# Detailed Requirements Document (DRD)

**Rail Engineering Advanced Technician Level 4**

**Traction & Rolling Stock 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 Traction and Rolling Stock (T&RS) 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.

## Contents

## The Standard: Traction & Rolling Stock 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 T&RS specific Knowledge requirements of the Standard:

| **Traction & Rolling Stock 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:** |
|---|
| Understanding of vehicle design, construction, maintenance operation and failure modes. |
| In depth and detailed technical knowledge of traction and rolling stock systems, sub systems and components and how they interact, these include mechanical, electrical, electronic, pneumatic and hydraulic applications. |
| Understand the maintenance procedures and standards as applicable to the vehicle type. |
| Understand the physical and systems interfaces between Traction & Rolling Stock assets and systems and other aspects of The Railway and the operating requirements, implications and constraints of these |
| Understand the requirements of and planning for vehicle overhaul |

| **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 Traction & Rolling Stock (T&RS) specific Skills requirements of the Standard:**

| **T&RS Specific Skills**<br><br>**T&RS 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 isolate equipment prior to carrying out maintenance and maintain and renew traction and rolling stock. |
| Able to interrogate and understand advanced diagnostic systems and analyse data packages to identify and understand faults and potential faults and defects |
| Able to implement corrective actions to enhance vehicle reliability and to recommend design alterations and amendments to maintenance procedures in accordance with current rail legislation |

## 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. |
| The extent of your own authority and to whom you should report if you have problems that you cannot resolve |
| The procedure for involving the appropriate people when operating/using the equipment |
| The importance of making system integrity checks before proving the equipment with the electrical supply on |
| **Statutory Regulations** |
| The health and safety requirements of the area in which you are carrying out the fault diagnosis /maintenance/overhaul activities, and the responsibility these requirements place on you |
| The specific health and safety precautions to be applied during the maintenance/overhaul activity, and their effects on others |
| **Organisational Safety** |
| The equipment operating and control procedures to be applied during the maintenance/overhaul activity |
| Dispose of waste materials in accordance with safe working practices and approved procedures |
| Company policy on repair/replacement of components during the maintenance/overhaul activities |
| The protection and disconnection requirements or permit-to-work procedure that applies to the maintenance activities (such as electrical isolation, locking off switchgear, placing of maintenance warning notices, proving the isolation has been achieved and secured) The protection and disconnection requirements or permit-to-work procedure that applies to the maintenance activities (such as electrical isolation, locking off switchgear, placing of maintenance warning notices, proving the isolation has been achieved and secured) |
| As applicable, the specific health and safety precautions to be applied during the maintenance/overhaul procedure, and their effects on others (to include the prevention of water cross contamination, The Prevention and Control of Legionellosis, and Safe working in Confined Spaces 1997) |
| The effects, and likely symptoms, of contamination in the system |
| The importance of following the correct preventative contamination procedures |
| The specific safety practices and procedures that you need to observe when replacing communication-electronic systems (including any specific legislation, regulations/codes of practice for the activities, equipment or materials) |

| |
|---|
| The specific safety precautions to be taken when carrying out testing of communication- electronic equipment |
| The hazards associated with testing communication-electronic systems (such as high voltages/currents, stored capacitive/inductive energy, radio frequencies, misuse of tools), and how to minimise them and reduce any risks |
| The hazards associated with replacing communication-electronic systems, and how to minimise them and reduce any risks |
| Hazards associated with carrying out maintenance activities on a process controlled integrated system (such as handling fluids, stored pressure/force, electrical supplies, process controller interface, using damaged or badly maintained tools and equipment, not following laid-down maintenance/overhaul procedures), and how to minimise these and reduce any risks |
| Hazards associated with carrying out maintenance/overhaul activities on air conditioning equipment (such as handling oils, greases, stored pressure/force, misuse of tools, using damaged or badly maintained tools and equipment, not following laid-down maintenance procedures), and how to minimise them to reduce any risks |
| Hazards associated with carrying out maintenance/overhaul on effluent waste water systems, and how to minimise them to reduce the risks |
| Hazards associated with carrying out maintenance/overhaul activities (such as contact with live electrical components, misuse of tools, using damaged or badly maintained tools and equipment, not following laid-down maintenance procedures), and how to minimise these and reduce any risk |
| The methods and techniques to be used for soldering and de-soldering, and the importance of adhering to these procedures |
| The importance of ensuring that any exposed electrical connectors or pipe ends are correctly covered/protected |
| The importance of making `integrity' checks before proving the equipment with the systems supplies turned on e.g switching |
| The importance of ensuring that the completed circuit is free from foreign objects, and that all terminations are electrically and mechanically sound and secure |
| Why electrical bonding is critical, and why it must be both mechanically and electrically secure |
| What constitutes a hazardous voltage/current and how to recognise victims of electric shock |
| The importance of ensuring that the completed circuit is free from foreign objects, and that all terminations are electrically and mechanically sound and secure |
| Hazards associated with carrying out fault diagnosis on communication-electronic systems (such as high voltages/currents, stored capacitive/inductive energy, radio frequencies, misuse of tools), and how to minimise them and reduce any risks |
| Methods of lifting, handling and supporting the components/equipment during the maintenance/overhaul activities |

## 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. |
|---|
| **Overground vehicle traction, suspension, wheelsets, brakes and associated systems** |
| **Detailed understanding of the fundamentals of traction and rolling stock suspension and tilt systems**<br><br>• Describe the relationship between the design, construction, maintenance and operation of train suspension.<br>• Differentiate between the different suspension systems fitted to trains in relation to their purpose<br>• Describe the operation and control of a high speed train tilt system, list potential failure modes and the mitigation that may be applied in the event of failure<br>• Illustrate mathematically how failed suspension increases damage to both track and vehicles<br>• Write a planned maintenance programme for a typical train suspension mechanism<br>• Write a planned maintenance programme for a typical train tilt mechanism<br>• Compare conventional body/bogie mountings<br>• Write a winterisation procedure for a high speed train tilt system |
| **Detailed understanding of the fundamentals of traction and rolling stock braking systems**<br><br>• Describe a typical air/electric brake system<br>• Compare and contrast tread brake, cheek disc and inboard disc braking systems<br>• Describe how a variable load valve works and what symptoms would become apparent in the event of failure<br>• Describe the various types of friction pad in use on main line traction and rolling stock<br>• Describe with the aid of schematics the operation of a typical wheel slide prevention system<br>• Describe the safety systems that can take over the operation of a train braking system in the event of operator error<br>• Describe why automatic sanding is necessary<br>• Explain the implications to the Train Operating Company (TOC) of a unit in service being unable to release brakes whilst on the mainline<br>• Write a planned maintenance programme for a typical train braking system |

