

Unit 49: Function and Characteristics of Railway Signalling Systems

NQF Level 3: BTEC National

Guided learning hours: 60

Unit abstract

This unit will give learners an understanding of the evolution of railway signalling systems and their use within the railway system as a whole. This will include how signalling developed into the various types in use today and will enable learners to appreciate the foundations from which our modern day signalling technologies have been derived.

Learners will gain an understanding of the way signalling is used to control train movements and the various factors that influence the signalling used today. This will include an understanding of the components that are controlled by a signalling system as well as the physical parts that affect the signalling system itself. Learners will explore the interface between the signalling system and those who have to use it and the consequences of when it goes wrong.

The unit will also give learners an underpinning knowledge of the principles of safe and high integrity systems, as they apply in the railway environment. This will include the study of the system life-cycle for signalling equipment and the application of various concepts used to ensure that system integrity is maintained. Learners will gain an understanding of the many abbreviations and symbols used in relevant railway documentation and how documentation is updated and controlled. The unit also covers the various bodies that provide information and that control the standards to which the rail industry is required to work.

Learning outcomes

On completion of this unit a learner should:

- 1 Understand the railway as a system and the role of rail signalling systems within it
- 2 Understand the principles of safety and high integrity systems as applied to a railway signalling system
- 3 Know the functions and characteristics of lineside signalling elements
- 4 Know the major sources and categories of controlled documentation, signalling information, notation and terminology.

Unit content

1 Understand the railway as a system and the role of rail signalling systems within it

Historical landmarks for signalling: history of railway operations eg hand control of movements, space interval, block system; signals eg fixed, colour light, multiple aspect; multiple train movement; impact of speed

Scope of a signalling system: detection; separation of trains; use of points; route-setting; signal formation and permanent way eg interface between ballast, track, traction systems (electrification – catenary, third rail), train braking systems; signalling and control methods eg staff and competence, rules and regulations (control of train movements), capacity planning (headway, basis of timetable); signalling and external interfaces eg level crossings, other infrastructure owners

Man-machine interface: the driver and signaller interface; warning and advisory systems eg advanced warning system (AWS), train protection warning system (TPWS), automatic train protection (ATP), accidents and preventive measures, automation

Main lineside elements: eg control cabinets, signal posts/gantries, ground signals, route displays (feathers, theatre boxes), power systems, illumination systems/lamps

2 Understand the principles of safety and high integrity systems as applied to a railway signalling system

Signalling system lifecycles: design; construction; commissioning; life span of equipment; maintenance; repair; operation; decommissioning

High-integrity systems: principles eg fail-safe, wrong-side, right-side, failures, resilience, graceful degradation; components of signalling system eg control circuitry (logic control and computing systems), lamps/bulbs, relays

Application of principles throughout lifecycle: reliability, availability, maintainability and safety (RAMS); concept of redundancy; inherent safety characteristics; independent checks

3 Know the functions and characteristics of lineside signalling elements

Function of elements: relationship between points, signals, train detection, communications and power; interfacing with signaller and driver

Consequences of failure/incorrect commissioning: concepts of protected and unprotected failures; concept of as low as reasonably practicable (ALARP)

Risks and mitigation: design and construction features; testing and commissioning; preventive maintenance

4 Know the major sources and categories of controlled documentation, signalling information, notation and terminology

Obtaining information: Government sources eg Her Majesty's Railway Inspectorate (HMRI), infrastructure controller (Network Rail national records group); contractors (manufacturers' operations manuals); professional bodies eg Institution of Engineering and Technology (IET), Institution of Railway Signal Engineers (IRSE); role of IRSE licensing; Rail Safety and Standards Board (RSSB) Railway Group Standards(RGSs); company standards and instructions eg specifications, drawings and records

Document control: categories of documents eg signalling plans, content identification; issue and distribution control, authorisations and signatures; correction systems; feedback from site after alterations; change control eg asset registers, management of versions (especially software), compatibility and obsolescence effect

