

Unit 55: Railway Signalling Systems Testing and Maintenance

Unit code:	T/600/0347
QCF Level 3:	BTEC Nationals
Credit value:	10
Guided learning hours:	60

● Aim and purpose

This unit is designed to give learners an understanding of railway signalling systems and the stages required to maintain these systems in an operational state.

● Unit introduction

This unit will look at the functions of the various sub-systems that make up the railway signalling system and will give learners an understanding of the system's life cycle, from design through to construction, installation, testing and maintenance. The impact of other systems on the signalling system will also be explained.

The unit will give learners an opportunity to use the tools and instruments associated with railway signalling and learners will consider the limitations of such equipment in relation to system maintenance requirements.

A main focus of the unit will be to ensure that learners appreciate the implications of scheduling signalling work on the railway track. Specifically, it will introduce learners to safe systems of working for both individuals and teams.

The unit will also introduce learners to the principles of signal design and how to use specific tools in the design process. This will apply to the various types of rail operations such as heavy rail, metro and light rail.

● Learning outcomes

On completion of this unit a learner should:

- 1 Understand the sub-systems and components of the main line-side equipment types
- 2 Be able to use railway signalling maintenance and testing equipment
- 3 Understand how safe working procedures apply to signalling equipment operations
- 4 Know signalling design processes.

Unit content

1 Understand the sub-systems and components of the main line-side equipment types

Line-side equipment types: heritage systems eg mechanical signalling, lever frames, semaphore signals, block instruments, single line instruments; points; signals; relay interlocking; computer-based interlocking; vital radios; track circuits; axle counters; balises; train protection and warning; train control systems

Structure and design: functional elements of signalling system; reliability, availability, maintainability and safety (RAMS) characteristics; use of schematic illustration (block diagrams)

Construction and implementation: choice of materials, 'fail-safe/right-side' properties; circuit design; evolution based on accidents and lessons learned

Installation, testing and commissioning: independent check (consequences of poor techniques or procedures); formal procedures eg hand over, licensing of organisations/individuals, routines and procedures to check compliance (go-live procedures)

Maintenance and repair: effects of intrusive testing; potential impact of testing; difference of working on new installations and live signalling systems

Related systems and effects: level crossing principles and types eg fully automatic, half barrier, closed circuit TV; hot axle box detectors; electromagnetic interference (EMI); electromagnetic compatibility (EMC); impact on systems eg alternating and direct current, immunisation; silver migration; insulation degradation

2 Be able to use railway signalling maintenance and testing equipment

Types of railway signalling maintenance and testing equipment: multi-meter; AWS flux-meter; Megger test instrumentation; track circuit shunt box; point gauges; crimping tools; torque wrench; data recorder; SSI error rate detector; LED light measuring tool

Precautions in use: purpose and limitations eg precision, accuracy, consistency and tolerances; effect on the system of introducing the instrument; adjusting tool settings; instrument ranges; competence and certification requirements for instruments eg heat shrink gun, crimping tool; interpreting and recording results eg orders of magnitude, significance, recording methods

Care: calibration and testing eg standards and calibration frequencies, preservation of performance; damage and its avoidance; identifying tool or instrument failure

3 Understand how safe working procedures apply to signalling equipment operations

Safe methods of working (SMOW): formalities and practicalities of SMOW; personal and system safety eg role of controller of site safety (COSS), personal track safety (PTS) competence; taking and giving up 'possessions' (railway infrastructure); appreciation of plan of works eg safety implications of time, people, materials

Testing methods, records and personal accountability: correlation of records to actual site installation; testing and commissioning plans and procedures eg use of standard technician handbooks; records and correct completion of mandatory and company records; personal accountability eg competence and certification on specific equipment, procedures for independent checks, signatures and authorisations

4 Know signalling design processes

Stages of signalling system design process: planning eg scheme plans, layouts, control tables, circuit drawings; implementation eg choice of equipment, appropriateness of design to size of installation; applications eg heavy rail, metro, light rail

Components of a control table: the components that make up a control table eg signal positioning, sighting distances, relationships between line speed and signal spacing; effect of gradients; effect of junctions

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:	To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:
P1 describe an application of each type of line-side equipment	M1 compare the elements, implementation, installation and testing of two different signalling systems	D1 analyse the factors affecting the integrity of signalling systems and any interrelationships
P2 explain the structure and design of a signalling system using a block diagram approach	M2 explain the consequences of using inappropriate tools/equipment	D2 justify the design of a signalling system in terms of its application.
P3 describe the principal elements of construction and implementation of a signalling system	M3 describe the interdependencies between the installation, testing and commissioning processes.	
P4 explain the installation, testing and commissioning of a signalling system		
P5 describe the principle processes of maintenance and repair		
P6 describe and explain an application of each of the range of related systems and the effects that may impact on each system		
P7 use three different types of railway signalling maintenance and testing equipment [SM3, SM4]		
P8 describe the purpose, the precautions in use and care for each of the three types of railway signalling maintenance and testing equipment used		
P9 explain the need for safe methods of working when working on signalling equipment		

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:	To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:
P10 explain the need for testing methods, records of work and personal accountability when working on signalling equipment		
P11 describe the stages of a signalling system design process for a given application		
P12 describe the component parts of a control table and the sources from which these are drawn..		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers CT – creative thinkers	RL – reflective learners TW – team workers	SM – self-managers EP – effective participators
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Essential guidance for tutors

Delivery

This unit is likely to be delivered predominantly in a classroom environment allowing learners to gain an overview of signalling systems procedures. However, for learning outcome 2 learners will require access to a suitable workshop so that they can work with and railway signalling maintenance and testing equipment.

