of the "signaling specific" content in the Standard)

Testing

Conduct compliance testing of the following types of maintained, repaired and / or newly installed signalling equipment:

- Points
- Train control (such as signals or other method of authorising train movements)
- Train detection (such as track circuits or axle counters)
- Power supplies

Optional:

- Balises
- ETCS

Other industry specific signalling equipment

Know how to use test equipment so as to ensure true and accurate measurements are taken
Be able to instruct others in the use of test equipment so as to ensure true and accurate measurements are taken
Understand the difference in process between scheme /project testing and maintenance testing and when each of these should be applied i.e when things are altered not on a like for like basis?

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.
Fault Diagnosis
The types of defects or variations that could occur in signalling equipment, products and assets
Understanding of the role of Functional tester and the need for technical support / technical investigation centre Understand when components should be referred Understand the concept of NDT and when components should be referred Analyse previous documentation for fault repetition etc.
Analyse Problems
How and when signalling activities cannot be achieved and the impact of any deviations from the planned activities
Apply appropriate business improvement and problem solving techniques, to identify and find solutions to problems

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 signalling 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.
Resources
Allocate and monitor resources for the following signalling engineering activities: • Installation • Maintenance • Fault finding • Testing • Other industry specific signalling activity

Resource: People, Tools & Equipment
Allocate and monitor the following resources as applicable to the signal engineering activities: • Documentation (current and appropriate) • Tools, plant and test equipment (calibrated and serviceable) • Materials, replacement equipment and consumables • Communications equipment • Personnel (total required and competence) Access arrangements
Manage small teams including: • Job allocation • Performance management of individuals • Performance management of team
Allocate and monitor resources for the following types of signalling equipment: • Points • Train control (such as signals or other method of authorising train movements) • Train detection (such as track circuits or axle counters) • Power supplies • Balises • ETCS • Other industry specific signalling equipment

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 signalling specific content

16. Communicate effectively across all management levels

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.
See Trailblazer document – no signalling specific content

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