

## Category 1 Standard

# S1195 Signalling - Functional Requirements

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## 1 Purpose

- 1.1 The purpose of this Standard is to define the Signalling Functional Requirements which are mandatory to the design and modification of all Signalling Systems used anywhere on the London Underground Railway.

## 2 Scope

- 2.1 This Standard applies to mainline and signalled depot sections of the London Underground Railway.
- 2.2 This standard covers requirements that are applicable for conventional and transmission based technologies except where specifically noted otherwise.

**Note:** The Standard is written in terms which reflect, in some instances, the historical design and implementation existing before the advent of modern signalling systems such as Communication Based Train Control (CBTC). Where specific terms have been used that imply a particular implementation that is not applicable to a new design, then the original term may be read as being equivalent to a new term. For example, 'trainstop' may be the equivalent to an 'Automatic Train Protection (ATP) stop code' used in a new system.

- 2.3 The requirements apply to existing signalling systems used on London Underground.
- 2.4 The requirements are to be applied to signalling systems that are new to London Underground.
- 2.5 This Standard focuses on requirements of the Signalling System functionality. The totality of requirements contained within the complete suite of Signalling and Signalling Control Standards, see 5.2.1, must be complied with for these systems.

## 3 Requirements

### 3.1 Design philosophy

#### 3.1.1 Safe train movement

- 3.1.1.1 The system design shall minimise the risk of collision and derailment to be As Low As Reasonably Practical (ALARP). It shall maintain a safe distance between trains, or to other obstructions, and enforce secure routing through junctions.
- 3.1.1.2 In modern signalling systems the speed of the train shall be continuously monitored and speed limits enforced using safety signalling principles to aid the achievement of 3.1.1.1.
- 3.1.1.3 The minimum safe braking distance permissible shall allow a train at any instant to brake and come to rest before the position at that instant of another train or other obstruction ahead. The minimum safe braking distance shall allow for abnormal and degraded conditions, such as system response times, wheel to rail adhesion and train brake degradation.

**Note:** Determination of the safe braking distance requires knowledge of the track geometry and gradients, the environment and the rolling stock performance.

The obstruction ahead should be assumed to be stationary when calculating the safe braking distance.



### 3.1.2 Safety During Failure Conditions

- 3.1.2.1 Any single independent component failure shall result in a safe condition.
- 3.1.2.2 Component failures which are not independent (that is failures that occur as a direct result of another failure) shall be considered in combination with the original failure and all other failures resulting from the same original failure. These combined failures shall not lead directly to a collision or derailment.
- 3.1.2.3 Multiple component or system right side failures, such as broken wires, damaged or dirty contacts, failure of a watch-dog function, loss of correspondence, failure of any device to respond, loss of power, or any similar failure, shall not lead directly to a collision or derailment in any combination.
- 3.1.2.4 The risk associated with one wrong side failure shall be reduced to be ALARP.

**Note:** The ALARP assessment should include right-side failures which may mitigate hazards arising from the wrong-side condition.

- 3.1.2.5 Faults which occur in the safety signalling system shall be self announcing.
- 3.1.2.6 The system shall ensure that faults are rapidly detected such that the risk of a second fault combining with the first to produce a potentially unsafe condition is minimised.
- 3.1.2.7 Safety signalling systems shall be designed to defend against any effect that a system interface with a lower integrity can cause.

### 3.1.3 System areas with a high safety criticality

- 3.1.3.1 The design of the signalling system shall give particular emphasis to areas where analysis has demonstrated a high potential risk or other known areas of concern (such as train detection and 'authority to proceed' instructions). In these areas, diverse safety techniques shall be used, however redundancy techniques are acceptable if diverse techniques are shown to be not reasonably practical.

**Note:** Diversity can be achieved by the use of two, or more, physically different sub-systems which either perform the same system function or are arranged so that one sub-system performs a check on the correct operation of another sub-system.

An example of a diverse technique is that of monitoring sequences. In these cases it is imperative that right side failures or operations within the sequence checking do not have a significant effect on the system operation.

Another technique is the use of 'proving'. This diverse process monitors the return of an element to its safe state prior to its next use using safety signalling techniques. For example, train presence detectors would be 'down-proved' before use, if required by the signalling system design.