Before starting this unit learners should have already completed *Unit 48: Function and Characteristics of Railway Signalling Systems*, or have sufficient background knowledge from their own industrial experience with railway signalling. It is the responsibility of the centre to ensure that learners have sufficient underpinning knowledge and experience before undertaking this unit. Learners with little knowledge of such systems will need to be encouraged to undertake a considerable amount of self-study of relevant standards and handbooks.

Although the unit content has been broken down for ease of reference, delivery should concentrate on the integrative nature of all the elements of signalling. Delivery should ensure that learners gain an overall understanding of signalling as an integrated system, rather than just learning about any one element by rote. Safety, the potentially catastrophic impact of signalling systems failure and the importance of effective signalling systems must be a continuous underlying theme throughout this unit.

Although this unit could be delivered as a stand-alone package, it would also benefit from being integrated with other electrical and railway units to achieve a more holistic approach for the learner's study.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
<p><i>Whole-class teaching:</i></p> <ul style="list-style-type: none">• introduction to unit, scheme of work and methods of assessment• explain main types of line-side equipment. Describe structure and design of signalling systems• explain the construction, implementation, installation and testing of signalling systems• explain maintenance and repair methods for signalling systems• explain related systems and effects on signalling. <p><i>Individual research activity:</i></p> <ul style="list-style-type: none">• investigate the main elements of a signalling system, their function and operation.
<p>Preparation for and carrying out Assignment 1: Line-side Equipment Sub-systems and Components (P1, P2, P3, P4, P5, P6 and M1)</p>
<p><i>Whole-class teaching:</i></p> <ul style="list-style-type: none">• explain and demonstrate use of maintenance and testing equipment• explain main precautions to be followed when using testing equipment• explain and demonstrate care procedures for maintenance and testing equipment. <p><i>Practical workshop activities:</i></p> <ul style="list-style-type: none">• investigate and practise the use of a range of railway signalling maintenance and testing equipment.
<p>Preparation for and carrying out Assignment 2: Signalling Maintenance Equipment (P7 and P8)</p>
<p><i>Whole-class teaching:</i></p> <ul style="list-style-type: none">• explain the main methods of safe working that apply to signalling equipment operations• explain the use of testing methods and records and personal accountability. <p><i>Site visit/case study:</i></p> <ul style="list-style-type: none">• identify and research the use of safe working procedures for a particular application of signalling equipment.
<p>Preparation for and carrying out Assignment 3: Safe Working Procedures (P9, P10, M2)</p>
<p><i>Whole-class teaching:</i></p> <ul style="list-style-type: none">• explain the planning, implementation and applications of signalling system design process• identify and describe the main components that make up a control table.
<p>Preparation for and carrying out Assignment 4: Signalling Systems Design (P11, P12, D1, D2)</p>
<p>Feedback on assessment and unit evaluation.</p>

Assessment

A variety of assessment methods could be used for this unit. However it is recommended that centres try and apply a 'hands-on' approach and should consider the best way of capturing work-based evidence where available.

Learning outcome 1 has six pass criteria (P1-P6) relating to it and as such acts as a foundation for the other learning outcomes.

For P1 learners need to describe an application of each type of line-side equipment. This must include at least one heritage system plus the remaining systems listed in the unit content. Although this could be achieved through a stand-alone test, ideally it would be covered in a more integrative way.

The remaining criteria relating to learning outcome 1 (P2-P6) could be combined into one assignment that first requires learners to explain the structure and design of a signalling system using a block diagram approach (P2). Then, for that signalling system, they should describe the principal elements of construction and implementation (P3). Learners could then explain the installation, testing and commissioning of the same signalling system (P4) and describe the principle processes of maintenance and repair (P5) within the context of the system being considered. Finally, they could describe an application of each of the range of related systems (that would more than likely be integral to the system considered anyway) and the effects that may impact on each system. M1 can be effectively linked with the work for P3 and P4 and the assignment should provide an opportunity for learners to achieve this merit criterion.

P7 and P8 relate to learning outcome 2. In order to achieve this learners need to carry out relevant practical work that enables them to use three of the items listed in the unit content (ie multi-meter, AWS flux-meter, Megger test instrumentation, track circuit shunt box, point gauges, crimping tools, torque wrench, data recorder, SSI error rate detector, LED light measuring tool). Any three items would be sufficient, although ideally the evidence would include both maintenance and test equipment. For example, it is recommended that a single piece of maintenance equipment is selected (eg crimping tool) and two test instruments (eg multimeters and point gauges).