**Detailed understanding of the fundamentals of traction and rolling stock axles, wheels and bearings**

- Draw a typical wheelset, identifying all components
- List the different types of wheel profile in common use on the network, identifying typical duties and the rationale for selection
- Write a wheelset and axle bearing maintenance policy
- Describe the process of changing out a wheelsets as routine maintenance, identifying all risks associated with the operation
- Describe in situ test and inspection methodology for Traction and rolling stock wheelsets
- Discuss the implications of a 'flat' on a wheelset
- Discuss ways in which wheelset life may be extended, listing determining factors

**Detailed understanding of AC electric power collection and transmission**

- Describe the relationship between the design, construction, maintenance and operation of an AC electric powered traction unit
- Describe AC traction supply in terms of the relationship between voltage, current and frequency
- Explain the construction and function of a typical high speed pantograph
- Describe what systems are in place to off load and prevent arc dragging at neutral sections
- Describe how an AC vehicle's main transformer works and the need for different voltage outputs
- Draw a schematic of a typical AC traction power control system that shows variations to allow for the control of both AC and DC traction motors
- Compare and contrast the performance, reliability characteristics and maintenance implications of AC and DC traction motors
- Describe the bonding and earth return requirements and arrangements for a typical 25kv traction unit
- Explain the principles of rheostatic/regenerative braking
- Develop a winterisation instruction for a typical 25Kv AC electric traction unit

**Detailed understanding of the fundamentals of DC Electric power collection and transmission**

- Describe the relationship between the design, construction, maintenance and operation of an DC electric powered traction unit
- Describe DC traction supply in terms of the relationship between voltage, current and frequency
- Describe typical 750V DC collection equipment
- Describe the systems that are in place to off load and prevent arc dragging at section gaps
- Describe how the speed of DC traction motors is controlled
- Draw a typical current/ speed/temperature curve for DC traction motors
- Describe the main performance issues resulting from sub-zero temperatures and snowfall
- Describe how a traction unit operating on a DC electrified railway may utilise AC traction motors
- Describe the earth return and bonding requirements for a typical 750V DC traction unit
- Write a planned maintenance programme for a typical DC traction unit operates

**Detailed understanding of diesel hydraulic and diesel electric power generation and transmission**

- Describe the relationship between the design, construction, maintenance and operation of an diesel powered traction unit
- Draw a schematic diesel engine showing all the key internal and external components
- Explain the operation of a diesel engine
- Describe how a diesel engines performance is controlled, showing mathematically how operation of the control system produces a variation in power output
- Describe mathematically how the performance of a turbo charger affects the performance of a diesel engine
- Describe with the aid of diagrams how a diesel hydraulic power unit
- Describe with the aid of diagrams how a diesel electric power unit operates
- Write a planned annual preventative maintenance programme for a diesel engine listing the components to be inspected and the periodicity of inspections

**Underground rail vehicle traction and associated systems**

**Detailed understanding of traction and rolling stock suspension systems**

- Describe the design, construction, maintenance and operation of train suspension
- Describe the purpose of the different suspension systems fitted to trains
- Explain how failed suspension increases damage to both track and vehicles
- Compare conventional body/bogie mountings

**Detailed understanding of the fundamentals of traction and rolling stock braking systems**

- Describe the operation of a typical air/electric brake system
- Describe how a variable load valve works and what symptoms would become apparent in the event of failure
- Describe the various types of friction pad in use on traction and rolling stock
- Describe the operation of a wheel slide prevention system
- Describe the safety systems that can take over the operation of a train braking system in the event of operator error
- Describe why automatic sanding is necessary
- Explain the implications to the Train Operating Company (TOC) of a unit in service being unable to release brakes whilst on the line
- Explain the use of round train circuits and the implications of their failure

**Detailed understanding of the fundamentals of traction and rolling stock axles, wheels and bearings**

- Describe a typical wheelset, identifying all components
- Identify the different types of wheel profile and their specific use
- Explain the risks associated with changing out a wheelsets
- Describe in situ test and inspection methods for traction and rolling stock wheelsets
- Discuss the implications of a 'flat' on a wheelset
- Discuss ways in which wheelset life may be extended
- Explain the importance of a regular maintenance programme for traction and the implications of a delay in this

**Detailed understanding of AC electric power collection and transmission**

- Describe the relationship between the design, construction, maintenance and

operation of an AC electric powered traction unit
- Describe AC traction supply in terms of the relationship between voltage, current and frequency
- Describe the systems that are in place to off load and prevent arc dragging at dragging gaps
- Describe how an AC vehicle's main transformer works and the need for different voltage outputs
- Describe the operation of a typical AC traction power control system that shows variations to allow for the control of both AC and DC traction motors
- Compare the performance, reliability characteristics and maintenance implications of AC and DC traction motors
- Explain the principles of rheostatic/regenerative braking

**Detailed understanding of the fundamentals of DC Electric power collection and transmission**

- Describe DC traction supply in terms of the relationship between voltage, current and frequency
- Describe typical 630/750V DC collection equipment
- Describe the systems that are in place to off load and prevent arc dragging at dragging gaps
- Describe how the speed of DC traction motors is controlled
- Describe the main performance issues resulting from sub-zero temperatures and snowfall
- Describe how a traction unit operating on a DC electrified railway may utilise AC traction motors

**Overground passenger comfort, safety and security**

**Detailed understanding of Closed Circuit Television systems**

- Explain the purposes of a Closed Circuit Television system in terms of passenger security and comfort
- Explain the components used, technical requirements and their function in a typical Closed Circuit Television system
- Describe the implications of a Closed Circuit Television system failing due to incorrect or inadequate maintenance and the methods used for fault finding on the system
- Compare and contrast the performance and reliability characteristics of the different types of recording media used in typical Closed Circuit Television systems
- Explain the implications of using and maintaining a Closed Circuit Television system with respect the privacy of passengers
- Draw a diagram of the layout of a typical Closed Circuit Television system including all components and their interconnections
- Write a planned maintenance programme for a Closed Circuit Television system listing the components to be inspected and the inspection criteria

**Detailed understanding of Heating Ventilation and Air Conditioning Systems**

- Explain the principles of heat transfer in terms of conduction, convection and radiation
- Explain the relationship between temperature and pressure and how this relationship is used in HVAC systems
- Draw a diagram which shows the stages and operation of a typical rolling stock HVAC system