- 3.1.3.2 The techniques employed shall, as far as reasonably practical, be designed to reduce the risks of common mode failure.
- 3.1.3.3 The application of diverse or redundant techniques shall include management systems to identify failures within those systems, such that they can be repaired prior to a system failure, or as necessitated by the system safety analysis.
- 3.1.3.4 The signalling system shall make use of diverse means of ensuring safe operation of sub-systems in critical areas where analysis has demonstrated a high potential risk or other known areas of concern such as the primary train detection system and the 'authority to proceed' instruction.



### 3.1.4 Safe Maintenance

- 3.1.4.1 Where reasonably practicable the system design shall minimise the need for manual adjustments following the initial set-up.
- 3.1.4.2 The use of trackside equipment shall be kept to a minimum to allow the need for access to the track to be ALARP.
- 3.1.4.3 Each element of the signalling system shall, where reasonably practicable, monitor its own health and provide suitable outputs for use by the maintainer.

### 3.1.5 System life

- 3.1.5.1 Safety signalling systems shall be designed to achieve a 40 year life.

**Note:** It is recognised that the software and hardware may require modular change during this life to achieve the same functional requirements.

### 3.1.6 Service capacity

- 3.1.6.1 Service capacity shall be addressed by expressing performance requirements within the specifications for the new or modified signalling system.

**Note:** Operability covers both normal and abnormal services where the signalling system needs to maximise the use of the railway infrastructure and recognise the implications on operators. Three examples of good practice are:-

- a) Avoid situations where trains are held outside stations with the platform empty. Simple speed control has been provided to allow trains to pull forward into the platform to reduce the safety implications of de-training trains outside the platform.
- b) Junctions have been given special attention to recognise that conflicts rapidly develop when delays occur. An example of this would be allowing trains to draw forward such that other routes can be set behind. Another would be the preceding train being proved moving from a platform in a situation where there are multiple platform choices, to avoid the train locking out the route to the other platform.
- c) Conflicts at flat junctions are another critical example where the synchronisation of movements over the junction cannot be guaranteed and such examples as draw up signals provided to reduce the conflict times.

- 3.1.6.2 To enable the railway system to return to normal operation in the shortest possible time after a service disruption, the design shall include allowances for minor delays and for Train Operator and train performance variations.

### 3.1.7 Response to loss of power

- 3.1.7.1 The power supply to the signalling system shall be configured to enable all trains to be signalled into the next platform during power supply cessations. Moving trains shall be allowed to coast into the next station during loss of traction power if signalling conditions determine it is safe to do so.

## 3.2 Reliability, Availability, Maintainability and Safety (RAMS)

### 3.2.1 Safety requirements

- 3.2.1.1 The safety of the railway depends on all the component parts and hence the safety system design shall embrace the train braking and control systems, the signalling



control system, the LU Rule Book, the railway infrastructure and the environment as well as the signalling system itself.

- 3.2.1.2 Signalling systems and equipment are classified as safety systems and shall be designed, constructed, operated and maintained in accordance with the requirements of BS EN 50126, BS EN 50128, and BS EN 50129. Their required safety integrity levels shall be determined in accordance with these standards.
- 3.2.1.3 The signalling system architecture shall be determined having due regard for:
- a) The required functionality;
  - b) Ease of verification and validation;
  - c) Diverse protection for critical elements of the system;
  - d) The ability of the system to sustain the required functionality throughout its lifecycle;
  - e) Normal and degraded modes of operation;
  - f) Graceful degradation to ensure safe system functioning;
  - g) The effect of human error during operation and maintenance;
  - h) Ease of modification and maintenance.
- 3.2.1.4 The overall architecture and the individual elements of the signalling system shall, so far as reasonably practicable, be designed to eliminate any credible threat to their intended performance resulting from human error in implementation, maintenance or operation.
- 3.2.1.5 A positively identifiable and physical demarcation shall be provided between all safety and safety-related components and wiring in order to preserve the superior design and safety, maintenance and testability characteristics required of items categorised as 'safety' components. When this cannot be achieved then all components shall be considered as safety components.
- 3.2.1.6 The signalling system design shall ensure that a wrong-side operation does not occur when a credible out of tolerance voltage or frequency, of any duration, is produced by the power supply to the system, or by any power supplies used for any of the interfaces.
- 3.2.1.7 The signalling system design shall ensure that the equipment response times of each element have no adverse effect on the safety of the overall system.
- 3.2.1.8 The signalling system design shall ensure that any degradation in system response times will have no effect on the safety of the automatic train protection sub-system functionality.
- 3.2.1.9 The signalling system shall be designed to minimise the possibility of any incorrect connection of the system or its sub-systems.
- 3.2.1.10 Where trains are required to change from one mode of protection to another there shall be a system installed on the train and on the track to enforce the changeover of the train borne equipment.
- 3.2.1.11 The signalling system safety analysis shall justify an expectation that the unprotected 'wrong-side failure rate' will not exceed 1 in  $10^8$  hours for the complete system for a whole Line.
- 3.2.1.12 The signalling system shall be designed to ensure that an unsafe or a potentially unsafe condition shall occur no more frequently than the following:



- a) Each localised point and crossing area shall not produce an unsafe or potentially unsafe condition more than once every  $10^9$  hours;
- b) Each station area, where there are no points and crossing work, shall not produce an unsafe or potentially unsafe condition more than once every  $10^{10}$  hours.

|              |                                                                                                                                                                        |
|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Note:</b> | A localised point and crossing area will normally include all the point and crossing work within a station area or remote junction work where isolated from a station. |
|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

### 3.2.2 Availability

The signalling system design shall aim to reduce the Mean Time To Repair (MTTR), maximise Mean Time Between Service Failure (MTBSF) and ensure that any preventative maintenance can be easily and quickly carried out in a cost effective and safe manner.

#### 3.2.2.1 Duality

3.2.2.1.1 High availability by redundancy (e.g. dualling of modules or sub-systems) is a significant factor in the design of LU signalling systems. Systems shall be fully redundant, so far as reasonably practicable, with any failure of a path being self announcing. The system design shall also ensure that the dualled sub-systems are truly independent to minimise the risk of common mode faults.

3.2.2.1.2 Dualling shall also be used to provide facilities for certain preventative maintenance to be carried out on off-line systems during traffic hours.

#### 3.2.2.2 Degradation

3.2.2.2.1 The signalling system facilities shall gracefully degrade under failure conditions with back-up systems and procedures invoked to maintain safety.

3.2.2.2.2 Operational procedures shall be developed by the Supplier in co-operation with LU Operations.

3.2.2.2.3 The impact of a single failure in the ATC system shall be limited to a defined area, which shall be system specific but shall not exceed a distance of 1 km of track.

3.2.2.2.4 If a fully redundant system is not provided for new signalling systems then a suitable back-up system shall be provided where required. The back-up facilities shall cover the deficiencies of the primary system and shall meet the same safety criteria. The primary system shall include duality in trainborne vital equipment.

### 3.2.3 Maintainability

3.2.3.1 All elements of the signalling system shall incorporate diagnostic features to permit the efficient diagnosis and correction of hardware and software problems.

3.2.3.2 For processor based systems, the diagnostic features shall be available for execution while the system is either on-line or off-line.

3.2.3.3 Facilities for fault logging, fault finding and system interrogation shall be provided for processor-based systems.

3.2.3.4 The fault logging shall include diverse equipment for recording of system processor states for the inputs and outputs.

3.2.3.5 Portable plug-in devices used for system interrogation and fault finding shall not have the potential for causing a wrong side failure.



- 3.2.3.6 The signalling system shall be able to transmit all detected failures for display both locally and in the Service Control Centre (SCC).
- 3.2.3.7 The signalling system shall be able to record all detected failures.
- 3.2.3.8 The diagnostic facilities shall not significantly affect the functional operation or performance of the signalling system.
- 3.2.3.9 The system design shall incorporate features to facilitate the acceptance testing, commissioning and subsequent maintenance testing of the signalling system.
- 3.2.3.10 Labelled test points shall be provided in locations which allow observation of equipment operation whilst taking measurements using test leads with a maximum length of 3 metres.

### 3.2.4 Depot RAMS requirements

#### 3.2.4.1 Reliability

The depot signalling equipment shall have a Mean Time Between Wrong Side Failures (MTBWSF) of better than  $10^6$  hours.

#### 3.2.4.2 Availability

The depot signalling application shall achieve fault tolerance through minimising the scope for loss of operation due to single faults.

**Note:** For example, a single fault should not affect both ends of a double-ended depot. The passenger train service is sensitive to interruptions to operation of the depot transfer road(s) which exceed 3 minutes.

## 3.3 Train detection

### 3.3.1 Train Detection attributes

- 3.3.1.1 The safety signalling system shall be equipped with continuous train detection.

**Note:** For details of usage and requirements relating to track circuits, position detectors and axle counters see Standard S1197, Signalling and Signalling Control - Design and Implementation.