More critical than the choice of items used, is the context within which they are used and the clarity with which learners explain the purpose, precautions in use and care of each item. As a minimum learners should include the purpose and limitations, effect on the system of introducing the instrument, adjusting tool settings, instrument ranges, competence and certification requirements for instruments and interpreting and recording results. They should also be able to describe and explain calibration and testing procedures, typical damage and how it can be avoided and identify typical tool or instrument failures. Again, these should be relevant to the piece of equipment.

P9 and P10 relate to learning outcome 3. A case study may be the most appropriate form of assessment for this learning outcome. Wherever possible centres should consider whether work-based evidence could be used for this criterion. M2, which also relates to SMOW, could be effectively linked with the work done for P9.

P11 and P12 relate to learning outcome 4 and ideally would be assessed together through one assessment activity. For P11, learners must describe the stages of a signalling system design process for a give application. This must include the planning and implementation issues for a given application (eg heavy rail, metro, light rail). The term 'given' in this context is intended to mean one of the three or similar applications, but it can be chosen by the tutor or the learner.

P12 requires learners to describe the component parts of a control table and the sources from which these are drawn. Their evidence should include, for a given control table, a description of all the relevant components (eg signal positioning, sighting distances, relationships between line speed and signal spacing) and the effect of gradients and junctions. The control table used could be chosen by either the centre or the learner. In either case, the control table must allow all the content to be covered. In terms of the quantity of assessment evidence for this last criterion, the control table should typically deal with at least all of the components listed as examples in the unit content (plus cover at least one gradient and two junctions).

Although there are opportunities to integrate assessment of the merit and distinction criteria into that covering the pass criteria, it may be as well to have separate pieces of work that the learner presents for evidence. The merit criteria require learners to bring together the individual parts of the unit by considering the elements, implementation, installation, testing and commissioning of a signalling system as a whole. The work done for M1 could be used as the main focus through which the other two merit criteria could also be met.

The work for the merit criteria may also provide scope for achievement of D1 and D2, although again it may be that a specific piece of work/research is used to meet the requirements of each individual criterion. It is important however, that irrespective of the approach taken, evidence for the merit and distinction criteria should demonstrate that learners are capable of careful, thorough and coherent thought with respect to the railway signalling applications considered.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, P3, P4, P5, P6 and M1	Line-side Equipment Sub-systems and Components	A signalling systems contractor on one of the main rail networks needs to provide information for key workers to train them in the use line-side equipment.	A written assignment in the form of an information leaflet detailing the main sub-systems and components.
P7 and P8	Signalling Maintenance Equipment	A signalling systems contractor on one of the main rail networks needs to provide information for key workers to train them in the use line-side equipment.	A practical assignment supported by witness statements.
P9, P10, M2	Safe Working Procedures	A signalling systems contractor on one of the main rail networks needs to provide information for key workers to train them in the use line-side equipment.	A written assignment based on case study materials.
P11, P12, D1, D2	Signalling Systems Design	A signalling systems contractor on one of the main rail networks needs to provide information for key workers to train them in the use line-side equipment.	A written assignment in the form of an information leaflet.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with:

Level 1	Level 2	Level 3
		Electrical and Electronic Principles
		Function and Characteristics of Railway Signalling Systems
		Electrical Technology

This unit supports some aspects of the Level 3 National Occupational Standards in Signal Engineering, particularly:

- Unit 3: Determine requirements for safe access to work locations for signal engineering
- Unit 8: Carry out planned preventative maintenance of signalling equipment
- Unit 13: Conduct specific testing of signalling assets.

Essential resources

Learners will need access to real or demonstration signalling equipment, sub-systems and components. Centres must also provide access to a range of railway maintenance and testing equipment and relevant suitable documentation.

Employer engagement and vocational contexts

Much of the work for this unit can be set in the context of learners' work placements or be based on case studies of local employers. Further information on employer engagement is available from the organisations listed below:

- Work Experience/Workplace learning frameworks – Centre for Education and Industry (CEI, University of Warwick) – www.warwick.ac.uk/wie/cei
- Learning and Skills Network – www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk
- National Education and Business Partnership Network – www.nebpn.org
- Local, regional Business links – www.businesslink.gov.uk
- Work-based learning guidance – www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbook

Nuck O – *Railway Signalling* (IRSE Publications, 2002) ISBN 0902390155

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are ...
Self-managers	organising time and resources and anticipating and managing risks when using different railway signalling maintenance and testing equipment.

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are ...
Independent enquirers	analysing and evaluating information relating to different railway signalling maintenance and testing equipment
Team workers	collaborating with others when working in small groups to maintain and test railway signalling systems.

● Functional Skills – Level 2

Skill	When learners are ...
English	
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching information on the construction of signalling equipment, correct use of tools and equipment and signalling system design processes
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing the construction, operation and applications of railway signalling maintenance and testing equipment.