Signalling abbreviations, symbols and definitions: abbreviations eg Advanced Warning System (AWS), Solid State Interlocking (SSI); symbols eg semaphore signal, point machine, multiple aspect signal, ground signal; definitions eg vital, non-vital

Grading grid

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

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:
<p>P1 describe the historical landmarks for signalling in the rail industry</p> <p>P2 describe the scope of a signalling system</p> <p>P3 explain the man-machine interfaces, their problems and how they are addressed</p> <p>P4 define and describe the main lineside elements of a typical railway signalling system</p> <p>P5 describe a signalling system lifecycle from design to decommissioning</p> <p>P6 explain the principles of high-integrity engineering with reference to the components of a signalling system</p>	<p>M1 identify and describe the sequence of events as blocks of track are occupied and released</p> <p>M2 explain the RAMS issues relating to railway signalling elements</p> <p>M3 explain the need for personal competence associated with documentation and change control.</p>	<p>D1 analyse and evaluate the strengths and weaknesses of a railway signalling system as a whole explain and the compromise between safety and reliability</p> <p>D2 analyse and evaluate the concepts and techniques of risk mitigation.</p>

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:
<p>P7 describe the application of principles throughout the signalling lifecycle</p> <p>P8 explain the function of elements, consequences of failure and risk mitigation for a given signalling application</p> <p>P9 describe how information is obtained and the importance of documentation control</p> <p>P10 identify and explain signalling abbreviations, symbols and definitions.</p>		

Essential guidance for tutors

Delivery

The underpinning knowledge for this unit is likely to be delivered in a classroom environment allowing learners to gain a general overview of railway signalling systems. It is essential that the person delivering this unit has first hand experience of control systems and can relate the unit content directly to the railway environment.

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 systems failure and the importance of effective signalling systems must be a continuous underlying theme throughout this unit.

Some learners will be working in, or have experience of, railway installations and tutors should make as much use of this prior knowledge as possible. Learners with little knowledge of such systems should be encouraged to undertake a considerable amount of self-study of relevant standards and handbooks. Wherever possible, site visits should be arranged to ensure that all learners gain first hand experience and begin to appreciate the scope, scale and complexity of railway signalling systems. Video/internet footage may also be a useful way of illustrating the application of signals and signalling systems.

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.

Assessment

The learning outcomes of this unit are ordered logically and assessment is likely to follow this order. However, as stated above, it is important that the assessment instruments used do not fragment the learning but rather encourage an understanding of the unit content as a whole. To achieve this, each assessment activity could make clear in its introduction the relationship between the work being undertaken for the set activity and the other assessment activities being used. This could help learners appreciate the interrelationships between the learning outcomes and the importance of signalling systems as a critical part of efficient and safe operation of a railway system.

There are a number of possible assessment strategies, although the one described below assumes the use of three assessment instruments, which may or may not be interlinked with a common theme. Where a common theme is used then the approach would be similar to an extended project but it is important to build in points (as described below) to monitor progress and provide staged feedback.

Because of the interrelationships between the four learning outcomes and the need for a coherent approach to the unit content, testing or examinations are not considered appropriate for this unit.

For learning outcome 1, learners will need to produce satisfactory evidence for P1, P2, P3 and P4. This could be achieved through a single piece of work in the form of a case-study. Learners would need to describe (within the context of the case study) the historical landmarks for signalling in the rail industry (P1). Then (still within the same context), describe the scope of a signalling system (P2) and explain the man-machine interfaces, their problems and how they are addressed (P3). Finally, the case-study should be chosen to ensure sufficient scope for learners to then define and describe the main line-side elements of a typical railway signalling system (P4). A case-study approach of this type would mean that individual learners could investigate and prepare their evidence based on quite different sections of the railway network, ensuring individual work. The assessment activity could also include an opportunity for learners to address M1. Again, this could be set within the same context as that used for the pass criteria.