Where methods of train detection other than track circuits are used, additional precautions may be necessary. The need for such precautions should take account of the hazards on the railway system to which the train detection system may provide full or partial mitigation. These hazards include:

- a) Collision or derailment (Train separation, route holding, authority to proceed, train following and service management);
- b) Trains becoming divided (Train integrity);
- c) Engineer's vehicle or wagon left after works;
- d) Broken Rail detection;
- e) Object on the line (such as train derailment that fouls the adjacent line);
- f) System failure (assistance in system recovery);
- g) Operation in degraded modes (verbal authorisation and need for known location of vehicles).



- 3.3.1.2 Broken rail detection shall be considered within the overall railway system design as the train detection system may contribute to the detection and protection against broken rails.
- 3.3.1.3 The train detection system shall be compatible with all trains authorised to operate on the section concerned.
- 3.3.1.4 Suppliers shall state the boundary conditions of train characteristics for correct operation of the train detection system provided.

|              |                                                                                                                                                                                                          |
|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Note:</b> | The boundary conditions should cover:                                                                                                                                                                    |
| a)           | Maximum levels of Electromagnetic interference.                                                                                                                                                          |
| b)           | Maximum length of trains (Two passenger trains for push or pull out and Long welded rail vehicle).                                                                                                       |
| c)           | Minimum length of vehicle (maximum spacing between axles/bogies on one carriage or vehicle).                                                                                                             |
| d)           | Quality of shunting (number of axles, weight loading on axles, condition of wheel and rail surfaces).                                                                                                    |
| e)           | Accuracy or resolution of train detection (sufficiently precise to ensure that the position of the train in relation to the point to be protected is known with an accuracy necessary to ensure safety). |

- 3.3.1.5 A facility shall be provided to detect and indicate that a train has moved into an unauthorised area (such as into a sand drag or past a trapping point).
- 3.3.1.6 The train detection system shall be capable of adjustment for various rail profiles and to cater for rail wear and shall not require more than an annual adjustment of the equipment.

### 3.3.2 Detection techniques

#### 3.3.2.1 Track circuits

- 3.3.2.1.1 The track circuit shall be capable of detecting the electrical shunt caused by the presence of a single train axle within its boundaries, subject to the conditions defined below.
- 3.3.2.1.2 Any track circuit based system of train detection shall detect:
- a) a shunt of 1 ohm where there is dependency on detection of a single axle;
  - b) a shunt of 0.5 ohm where there is dependency on detection of two axles.
- 3.3.2.1.3 The maximum permitted length of undetected track shall be as follows:
- a) At the interface between adjacent tuned track circuits a total of 9 metres, being 4.5 metres within the boundary of each track circuit;
  - b) At the interface between a tuned track circuit and un-tuned track circuit a total of 4.5 metres, being entirely within the tuned track circuit;
  - c) Between adjacent un-tuned track circuits a total of 3.3 metres;
  - d) Within point and crossing areas a maximum of 0.5 metres.

#### 3.3.2.2 Axle counters

- 3.3.2.2.1 These systems may be used as the primary train detection method for applications involving double track passenger lines provided that:



- a) the Line is not immediately adjacent to Network Rail lines; or
- b) the area has a physical barrier at the boundary between the Line and the Network Rail lines;
- c) the full system impact of using this technology shall be fully addressed.

3.3.2.2.2 This type of system can be used as the primary means of train detection in depots or single track lines, and can also be used as a back-up system to a primary train detection system.

3.3.2.2.3 The axle counter system shall provide train detection from the time that the first train axle passes the axle counter head until the last train axle is counted out of the block. Any miscount shall cause the system to remain at 'block occupied' until reset by an authorised means.

3.3.2.2.4 The axle counter system shall incorporate diversity such that should the train fail to operate the axle counter system when entering the block, the signal before shall remain at danger and a fault condition shall be indicated.

3.3.2.2.5 The axle counter system shall be designed such that it may be re-set using an agreed procedure in the event of a miscount. The prime elements of this procedure shall be permanently displayed on a clear label adjacent to the evaluator.

3.3.2.2.6 To maintain the 'fail-safe' philosophy, the output (or interfacing relay) shall be energised when the block is unoccupied and shall be de-energised when the block is occupied or there is a system failure.

### 3.3.2.3 *Position detectors*

3.3.2.3.1 Train position detectors shall operate with any rolling stock fleet without the use of any associated trainborne equipment.

3.3.2.3.2 Train position detectors shall be suitable for use in the following applications:

- a) Diverse protection for the control of route releasing;
- b) Initiation and termination of average speed measurement between defined points;
- c) Any applications that require specific locational information.