- Describe the components and their function in a typical rolling stock HVAC system
- Compare and contrast the different types of refrigeration including mechanical, chemical and venture
- Describe the safety precautions to be used when working on and around HVAC systems
- Describe a typical electronic control unit for an HVAC used within rolling stock and any associated maintenance software
- Explain the environmental and legal implications of a release of refrigerant into the atmosphere

**Detailed understanding of Passenger Information Systems**

- Draw a diagram of a typical Passenger Information System showing all of the key components including controllers, displays, passenger alarms and on train audio
- Demonstrate an understanding of the relationship between passenger alarms and emergency brakes
- Describe the function and operation of each of the Passenger Information System components and how they all interact and communicate with each other
- Explain how automatic announcements are controlled on a typical Passenger Information System
- Demonstrate the ability to fault find on the Passenger Information Systems using downloads, system schematics and MVB analysis if applicable
- Explain the importance of having a functioning Passenger Information System in terms of passenger safety and comfort

Write a planned maintenance programme for a Passenger Information System listing the components to be inspected and the inspection criteria

**Detailed understanding of train interior and exterior, saloon and cab door systems**

- Explain the operating principles of electrical and pneumatic, exterior and interior, cab and saloon doors systems
- Explain the components, materials used and operational requirements of exterior cab and saloon doors systems
- Describe the electrical/ electronic methods used for the control and operation of exterior cab and saloon door systems
- List the safety devices fitted to exterior saloon doors and describe the operation of these devices
- Explain the term 'wrong side failure' and any implications that such a failure would have on the exterior saloon door system
- Draw an electrical diagram to explain a door loop interlock for the exterior door system and explain how this interlock affects the braking system
- Demonstrate the ability to fault find on the cab and saloon interior and exterior door systems using downloads, diagnostic software, system schematics and MVB analysis if applicable
- Explain the importance a correct mechanical saloon door set up with regard to normal operation, safety implications and impact on the serviceability of door components
- Describe the differences between cab back wall doors and standard interior doors explaining the reasons for these differences and the different implications of any failures
- Write a planned maintenance programme for exterior and interior, saloon and cab door systems listing the components to be inspected, any preventative maintenance and the inspection criteria
- Use of manufacturers diagnostic software and systems

**Awareness of train toilet systems**

- Explain the operating principles of a typical toilet system
- Explain the components that make up a toilet system and operational requirements of each component
- Describe any current legislation with regards to on train toilets and how this effects rolling stock design
- Describe any health and safety requirements of working on and changing components in any toilet system
- Describe the limitations of using fresh and waste water tanks, and explain any affect they may have on a TOC's diagram choice
- Write a planned maintenance programme for toilet systems listing the components to be inspected, any preventative maintenance and the inspection criteria

**Understand train vehicle trim**

- Describe the required properties of the glazing used on passenger trains in both the cab and saloon areas
- Explain the minimum lighting requirements of a passenger train if it were to lose its main source of electrical power
- Describe the logistics of maintaining a clean and tidy service for passengers from the perspective of train down time and manpower requirements

**Underground rail passenger comfort, safety and security**

**Detailed understanding of closed circuit television systems**

- Explain the purposes of a closed circuit television system in terms of passenger security and comfort
- Explain the components used, technical requirements and their function in a typical closed circuit television system
- Describe the implications of a closed circuit television system failing the methods used for fault finding on the system
- Explain the reasons for the different types of recording media used in typical closed circuit television systems
- Explain the implications of using a closed circuit television system with respect the privacy of passengers

**Detailed understanding of heating ventilation and air conditioning systems**

- Explain the principles of heat transfer in terms of conduction, convection and radiation
- Explain the relationship between temperature and pressure and how this relationship is used in HVAC systems
- Explain the stages and operation of a typical rolling stock HVAC system
- Describe the components and their function in a typical rolling stock HVAC system
- Compare and contrast the different types of refrigeration including mechanical, chemical and venture
- Describe the safety precautions to be used when working on and around HVAC systems
- Describe a typical electronic control unit for an HVAC used within rolling stock and any associated maintenance software
- Explain the environmental and legal implications of a release of refrigerant into the atmosphere

| |
|---|
| **Detailed understanding of passenger information systems**<br>• Describe a typical Passenger Information System showing all of the key components including controllers, displays, passenger alarms and on train audio<br>• Demonstrate an understanding of the relationship between passenger alarms and emergency brakes<br>• Describe the function and operation of each of the Passenger Information System components<br>• Explain how automatic announcements are controlled on a typical Passenger Information System<br>• Demonstrate the ability to fault find on the Passenger Information Systems using downloads, system schematics and MVB analysis if applicable<br>• Explain the importance of having a functioning Passenger Information System in terms of passenger safety and comfort |
| **Detailed understanding of train door systems**<br>• Explain the operating principles of electrical and pneumatic, door systems<br>• Explain the components, materials used and operational requirements of exterior door systems<br>• Describe the electrical/ electronic methods used for the control and operation of exterior door systems<br>• List the safety devices fitted to exterior saloon doors and describe the operation of these devices<br>• Explain the term 'wrong side failure' and any implications that such a failure would have on the exterior saloon door system<br>• Demonstrate the ability to fault find on the cab and saloon interior and exterior door systems using downloads, diagnostic software, system schematics and MVB analysis if applicable<br>• Explain the importance a correct mechanical saloon door set up with regard to normal operation, safety implications and impact on the serviceability of door components |
| **Detailed understanding of train vehicle trim**<br>• Describe the required properties of the glazing used on passenger trains in both the cab and saloon areas<br>• Explain the minimum lighting requirements of a passenger train if it were to lose its main source of electrical power<br>• Describe the logistics of maintaining a clean and tidy service for passengers from the perspective of train down time and manpower requirements |
| **Traction Motors** |
| The different types of electric traction motors |
| **System Knowledge** |
| The different types of control systems and their various components |
| Advanced principles of how the system functions, its operation sequence, the working purpose of individual units/components, and how they interact |
| Advanced principles of how the system functions, and the working purpose of the various integrated systems |

| |
|---|
| Detailed principles of how the equipment functions, its operation sequence, the working purpose of individual units/components and how they interact (such as sterilisers) |
| The testing methods and procedures to be used to check that the system conforms to acceptable limits |
| How subsystems and assemblies function within a system |
| How to determine suitable test points within a system, subsystem or assembly |
| The purpose of each Line Replaceable Unit within a given system |
| The principles of how high and low system pressures function |
| The correct system operating ranges, including temperature and pressures |
| The different types of ancillary systems and their various components |
| The devices and systems for storing programmes On Train Data Recorder (OTDR) |
| What procedures are in place and have to be followed for non-safety critical permitted defects e.g. seat reservations, out of order toilet, passenger announcements |
| The procedure for the removal/transfer and configuration of data from the system components prior to testing |
| Detailed applications of different heating systems (such as radiators, in line duct heaters, skirting heating, fan coil, convectors, storage pipe heaters and air handling units) fault finding, understand interaction between one system to another |
| The applications of the different types of pipework system (such as flexible, copper, plastic) |

