

# Unit 48: Function and Characteristics of Railway Signalling Systems

<b>Unit code:</b>	<b>K/600/0331</b>
<b>QCF Level 3:</b>	<b>BTEC Nationals</b>
<b>Credit value:</b>	<b>10</b>
<b>Guided learning hours:</b>	<b>60</b>

## ● Aim and purpose

This unit will give learners a knowledge and understanding of the function and characteristics of railway signalling systems.

## ● Unit introduction

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

# Unit content

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## 1 Understand the role of rail signalling within the railway system

*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

*Purpose and 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 line-side 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 line-side 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

## 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:
<b>P1</b> describe the historical landmarks for signalling in the rail industry	<b>M1</b> describe the sequence of events as blocks of track are occupied and released	<b>D1</b> analyse the strengths and weaknesses of a railway signalling system as a whole and explain the compromise between safety and reliability
<b>P2</b> explain the purpose and scope of a signalling system	<b>M2</b> explain the RAMS issues relating to railway signalling elements	<b>D2</b> evaluate the concepts and techniques of risk mitigation.
<b>P3</b> explain the man-machine interfaces, their problems and how they are addressed	<b>M3</b> explain the need for personal competence associated with documentation and change control.	
<b>P4</b> describe the main line-side elements of a typical railway signalling system		
<b>P5</b> describe a signalling system lifecycle from design to decommissioning		
<b>P6</b> explain the principles of high-integrity engineering with reference to the components of a signalling system		
<b>P7</b> describe the application of principles throughout the signalling lifecycle		
<b>P8</b> explain the function of elements, consequences of failure and risk mitigation for a given signalling application		
<b>P9</b> describe how information is obtained and the importance of documentation control [IE4]		
<b>P10</b> describe signalling abbreviations, symbols and definitions.		

**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.

<b>Key</b>	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

# 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.

## 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

*Whole class teaching:*

- introduction to unit content, scheme of work and assessment
- explain the general history of railway operations, the historical role of signalling and the scope of signalling systems
- explain the man-machine interface, the use of warning and advisory systems and explain the main line-side elements.

*Individual research:*

- investigate the development of signalling systems

Prepare for and carry out **Assignment 1: The Railway Signalling System** (P1, P2, P3, P4, M1)

*Whole class teaching:*

- explain the lifecycle of railway signalling systems
- explain the principles of high-integrity systems, the components of signalling systems and the applications of principles throughout the lifecycle of a signalling system.

*Site visit:*

- identify and view high-integrity systems and signalling components in use.

## Topic and suggested assignments/activities and/assessment

*Whole class teaching:*

- describe the function of line-side signalling elements
- explain the main consequences of failure and incorrect commissioning of signalling equipment
- explain the risks and mitigation related to signalling systems.

*Case study research:*

- investigate cases of signalling failure, incorrect commissioning and the preventative procedures that can be carried out to mitigate the risks.

Prepare for and carry out **Assignment 2: High-integrity Systems and Line-side Signalling Elements** (P5, P6, P7, P8, M2, D1, D2)

*Whole class teaching:*

- identify and describe the different sources of information.
- identify and describe the different categories of information and main forms of document control.
- identify and describe the use of the main signalling abbreviations, symbols and definitions.

*Industry visit:*

- identify and view the storage, control and use of documentation, signalling information, notation and terminology.

Prepare for and carry out **Assignment 3: Document Control** (P9, P10, M3)

Unit evaluation and feedback.

## 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 describe 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.

## 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, M1	The Railway Signalling System	Investigate and report on a railway signalling system.	Written assignment based on case study and visits.
P5, P6, P7, P8, M2, D1, D2	High-integrity Systems and Line-side Signalling Elements	Investigate and report on safety, risk and failure of signalling systems.	Written assignment based on case study and visits.
P9, P10, M3	Document Control	An informatics department in a railway network is about to be audited and needs to produce a report on documentation control.	A written report on document control which could contain flow charts, diagrams and other visual material.

## 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 the following unit titles in the Engineering suite:

Level 1	Level 2	Level 3
		Electrical and Electronic Principles
		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.

## Employer engagement and vocational contexts

There are a range of organisations that may be able help centres engage and involve local employers in the delivery of this unit, for example:

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

## Indicative reading for learners

### Textbook

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

## 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 ...
Independent enquirers	analysing and evaluating how information is obtained, and the importance of document control.

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 ...
Reflective learners	setting goals with success criteria for their development and work.

## ● Functional Skills – Level 2

Skill	When learners are ...
<b>ICT – Find and select information</b>	
Access, search for, select and use ICT-based information and evaluate its fitness for purpose	researching and accessing controlled documentation, signalling information, notation and terminology
<b>English</b>	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	describing and explaining the role, principles and purpose of signalling systems, line-side elements and signalling documentation
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching and analysing information relating to railway signalling systems, line-side elements and signalling documentation
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing and explaining the role, principles and purpose of signalling systems, line-side elements and signalling documentation.