3.3.2.3.3 Train position detectors shall not require mechanical interaction with the rolling stock.

3.3.2.3.4 In normal operation the position detector system shall only provide an output when a train is present within its defined detection limits.

### 3.3.3 *Performance requirements*

#### 3.3.3.1 *Initialisation*

The detection system shall take less than one minute after power is applied to complete all self-tests and become available for use within the system. All outputs shall be held in their restrictive state until initialisation is complete.

**Note:** This time relates to train detection only and does not include the time to restore the system to full operational use.

#### 3.3.3.2 *Spurious outputs*

Any incorrect setting by the train detection system of a safety AC or DC output shall not exist for a duration that would allow any output device, or any other input connected to an affected output, to respond to the false output.

## 3.4 Signals

**Note:** Sections 3.4.1 and 3.4.2 are applicable to lines equipped with colour light signals.

### 3.4.1 Signal attributes

3.4.1.1 Signals shall present information to the train operator in a clear and unambiguous manner, regardless of the position of the sun, or any external area illumination such as flood-lighting. The use of hoods and post mounting, or a combination of both, shall be employed to maximise compliance with this requirement.

3.4.1.2 The specific signal aspects shall be visible from the normal stopping position designed for that signal, under all lighting conditions.

3.4.1.3 The signal number plate shall be readable from the normal stopping position designed for that signal.

**Note:** Refer to Standard S1197, Signalling and Signalling Control - Design and Implementation, for requirements in relation to stopping position.

3.4.1.4 Train movements shall be controlled as follows:-

- a) On main running lines, by a colour light signal system;
- b) For shunting movements to, from or across running lines, by shunt signals.

3.4.1.5 Non-passenger (shunt) moves shall normally be controlled by shunt signals.

**Note:** If the route runs onto the main line and is protected by an appropriate speed overlap with passenger locking and route holding standards then a colour light signal may be used.

3.4.1.6 Semi-automatic signals shall be used at junctions and shall protect trains from conflicting and following moves.

3.4.1.7 Automatic signals shall be used on plain sections of track to keep following trains spaced at a safe distance. These signals shall be operated purely by the passage of trains.

3.4.1.8 On the approach to the first repeater signal aspect there shall be continuous visibility for a distance of 75 metres, or a lesser distance providing this shall achieve 4 seconds of visibility (see Standard S1197, Signalling and Signalling Control - Design and Implementation). This does not apply to platform repeating signals or any subsequent repeaters.

3.4.1.9 All stop signal aspects or their repeaters, except for Platform Starting Signals at 'all trains to stop' stations, shall be visible from the calculated sighting point. Over the final 120 metres to the stop signal there shall be continuous sighting of the signal or its repeater.

3.4.1.10 The location of the sighting point shall be indicated by a trackside plate carrying the legend 'SP', followed by the signal number for use for maintenance purposes.

**Note:** For the method of calculating the sighting point see Standard S1197, Signalling and Signalling Control - Design and Implementation

3.4.1.11 An illuminated junction indicator shall be visible no later than the point at which the proceed aspect can be read. The directional information shall be visible for sufficient time for the train operator to bring the train under control at the junction.

**Note:** There is no requirement to provide continuous sighting of the stop signal all the way from the sighting point.

### 3.4.2 Signal types

**Note:** This section applies to fixed block colour light signalling as currently applied to the LU railway. These requirements may not be appropriate for moving block signalling systems.

#### 3.4.2.1 Stop signals

- 3.4.2.1.1 All stop signals (including shunt signals but excluding pre-set shunt signals) on running lines, or reading to, from or across running lines, shall be provided with a trainstop device which operates in conjunction with the signal. The trip-arm of the trainstop shall be raised when the signal is at danger and lowered when the signal is clear.
- 3.4.2.1.2 If a train passes a stop signal at danger, the associated trainstop shall bring the train to a halt within the overlap, by operation of the trainborne tripcock.
- 3.4.2.1.3 A secure means of communication, in compliance with Standard S1145, Wired communication systems, shall be provided at defined positions where verbal authority to proceed is required.
- 3.4.2.1.4 The stopping position shall normally be 5 metres in front of the signal. Where other design constraints prevent this from being achieved, a stop mark shall be provided, after consultation with LU Operations.
- 3.4.2.1.5 All platforms shall be provided with a starting signal to authorise departure of passenger trains from the platform.
- 3.4.2.1.6 Where trains are not scheduled to stop, then the requirements of clause 3.4.1.9 shall apply. For platforms designated as “all trains to stop”, there shall be continuous sighting for a minimum of 16 metres, without taking into account platform repeaters.
- 3.4.2.1.7 When a passenger train is berthed at the defined platform stopping point, the train operator shall have clear visibility of the signal or co-actor whilst:
  - a) Monitoring the safe closing of the doors;
  - b) Looking forward, from the normal driving position, in the direction of travel.
- 3.4.2.1.8 On sections of line where trains run that rely on Train Protection and Warning System or Automatic Warning System equipment, or both, to provide enforcement without the use of trainstops, then lamp proving shall be fitted to all stop aspects.