### 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 knowledge under pinning the skills has been included in the "skills " section ( section 12 : Solve Problems)**<br><br>**Section 12 will need checking to ensure it incorporates all the skills and knowledge required to address the above** |

### 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. |
| **Business Improvement** |
| Apply the principles of workplace organisation to an operation or process using a 5S/5C audit |
| The steps in a 5S/5C audit and how to carry them out |
| How to score and audit the 5S/5C exercise |
| Apply the principle and processes of visual management to an operation or process using a variety of visual management techniques |
| The techniques required to communicate information using visual control systems (such as Kanban systems, card systems, colour coding, floor footprints, graphs, team boards, tool/equipment shadow boards) |
| Identify where information, and/or resources are missing and where improvement can be made to increase the 5S/5C score |
| Identify appropriate parts of the operation or process that will have visual controls |
| Detailed understanding of business improvement techniques to enable the improved efficiency of systems and processes |
| Understand how to review and analyse reliability data using trend analysis for preventative cure |

**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. |
| **See Trailblazer document document – no T&RS 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 T&RS 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 T&RS 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 T&RS 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. |
| |
| **The skills required under this section have been incorporated into Section 11:"Undertsake and direct a high standard of technical work"**<br><br>**Section 11 will need checking to ensure they incorporate all the skills and knowledge required to address the above** |

### 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. |
| **Activity Planning** |
| Review and evaluate various planned maintenance/overhaul schedules that are generally used (such as condition based maintenance, scheduled maintenance, and total preventative maintenance (TPM)) |
| Follow, write and review the relevant system maintenance/overhaul schedules to carry out the required work |
| **Gathering and Interpreting Information** |
| How to obtain and interpret drawings, circuit diagrams, specifications, manufacturers' manuals, test procedures and other documents needed to carry out the test |
| The interpretation of drawings, standards, quality control procedures and specifications used for removal and installation |
| Analyse data gathered in regard to the planning action required |
| Obtain and follow the relevant repair or modification specifications and job instructions |

### 11. Undertake 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..

**Maintenance and Overhaul**

Carry out the equipment maintenance/overhaul activities in the specified sequence and in an agreed time scale

Carry out maintenance/overhaul and fault finding activities on the following types of fluid power equipment, as applicable, e.g.

- Pneumatic
- Hydraulic
- Vacuum

Carry out the following maintenance/overhaul activities, as applicable to the equipment being maintained:

- Chocking/supporting actuators/rams/component
- Releasing stored pressure
- Draining, removing and replacing oil/fluids (as appropriate)
- Disconnecting/removing hoses, pipes and tubing
- Proof-marking/labelling of removed component
- Removing and replacing units/components (such as compressors, cylinders, valves, actuators)
- Replacing all 'lifed' items (seals, filters, gaskets, hoses)
- Checking components for serviceability
- Replacing damaged/defective components
- Setting, aligning and adjusting replaced components
- Tightening fastenings to the required torque
- Correct fitting of locking devices
- Making 'integrity' checks before re-pressurising system
- Priming and bleeding the system (where appropriate)

Functional/performance testing of the maintained system

How to set up and apply the appropriate test equipment

The problems that can occur during the maintenance/overhaul of the process controller system, and how they can be overcome

Carry out, and support the following maintenance/overhaul activities: Plan and communicate the maintenance activities to cause minimal disruption to normal working

- Obtain and use the correct issue of company and/or manufacturers' drawings and maintenance documentation
- Adhere to procedures or systems in place for risk assessment, COSHH, personal protective equipment and other relevant safety regulations and procedures to realise a safe system of work
- Ensure the safe isolation of equipment (such as electricity, mechanical, air or fluids)
- Provide and maintain safe access and working arrangements for the maintenance area
- Carry out the maintenance activities using appropriate techniques and procedures
- Re-connect and return the equipment to service on completion of the maintenance/overhaul activities
- Reconnect and return the vehicle trim and fittings to service on completion of the maintenance activities
- Dispose of waste items in a safe and environmentally acceptable manner, and leave the work area in a safe condition

Carry out maintenance/overhaul activities to component level the following fluid power components:

- Pumps
- Compressors
- Valves
- Motors

Actuators

Carry out planned maintenance/overhaul and fault finding activities on traction and rolling stock systems, involving the following interactive technologies, to sub-assembly/component level:

- Mechanical
- Fluid power
- Electrical
- Process control

Communication-electronics

Carry out, and support the following maintenance/overhaul activities, as applicable to the equipment being maintained:

- Take electrostatic discharge (ESD) precautions when working on or close to sensitive components
- Isolating and locking off equipment
- Removing and replacing damaged wires / cables
- Disconnecting / reconnecting wires and cables
- Removing and replacing wiring enclosures and support systems (as appropriate)
- Removing electrical units/components
- Checking components for serviceability
- Attaching suitable cable identification markers
- Replacing damaged/defective components
- Setting and adjusting replaced components
- Torque loading of fasteners and correct fitting of locking devices
- Making `integrity' checks before powering up the system
- Functionally testing completed system

Carry out, and support the following maintenance/overhaul techniques, as applicable to the equipment being maintained:

- Draining and removing fluids
- Proofmarking/labelling of components
- Dismantling equipment to unit/sub-assembly level
- Dismantling units to component level
- Replacing damaged/defective components
- Replacing all `lifed' items (such as filters, seals, bearings, gaskets)
- Checking components for serviceability
- Setting, aligning and adjusting replaced components
- Lightening fastenings to the required torque
- Correct fitting of locking devices
- Replenishing oils and greases
- Making `integrity' checks before reconnecting & powering up system
- Functionally testing the complete system, including for leaks

Carry out, and support the following program maintenance/overhaul activities on the process controller system:

- Select and use appropriate programming devices (such as terminals, handheld programmers and personal computers)
- Use ladder logic, statement lists, or system flowchart
- Carry out on-line monitoring of systems
- Upload data parameters
- Update/install program software
- Read and save programmes
- Interrogate controller memory for stored faults
- Interpret system fault log/records
- Download data parameters
- Analyse downloaded data
- Produce back-ups of completed programs
- Check controller condition, filters and cooling fans
- Reset system and warning codes
- Restore controller default settings