In order to achieve learning outcome 2 learners will need to meet the requirements of P5, P6 and P7. Once again, a single piece of work could be considered to cover all of these criteria. It may also be beneficial to include P8 (and hence, learning outcome 3) within the same piece of work. This would reinforce the interrelationships between principles of safety and the functions and characteristics of the line-side signalling elements.

To achieve P5 learners must be able to describe a signalling system lifecycle from design to decommissioning. Their description should cover, for a given system, the design, construction, commissioning, life span of equipment, maintenance, repair, operation and decommissioning processes for that system. For P6, learners must explain the principles of high-integrity engineering with reference to the components of a signalling system. This should include the principles being applied and the components of the signalling system.

Assessment of P5 and P6 could be set within the description carried out for P7. This should include a description of the reliability, availability, maintainability and safety (RAMS), concept of redundancy, inherent safety characteristics, and independent checks for the systems considered. It would be a natural extension then for learners to consider and explain the function of elements, consequences of failure and risk mitigation for a given signalling application (P8). Once again, to ensure an integrative approach, learners should also be encouraged to consider M2, D1 and D2 at this point.

Learning outcome 4 is covered by P9 and P10. A single piece of work could again be used to cover both criteria. For P9, learners must be able to describe how information is obtained and the importance of documentation control. This should include references to government sources, contractors (manufacturers' operations manuals), professional bodies, RSSB Railway Group Standards and company standards and instructions. Learners' understanding of document control should include the various categories of documents (eg signalling plans, content identification, issue and distribution control, authorisations and signatures), how documents are corrected, feedback from site after alterations and change control methods. Finally, and as part of their work with documents for P9, learners must identify and explain signalling abbreviations and symbols for P10. M3 is a natural extension to the work undertaken for P9 and P10 and there is an opportunity for learners to meet this within the same assignment.

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

The unit supports some aspects of the Level 3 National Occupational Standards in Signal Engineering.

This unit may also be effectively linked with *Unit 5: Electrical and Electronic Principles*, *Unit 52: Electrical Technology* and *Unit 56: Installing, Commissioning, Testing and Maintenance of Railway Signalling Systems*.

Essential resources

There are no essential resources for this unit, however centres will find it difficult to deliver this unit without access to either 'live' examples of relevant signalling systems or at least suitable video footage. Centres will need to provide learners with access to relevant sources and categories of controlled documentation and signalling information.

Indicative reading for learners

Goddard E – *Signal and Control Within the Railway System* (The 11th IET Professional Development Course On Railway Signalling and Control Systems)

Kerr D and Rowbothan T – *Introduction to Railway Signalling* (IRSE Publications, 2001) ISBN 0902390139

Mitchell I – *Mainline Signalling Control* (The 11th IET Professional Development Course On Railway Signalling and Control Systems)

Key skills

Achievement of key skills is not a requirement of this qualification but it is encouraged. Suggestions of opportunities for the generation of Level 3 key skill evidence are given here. Tutors should check that learners have produced all the evidence required by part B of the key skills specifications when assessing this evidence. Learners may need to develop additional evidence elsewhere to fully meet the requirements of the key skills specifications.

Communication Level 3	
When learners are:	They should be able to develop the following key skills evidence:
<ul style="list-style-type: none"> researching, describing and explaining aspects of railway systems and signalling. 	<p>C3.2 Read and synthesise information from at least two documents about the same subject. Each document must be a minimum of 1000 words long.</p> <p>C3.3 Write two different types of documents each one giving different information about complex subjects. One document must be at least 1000 words long.</p>
Information and communication technology Level 3	
When learners are:	They should be able to develop the following key skills evidence:
<ul style="list-style-type: none"> planning, researching and presenting written assignments on railway signalling systems, equipment and safety. 	<p>ICT3.1 Search for information, using different sources, and multiple search criteria in at least one case.</p> <p>ICT3.2 Enter and develop the information and derive new information.</p> <p>ICT3.3 Present combined information such as text with image, text with number, image with number.</p>