#### 3.4.2.2 Repeating signals (or 'repeaters')

- 3.4.2.2.1 Running repeating signals shall be installed where there is a possibility of a train operator not sighting a red signal in sufficient time to bring the train to rest using normal service braking to that signal.

**Note:** Trainstops are not required for repeating signals.

Repeating signals cannot be used in multiple aspect signal areas such as some parts of the Metropolitan Line. In these areas banner signals should be used where necessary.

- 3.4.2.2.2 Some running repeating signals for the signal ahead may be situated below the preceding running signal. This shall also be considered when a separate repeating signal of another signal is in close proximity to the running signal.



#### 3.4.2.2.3 Where platform repeating signals are specified by LU Operations:

- a) The signals shall repeat the aspects displayed by station starting signals, shunt signals and junction indicators;
- b) The 'Proceed at caution' aspect of a shunt signal shall be repeated by a black band at 45 degrees to the horizontal on an illuminated white background;
- c) A junction indicator shall be repeated by a line of white light at the appropriate angle.

#### 3.4.2.2.4 Junction indicators of a reduced size shall be provided at repeating signals of diverging running signals where the repeating signal can be sighted at green for the diverging route.

### 3.4.2.3 *Fog repeating signals*

#### 3.4.2.3.1 Where local weather conditions induce low visibility, a Fog Repeater shall be provided for each stop signal.

#### 3.4.2.3.2 Fog repeaters shall be provided at a nominal 120 metres before the signal they repeat.

#### 3.4.2.3.3 The yellow aspect lens shall have a black letter 'F' etched into the lens.

#### 3.4.2.3.4 Fog repeating signals shall be aligned at train operator's eye level to optimise the beam at a point 30 metres from the signal.

**Note:** Fog repeating signals may be mounted on the same post as a running signal. In multiple aspect areas of the Metropolitan Line a white aspect is used in place of the green aspect for Fog Repeaters.

### 3.4.2.4 *Home Signals*

#### 3.4.2.4.1 Where headway requirements dictate, a home signal shall be provided to protect a train in the station platform area, whilst allowing a following train to approach to a safe distance from the platform. The overlap of the home signal shall terminate not less than 15 metres from the entry end of the platform.

### 3.4.2.5 *Shunt Signals*

#### 3.4.2.5.1 A shunt signal shall be used to authorise shunting movements at caution speed to a reversing mark, limit of shunt or stop board, or as far as the line is clear.

**Note:** Where continuous ATP is fitted, the vital speed enforcement shall relate to the limit set by engineering conditions.

#### 3.4.2.5.2 Shunt signals shall either be:

- a) a mechanical disc type, with a horizontal red band on a white background, which shall be externally illuminated and cleared by the disc rotating 45 degrees in an anticlockwise manner; or
- b) a fibre optic type or Light Emitting Diode (LED) type which are self-illuminating and simulate the action of the mechanical signal by the use of an alternative horizontal or angled red bar of light on a background of white light.

#### 3.4.2.5.3 Redundancy shall be employed within the lighting arrangement for fibre optic or LED type disc signals such that in the event of a failure, the signal is recognisable and the fault is self-revealing.

#### 3.4.2.5.4 Shunt signals which authorise movements to, from or across the running line to two or more routes shall be provided with a route indicator. This shall be fixed adjacent

to the signal, and shall indicate the route selected in the form of a numeral which is illuminated on the display. The first route from the left shall be numbered '1', the second from the left '2', and so on.

3.4.2.5.5 Shunt signals may be situated on the same post as a running signal. In the case of the fibre optic or LED type of shunt signal on the same post as a running signal, the shunt signal aspect shall only be illuminated when it is required to display proceed and the stop running signal is showing a danger aspect.

3.4.2.5.6 Shunt signals and associated signs and indicators, where trains are not required to start from rest, shall be provided with a continuous sighting of 75 metres.