Carry out, and support maintenance/overhaul activities on the following types of electrical equipment:

- Single-phase power supplies
- Control systems and components
- Three-phase power supplies
- Direct current power supplies
- Wiring enclosures
- Traction motors
- Luminaires
- Switchgear and distribution panels
- Other specific electrical equipment

Ensure that all maintenance/overhaul activities comply with the following:

- Organisational guidelines and codes of practice
- Equipment manufacturer's operation range
- BS, ISO and/or BSEN standards
- Company standard operating procedures (SOP's)
- Documents such as technical procedures, vehicle maintenance instructions, vehicle overhaul instructions, workshop overhaul standards specifications

Carry out, and support the following during the maintenance/overhaul activities:

- Take electrostatic discharge (ESD) precautions when working on or close to sensitive components and circuit boards
- Proof-mark or label removed wires and components
- Inspect and/or test components for serviceability
- Change or add circuit boards
- Replace power supplies
- Replace peripherals (such as sensors, actuators, relays, switches)
- Replace process controller units
- Replace back-up batteries (as appropriate)
- Torque loading of fasteners and correct fitting of locking devices
- Functionally test the system

Follow the relevant maintenance schedules to carry out the required work

Take suitable precautions to prevent damage to components and the surrounding structure

The equipment operating and control procedures, and how to apply them in order to carry out the planned maintenance/overhaul activities

How to make adjustments to components and assemblies to ensure they function correctly

**Dismantling, Re-assembly & Replacement**

The techniques used to dismantle/assemble all types (e.g. integrated, air conditioning, mechanical) of equipment (such as release of pressures/force, proof-marking to aid re-assembly, plugging exposed pipe/component openings, dealing with soldered joints, screwed, clamped and crimped connections)

Methods of removing and replacing cables and wires in wiring enclosures, without causing damage to existing cables

Use appropriate dismantling and re-assembly techniques to deal with the following:
**Fluid power components: (no diesel for LU)**

- Releasing stored pressure
- Chocking/supporting cylinders/rams/components
- Disconnecting/removing hoses and pipes
- Removing and replacing units/components (such as pumps, valves, actuators)

**Electrical components:**

- Isolating the power using correct lock-off communication procedure
- Removing/replacing minor electrical components (such as relays, sensing devices, limit switches)
- Disconnecting and reconnecting wires/cables
- Removing and replacing major electrical components (such as motors, switch/control gear)
- Removing and replacing wiring supports (such as conduit, trunking, traywork, cable ways, looms)

**Process controller components:**

- De-activating and resetting program controller
- Disconnecting/reconnecting wires/cables
- Re-loading software/programs and making data amendments
- Removing and replacing peripherals
- Removing and replacing input/output interfacing

**Mechanical components:**

- Draining and replenishing fluids
- Removing major mechanical units (such as gear boxes, pumps, engines)
- Removing and refitting locking and retaining devices
- Removing minor mechanical units/sub-assemblies (such as guards, structures)
- Proof-marking components to aid reassembly
  Setting, aligning and adjusting replaced units

The techniques used to dismantle/assemble/replace equipment (such as unplugging, removal of screwed, clamped and crimped connections)

The sequence to be adopted for dismantling and reassembling the equipment, to both sub-assembly and individual component level for various types of assemblies

| |
|---|
| How to make adjustments to components/assemblies to ensure they function correctly |
| The application and fitting of static and dynamic seals |
| Carry out replacements which comply with the following:<br>• Organisational guidelines and codes of practice<br>• Equipment manufacturer's documents<br>• BS, ISO and/or BS EN standards<br>• Company standard operating procedures (SOP's)<br>• Documents such as technical procedures, vehicle maintenance instructions, vehicle overhaul instructions, workshop overhaul standards specifications |
| The various mechanical fasteners that will need to be removed and replaced and their method of removal and replacement (such as threaded fasteners, special securing devices) |
| Replace, position and secure the equipment and components in accordance with the specification |
| Methods of attaching identification marks/labels to removed components or cables, to assist with re-assembly |
| How to check that the replacement components meet the required specification/operating conditions (such as values, tolerance, current carrying capacity, voltage rating, power rating, working temperature range) |
| Methods of removing components that have interference fits (expansion, contraction or pressure) |
| Methods of checking that components are fit for purpose, how to identify defects and wear characteristics, and the need to replace `lifed' items (such as motor brushes, filters, seals, gaskets, bearings and overload protection devices) |
| Methods of checking that components are fit for purpose, and the need to replace items such as batteries, boards and other failed items |
| Methods of checking that components are fit for purpose, and the need to replace `lifed' items such as batteries, filters, seals, gaskets, belts, chains and bearings |
| Carry out repairs or modifications or testing and fault finding of the following electrical circuits, e.g.<br>• Single-phase power circuits<br>• Control systems and components<br>• Three-phase power circuits<br>• Direct current power circuits<br>• Wiring enclosures (such as conduit, trunking or tray work)<br>• Traction motor control<br>• Luminaires<br>• Switchgear and distribution panels |
| Methods of removing and replacing cables and wires in wiring enclosures without causing damage to existing cables |
| The techniques used to dismantle/assemble integrated equipment (such as release of pressures/force, proof marking to aid assembly, plugging exposed pipe/component openings, dealing with soldered joints, screwed, clamped and crimped connections) |
| How to make adjustments to components/assemblies to ensure that they function correctly (such as seats, mechanisms, settings travel and working clearance) |

Replace/refit a range of components, to include the following:

- Cables and connectors
- Cameras
- Routers
- Displays/screens
- Digital recorders
- Interfaces
- Batteries
- Relay components
- Switches
- Sensors
- Overload protection devices
- Solenoids
- Sockets
- Speakers
- Microphones
- Indicators
- Locking and retaining devices (such as cable ties, clips, proprietary fasteners)
- Circuit boards
- Other specific ancillary components

**Connections & Fittings**

The applications of the different types of coupling and their fittings (such as bends, branches, reduction pieces)

The different types of wiring supports that are used (to include conduit, trunking and traywork systems)

The different types of wiring enclosures that are used (to include conduit, trunking and traywork systems)

The different types of bearings that are used and their care, handling and fitting procedures

The torque loading and locking devices requirements for the maintained mechanical components

Disconnect/connect the following types of mechanical securing connections:

- Threaded fasteners
- Locking devices
- Screws
- Torque load bolts
- Quick-release fasteners
- Other specific securing device

Disconnect/connect the following types of electrical or electronic connection:

- Co-axial
- Screened
- Data cable
- Earth bonding points
- PCB header connectors
- Quad-shield connectors
- Multi pin connectors (such as 62GB)
- D-type connectors
- Free plugs and sockets
- Fibre-optic connectors
- Other specific electronic/electrical connection

| **Testing** |
|---|
| Know how the testing activities may affect the work of others, and the procedure for informing them of the work to be carried out |
| Know how to ensure that the test equipment is free from damage or defect |
| **Transfer Responsibility** |
| Carry out correct handover procedures for the following:<br>• Mechanical equipment<br>• Electrical equipment<br>• Electronic-communication equipment<br>• Fluid power equipment<br>• Process control/instrumentation and control equipment<br>• Environmental control equipment<br>• Other specific equipment |
| Confirm that everyone involved accepts the traction and rolling stock is in a satisfactory condition for handover to take place |
| Complete relevant maintenance/overhaul records accurately and pass them on to the appropriate person |
| Report any instances where the maintenance/overhaul activities cannot be fully met or where there are identified defects outside the planned schedule |

| **In depth and detailed technical-knowledge of the traction and rolling stock systems, sub systems and components, and how they interact, these include mechanical, electrical, electronic, pneumatic and hydraulic applications equipment.** |
|---|
| **In Depth Working Knowledge of Systems & Components:** |
| **a) Mechanical Components** |
| Carry out maintenance/overhaul activities on the following types of mechanical equipment:<br>• Gearboxes<br>• Mechanical structure<br>• Engines/ motors<br>• Pumps<br>• Doors<br>• Compressors<br>• Suspension<br>• Bogies<br>• Control valves<br>• Brakes<br>• Fuel tanks<br>• Auto<br>• Other specific mechanical equipment |
| Replace/refit a range of mechanical components to the following:<br>• Shafts<br>• Valves and seats<br>• Cams and followers |

- Pulleys and belts
- Couplings
- Brakes
- Axles
- Dampers
- Springs
- Slides
- Gears
- Bearing and seals
- Chains and sprockets
- Levers and links
- Clutches
- Fitting keys
- Locking and retaining devices (such as circlips, pins)

**b) Electrical Components & Systems**

Prepare the electrical circuit for the required repair or modification

Produce repaired or modified electrical circuits in accordance with the following:

- Organisational guidelines and codes of practice
- Equipment manufacturers' documents
- Engineering change documents
- BS, ISO and/or BSEN standards
- Company standard operating procedures (SOP's)
- Documents such as technical procedures, vehicle maintenance instructions, vehicle overhaul instructions, workshop overhaul standards specifications

Carry out the following during the circuit modification and rewiring activities:

- Obtain and use the correct issue of company and/or manufacturers' drawings and planning documentation
- Adhere to procedures or systems in place for risk assessment, COSHH, personal protective equipment and other relevant safety regulations and procedures to realise a safe system of work
- Ensure the safe isolation of equipment (such as electricity, mechanical, air or fluids)
- Provide and maintain safe access and working arrangements for the repair or modification area
- Repair or modify electrical circuits using approved techniques and procedures
- Apply safe working practices and procedures at all times
- Dispose of waste items in a safe and environmentally acceptable manner, and leave the work area in a safe condition

Replace/refit a range of electrical components, to include the following:

- Cables and connectors
- Switches
- Sensors
- Invertors
- Alternators
- Generators
- Controllers
- Contactors
- Solenoids
- Circuit boards
- Relay components
- Capacitors
- Lighting fixtures

| |
|---|
| • Transformers<br>• Rectifiers<br>• Batteries<br>• Overload protection devices<br>• Encoders or resolvers<br>• Locking and retaining devices (such as cable ties, clips, proprietary fasteners)<br>• Other specific electrical equipment |
| Carry out the following activities:<br><br>• Replacing cables<br>• Replacing connectors<br>• Replacing sockets<br>• Making changes to looms or circuits<br>• Changing or adding components to panels or sub-assemblies<br>• Changing the position or angle of breakout points<br>• Changing position of electrical units<br>• Adding or removing components from circuits<br>• Fitting new electrical circuits<br>• Changing the route of cables<br>• Removal of cables<br>• Adding further looms or circuits<br>• Addition of cables<br>• Repairing cable |
| Carry out the following processes:<br><br>• Terminating cables<br>• Heat shrinking (devices and boots)<br>• Bending and forming conduit<br>• Crimping (tags and pins)<br>• Bending and forming trunking and wiring trays<br>• Fitting mounting trays<br>• Stripping cable insulation/protection<br>• Replacing cable insulation/protection<br>• Sealing and protecting cable connections<br>• Removing cable end fittings<br>• Fitting cable end fittings<br>• Making mechanical/screwed/clamped connections<br>• Extracting/inserting components<br>• Soldering and de-soldering<br>• Allocating identification markings |
| |
| Ensure that the repaired or modified electrical circuit meets the specified operating conditions |
| The applications of the different pipework and equipment cleaning procedures (such as rod, water jet, solvents) |
| The different methods used to treat water supplies to meet user needs |
| The methods and principles used in leak detection systems |
| Replace/refit a range of fluid power components, to include the following:<br><br>• Bearings<br>• Compressors |

- Sensors
- Pistons
- Reservoirs
- Receivers
- Lubricators/filters/dryers
- Spools
- Accumulators
- Gaskets and seals
- Regulators
- Valves
- Pipework and hoses
- Actuators/cylinders
- Switches
- Pumps
- Other specific fluid power components

**d) Ancillary Equipment**

The application and use of a range of ancillary components (such as plugs, switches, sockets, displays, cameras, recording devices, audio equipment, passenger information systems)

The different types of connections and interfaces used on the ancillary equipment

Carry out maintenance/overhaul activities on the following types of ancillary equipment:

- At seat power connections
- Audio video on demand (AVOD)
- In train entertainment system (ITES)
- Seat reservation system (SRS)
- Route information
- CCTV
- On train monitoring recorder (OTMR)
- Digital recording systems
- Passenger displays
- Audio systems
- Call for aid system
- Wi-Fi
- Other specific ancillary equipment

**e) Air Conditioning & Ventilation continued**

Carry out maintenance/overhaul activities the following types of equipment:

- Air conditioning system
- Temperature control system
- Heaters

Maintain and/or replace a range of air conditioning/heating components to include the following:

- Motors
- Ducting/trunking
- Manifolds/flanges
- Matrix's
- Thermostats
- Dampers
- Silencers/attenuators
- Insulation