### 3.4.2.6 *Speed control signals*

3.4.2.6.1 Speed control signals shall be provided up to signals where there is insufficient overlap to permit a full speed approach. When the train occupies the timing section of the speed control signal, the red aspect shall remain on until one of the following is satisfied:

- a) A full speed overlap is available;
- b) The speed of the approaching train had reduced to a level appropriate to the overlap available;
- c) Appropriate 'route-away' conditions are satisfied at the signal ahead.

### 3.4.2.7 *Fixed red lights*

3.4.2.7.1 Fixed red lights shall be installed at all locations where there are no further colour light movements in that direction.

3.4.2.7.2 Single aspect fixed red lights shall be located at the ends of sidings and at terminal roads.

3.4.2.7.3 Fixed red lights shall be provided for each track, 2 side-by-side, approximately 3 metres beyond the normal stopping point and, if there is greater than 10 metres between the 2 fixed red lights and the end of the track, a third shall be placed at the extreme end of the track, at sidings and terminal platforms. If site geography does not allow 3 metres between the normal stopping mark and the 2 red lights then that distance may be decreased, but it shall not be less than 1.5 metres.

**Note:** Locations that may hold trains of different lengths may need more than one stop mark. In such cases, the requirements of this clause apply to the longest service train that is permitted to use the terminal road, and not to the shorter stock types.

3.4.2.7.4 Fixed red lights shall also be provided at strategic locations on the running lines, where requested by LU Operations, in order to prevent 'wrong road' movements.

3.4.2.7.5 'Wrong road' move red lights and signs shall be optimised for viewing from the normal driving position of the "rear" cab.

### 3.4.3 *Signal selection*

3.4.3.1 The signalling logic, termed 'the signal selection', shall evaluate the conditions to enable a proceed aspect to be set. This shall be based on a designed limit of control.

3.4.3.2 The limit of control shall be from a signal to the end of the overlap of the next signal ahead.

- 3.4.3.3 In trainstop protected areas, the distance from the signal to the first replacing track boundary in the direction of travel shall be sufficient to ensure that the tripcock, where fitted, is beyond the trainstop as the train moves onto the replacing track.

**Note:** Where there are layout constraints it may be necessary to replace the signal at the following track circuit, provided the first track has already been proved unoccupied in order to clear the signal.

#### 3.4.4 Starting signal control

The signalling system shall ensure that starting signals at "all trains to stop" stations cannot display a clear to proceed aspect, or ATP proceed commands, until the approaching train has been proved to be under control, or is stationary in the platform.

**Note:** This requirement is designed to provide protection in tripcock protected areas against a train approaching a starting signal at excessive speed where less than a full speed overlap at signals beyond the starting signal may have historically been provided. It also has a beneficial effect on passenger ambience and safety by reducing drafts caused by non-stopping, out of service trains.

**Note:** Sections 3.4.5, 3.4.6, 3.4.7 and 3.5.1 are relevant to fixed block colour light signalling as currently applied to the LU railway. These requirements may not be appropriate for moving block signalling systems.

#### 3.4.5 Aspect control

##### 3.4.5.1 Clear signal aspect

If the interlocking has identified a route as available and that route has been requested and the interlocking conditions are met, then the associated signal(s) shall display a clear to proceed aspect. In all other instances it shall display a stop aspect.

##### 3.4.5.2 Alternate red aspect

If the trainstop for the signal fails to lower when the signal is cleared, then the signal shall display a stop aspect in addition to the clear to proceed aspect.

##### 3.4.5.3 Replacement to danger or caution

As the train passes the clear to proceed signal, the system shall extinguish the clear to proceed aspect and illuminate the stop or caution (running repeaters only) signal as the train occupies the replacing track section.

##### 3.4.5.4 Repeater aspect control

In order for a repeater to display a clear to proceed aspect, the following conditions shall apply:

- a) The trainstop of the signal (being repeated) is 'OFF' (lowered);
- b) The signal (being repeated) is proved to be clear to proceed;
- c) Any track circuits between the repeater and the signal (being repeated) are proved clear.



In all other instances the repeater shall display a caution aspect.

### **3.4.5.5 Repeater mounted on same post as a running signal**

3.4.5.5.1 When the running signal on the same post is displaying a stop aspect, that signal takes priority and both aspects of the repeater shall be extinguished.

3.4.5.5.2 When the running signal on the same post is displaying a clear to proceed aspect, and its associated trainstop is lowered, the repeater may display either aspect, subject to the requirements of section 3.4.5.4.