- Pumps
- Vents/diffusers
- Gaskets/seals
- Electrical connectors
- Valves
- Gauges/indicators
- Timers
- Control relays
- Chilled beams
- Filters
- Sensors
- Safety devices
- Compressors
- Condensers
- Pipework
- Switches
- Evaporators
- Couplings
- Heaters
- HVAC modules
- Fans (supply and extraction)

**f) Vehicle Trim & Fittings**

The different types of bearings that are used and their care, handling and maintenance/overhaul requirements

The hazards associated with removing vehicle trim and fittings, and with the tools and equipment used (such as lifting and handling, misuse of tools) and how to minimise them and reduce any risks

The techniques used to remove trim and fitting components from the vehicle, without damage to integrated components or surrounding structure

How to reconnect trim and fittings into the vehicle (such as the use of gaskets/seals and jointing/sealing compounds; ensuring correct tightness of pipe fittings, eliminating stress on pipework and cable connections; carrying out visual checks of all components)

Remove components from the following vehicle trim and fitting equipment systems and replace components fro the following:

- Passenger fittings
- Cab fittings
- Vestibule panels
- Berth/bunk fittings (sleepers)
- Luggage and storage systems
- Toilet equipment
- Panel systems
- Auxiliary equipment
- Catering equipment
- Decorative trim and coverings
- Safety equipment

**Other vehicle equipment and furnishings:** Remove and replace the following:

- Fire extinguishers/blankets
- Galley storage boxes
- Seat covers / facing

- Hard trim
- Emergency escape/survival equipment
- Safety notes
- Footplates
- Hand rails
- Waste bins
- Advertising frames
- Pipes and hoses
- Curtains/blinds
- Medical equipment (such as first aid boxes)
- Other specific components

During the activities identified above, you must cover the removal and replacement of the following, as applicable:

- Seating (such as driver, attendant, passenger)
- Windows (such as side lights, windscreen
- Tables
- Bunks
- Entertainment equipment
- Flooring (such as carpets,
- Water heaters
- Fridges
- Beverage machines
- Panels (such as ceiling, side, floor, soft panels)
- Gangway bellows
- Screens/dividers/remo+E645vable bulkheads
- Sanitary units and fittings
- Equipment consoles
- Storage units (such as luggage racks, overhead storage)
- Other specific major components

| **Communication – electronic systems** |
| --- |
| The techniques used to remove, position, align, adjust and secure the components of the communication-electronic systems without damage |
| The techniques used to remove, position, align, adjust and secure the components of the communication-electronic systems without damage |
| The principles of how communication-electronic or associated systems function and interact |
| Your responsibilities under regulations relevant to the communication-electronic testing activities being undertaken |
| The components, communication-electronic systems, subsystems and assemblies to be replaced, and their function within the particular communication-electronic systems |
| Isolation procedures that are unique to communication-electronic systems |
| The classification of different voltage levels and the authority requirements for working on them |
| Carry out the following tests or measurements, as applicable to the equipment being tested:<br>• Correct function<br>• Resistance<br>• DC voltage/current levels |

- Heat dissipation
- AC voltage/current levels
- Frequency modulation/demodulation
- Clock/timer switching
- Performance of system, sub-system or assembly
- Pulse width/rise time
- Conditions of assemblies and components
- Open/short circuit
- Signal noise/interference levels

Use the following methods and techniques:

- Taking ESD precautions
- Disconnection
- Levelling and aligning
- Earth bonding
- Securing and locking

Replace systems that contain communication-electronic subsystems or assemblies
Any of the items below can be identified as a system, subsystem or assembly in its own right :

"**Communication – electronic" systems include:**

- Transmitters
- Transceivers
- Receivers
- Aerial systems
- Radar systems
- Staff communication systems (such as GSMR, PA, cab to cab)
- Train control systems (such as AWS, ATP, TPWS, ERTMS)
- Data transmission lines (such as fibre optics, coaxial, baluns, twin wire)
- Display systems (such as crew and passenger information)
- Driver-machine interface
- Optical systems (such as CCTV)
- Built-in test equipment
- Data network systems (such as LANs, WANs)
- Data network interfaces (such as switches, router, bridging networks)
- Any other identifiable electronic system, subsystem or assemblies to Line Replaceable Unit (LRU) level

**Associated equipment includes:**

- Environmental control systems (such as temperature, alarms, fire protection, fire suppression)
- Electromechanical systems (such as servos, motors, relays, complex switches)
- Power generation systems (such as AC/DC generators, batteries)
- Power distribution systems (such as single phase/3-phase distribution panels, shore connections)
- Traction supply control systems (such as inverters, rectifiers, regenerative braking)
- Monitoring systems (such as On Train Data Recorder (OTDR))
- Hybrid systems (such as ADC, DAC)

## 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. |
| **Data Analysis** |
| The numbering system and codes used for identification inputs and outputs |
| How to search a programme within the process controller for specific elements |
| The methods used to input data parameters and the codes used |
| **Able to interrogate and understand advanced diagnostic systems and analyse data packages to identify and understand faults and potential faults and defects** |
| **Fault Testing & Diagnosis** |
| The specific safety precautions to be taken when carrying out the fault diagnosis of the particular engineered system |
| Select, use and apply diagnostic techniques, tools and aids to locate faults |
| Carry out the following during the fault diagnostic activities:<br>• Plan the fault diagnosis activities prior to beginning the work<br>• Obtain and use the correct issue of company and/or manufacturers' drawings and maintenance documentation<br>• Adhere to procedures or systems in place for risk assessment, COSHH, personal protective equipment and other relevant safety regulations and procedures to realise a safe system of work<br>• Ensure the safe isolation of equipment (such as mechanical, electricity, air or fluids)<br>• Provide and maintain safe access and working arrangements for the maintenance area<br>• Warn others in the area if they are at risk of injury from the system being tested<br>• Collect and interpret/analyse equipment fault diagnosis evidence from system<br>• Carry out the fault diagnostic activities using approved procedures<br>• Disconnect or isolate components or parts of the system, when appropriate, to confirm diagnosis<br>• Connect and restore any components after diagnostics have taken place<br>• Identify and carryout the fault and determine appropriate corrective actions, select appropriate tests and prove through testing<br>• Dispose of waste items in safe and environmentally acceptable manner and leave the work area in a safe condition<br>• Update records in line with procedures |
| Carry out detailed fault diagnosis on the following types of interactive technologies, to sub-assembly or component level:<br>• Mechanical<br>• Electrical<br>• Fluid power<br>• Process controller |
| How to use, understand and interpret outputs from the various aids and reports available for fault diagnosis e.g. truth tables. |

| |
|---|
| Investigate and establish the causes of the faults including the use of data analysis over a period of time |
| The application of specific fault finding methods and techniques that are best suited to the problem<br><br>Able to interrogate and analyse diagnostic systems, data and appropriate components<br><br>Able to analyse data packages to identify and understand faults and potential faults and defects at component and system level |
| Use a range of fault diagnostic techniques, to include the following:<br><br>• Half-split technique<br>• Emergent problem sequence<br>• Functional/performance testing<br>• Input/output<br>• Six point technique<br>• Injection and sampling<br>• Unit substitution<br>• Equipment self-diagnostics<br>• Manufacturers software systems |
| The types of equipment that can be used to aid fault diagnosis (such as mechanical measuring instruments, electrical measuring instruments, test rigs, manufacturers software systems and pressure and flow devices), and how to check the equipment is calibrated or configured correctly for the intended use, and that it is free from damage and defects |
| Ensure that fault diagnostic activities comply with the following:<br><br>• Organisational guidelines and codes of practice<br>• Equipment manufacturer's operation range<br>• BS, ISO and/or BS EN standards<br>• Company standard operating procedures (SOP's)<br>• Documents such as technical procedures, vehicle maintenance instructions, vehicle overhaul instructions, workshop overhaul standards specifications |
| Find, diagnose and resolve faults that have resulted in the following breakdown categories:<br><br>• Intermittent problem<br>• Partial failure or reduced performance/out of specification<br>• Complete breakdown |
| Review and use all relevant information on the symptoms and problems associated with the products or assets |
| How to analyse and evaluate possible characteristics and causes of specific faults/problems |
| How to make use of previous reports/records of similar fault conditions including trend analysis |
| Carry out tests using a range of tools and test equipment using the following:<br><br>• Oscilloscope<br>• Temperature testing devices<br>• Power meters<br>• Logic analyser |

| |
|---|
| • Q meter<br>• Spectrum analyser<br>• Current tracer<br>• Time domain reflectometer<br>• Signal generator<br>• Frequency counter<br>• Multi-meter<br>• Protocol analyser<br>• Computer-aided diagnostic equipment<br>• Breakout box<br>• Special-purpose testing equipment<br>• Automatic test equipment<br>• Other specific test equipment<br>• Manufacturers software systems |
| Use the following types of test equipment to help in the fault diagnosis:<br>• Mechanical measuring equipment (such as measuring instruments, dial test indicators, torque instruments)<br>• Electrical/electronic measuring instruments (such as multi-meters, logic probes, analysers)<br>• Fluid power test equipment (such as test rigs, flow meters, pressure gauges) |
| Carry out the following during the testing activities:<br>• Plan the testing activities to cause minimal disruption to normal working<br>• Obtain and use the correct issue of company and/or manufacturers' drawings and maintenance/overhaul documentation<br>• Adhere to procedures or systems in place for risk assessment, COSHH, personal protective equipment and other relevant safety regulations and procedures to realise a safe system of work<br>• Ensure the safe isolation of equipment<br>• Provide and maintain safe access and working arrangements for the maintenance area<br>• Warn others in the maintenance area if they are at risk of injury from the system being tested<br>• Carry out the testing activities using appropriate techniques and procedures<br>• Take electrostatic precautions when handling components and circuit boards<br>• Re-connect and return the equipment to service on completion of the testing activities<br>• Dispose of waste items in a safe and environmentally acceptable manner, and leave the work area in a safe condition |

**13. Make informed and considered decisions and complex critical judgements**

| **Make informed and considered decisions and complex critical judgements** as appropriate |
|---|
| |
| **See core document – no T&RS 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. |
|---|
| **Resource: Tools & Equipment** |
| How to check that tools and equipment are free from damage or defects, are in a safe and usable condition, and are configured correctly for the intended purpose |
| How to determine the calibration state of the equipment, and the actions to be taken if equipment is out of calibration |
| The procedure for obtaining consumables and `lifed' items that will require replacing during the maintenance/overhaul activity |
| The need to correctly label and store components that require repair or overhaul and to check that replacement components have the correct part/identification markings |
| Company policy on the repair/replacement of components, and the procedure for obtaining replacement parts, materials and other consumables necessary for the maintenance/overhaul activities |
| The procedure for obtaining replacement parts, materials and other consumables necessary for the maintenance/overhaul |
| Procedures for ensuring that you have the correct tools, equipment, components and fasteners for the activities |
| The tools and equipment used in the activities, and their calibration/care and control procedures |
| Use the correct tools and equipment for the replacement operations and check that they are in a safe and usable condition |
| Why tool/equipment control is critical, and what to do if a tool or piece of equipment is unaccounted for on completion of the activities |
| How to use lifting and handling equipment in the maintenance/overhaul activity |
| The procedure for the storage/transport/disposal of the removed components |
| The care, handling and application of multi-meters and other electrical/electronic measuring instruments |
| Follow the appropriate procedures for use of tools and equipment to carry out the required tests |
| Carry out the following checks to ensure the accuracy and quality of the tests carried out:<br>• Test equipment is correctly calibrated<br>• Test equipment used is appropriate for the tests being carried out<br>• Test equipment is operated within its specification range<br>• Test procedures used are up to date |

**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 core document – no T&RS 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. |
|---|
| **Communicate Information** |
| Complete the relevant records/documents of the handover |
| The need to highlight, where appropriate, any new, current or changed operating features of the maintained or installed equipment |
| The importance of informing the appropriate person of any future maintenance/overhaul requirements |
| Report any instances where the maintenance/overhaul activities cannot be fully met or where there are identified defects outside the planned schedule |
| **Presenting Information** |
| How to prepare a handover report which complies with the company policy on fault diagnosis |
| Provide a record of the outcome of the fault diagnosis, using the following:<br>• Step-by-step analytical report<br>• Preventative maintenance/overhaul log/report<br>• Corrective action report<br>• Company-specific reporting procedure<br>• Job cards<br>• Electronic reports |
| The generation of maintenance documentation and/or reports on completion of the maintenance/overhaul activity |
| Complete the relevant paperwork/records from the following, and pass it to the appropriate people:<br>• Job cards<br>• Permits to work/formal risk assessment and/or sign on/off procedures<br>• Maintenance/overhaul log or report<br>• Company-specific documentation<br>• Electronic records |
| Record details on the extent and location of the faults in an appropriate format |
| Provide a record/report of the test outcome(s), using the following:<br>• Preventative maintenance/overhaul log/report<br>• Company-specific reporting procedure<br>• Inspection schedule<br>• Specific test report |

| |
|---|
| Complete the fault diagnosis within the agreed time and inform the appropriate people when this cannot be achieved |