### **3.4.5.6 Platform repeater aspect control**

The platform repeater signal aspect shall be directly controlled from the running signal control circuit such that their respective aspects correspond.

### **3.4.5.7 Fog repeater aspect control**

3.4.5.7.1 In order for a fog repeater to display a clear to proceed aspect, the following conditions shall apply:

- a) The fog repeater has been switched on by an LU Operator;
- b) The trainstop of the signal (being repeated) is 'OFF' (lowered);
- c) The signal (being repeated) is proved to be clear to proceed;
- d) Any track circuits between the repeater and the signal (being repeated) are proved clear.

In all other instances the signal shall display a yellow aspect while it is switched on.

3.4.5.7.2 When switched off by an LU Operator neither aspect shall be illuminated.

3.4.5.7.3 A means shall be provided for an LU Operator to exercise local control over the illumination of fog repeater aspects. All fog repeaters in the area of control shall be controlled as a group. Local control shall be exercised from a platform location or a signal cabin as appropriate to the circumstances.

### **3.4.5.8 Fog repeater mounted on same post as a running signal**

3.4.5.8.1 When the running signal on the same post is displaying a stop aspect, that signal takes priority and both aspects of the fog repeater shall be extinguished.

3.4.5.8.2 When the running signal on the same post is displaying a clear to proceed aspect, and its associated trainstop is lowered, the fog repeater may display either aspect in accordance with the requirements of section 3.4.5.7 above.

3.4.5.8.3 When switched off by an LU Operator neither aspect of the fog repeater shall be illuminated.

### **3.4.5.9 Approach lit signals**

An approach lit function, being one in which the signal is not illuminated until the train occupies a specified track, shall be provided when:-

- a) The signal may be mis-read if illuminated at long range;
- b) The signal is visible at long range and this may cause train operators to slow down unnecessarily.



### 3.4.6 Read through of signals

- 3.4.6.1 At locations where the train operator of a train being held at a controlled signal can observe a clear signal less than 250 metres beyond the train, the operating hazards shall be considered and the signal position reviewed and approach controls shall be considered to reduce the possibility of the train operator assuming that the immediate route has cleared.
- 3.4.6.2 The design shall ensure that a signal on one road cannot be misread by or confuse a train operator of a train on another road.

### 3.4.7 Signal number plates

- 3.4.7.1 All running signals and running repeating signals shall bear a number plate, with the signal number shown in letters and figures and shall be readable from a train stopped at the signal.

**Note:** The number plate must be readable from a train stopped at a signal by a Train Operator within the cab, but not necessarily from the sitting position.

- 3.4.7.2 The physical details of number plates for all signals shall be as specified in Standard S1004, Signage for Operational Purposes.
- 3.4.7.3 Where there is a possibility of confusion or mis-reading then the running, repeating, or shunt number plates shall bear an arrow, in black on a white background, pointing towards the track to which the signal applies.

## 3.5 Signs and indicators

- 3.5.1 Signs and indicators shall present information to the train operator in a clear and concise form.

**Note:** Standard S1004, Signage for Operational Purposes, defines the requirements for signage

- 3.5.2 The size, shape, mounting and design of all signs shall ensure that they are unmistakably visible to a train operator from a distance agreed by the Signal Sighting Committee.

### 3.5.3 Junction indicators

- 3.5.3.1 Signals authorising movements over diverging junctions shall comprise a two aspect stop signal together with one or more junction indicators.
- 3.5.3.2 A junction signal shall indicate the selected route by illumination of a junction indicator for all except the highest speed route.
- 3.5.3.3 A junction indicator shall be provided for all routes where the absence of a junction indicator on the highest speed route might confuse the Train Operator (for example when the route over a scissors crossover to the opposite road is in fact the highest speed route).
- 3.5.3.4 Long range junction indicators shall comprise a line of three white lights. Dependent on whether 1, 2 or 3 diverging routes are to be indicated, the position of the lights shall be as stated below:

| No. of diverging routes | Position of lights                       |
|-------------------------|------------------------------------------|
| 1                       | 45 degrees from the vertical             |
| 2                       | 45 and 90 degrees from the vertical      |
| 3                       | 45, 90 and 135 degrees from the vertical |



- 3.5.3.5 Reduced size junction indicators shall be provided at diverging signals in the tunnels.
- 3.5.3.6 The junction indicator lamps shall only illuminate if the selection for the signal is set and the train has been proved to have passed the associated sighting point.
- 3.5.3.7 For a three lamp junction indicator, at least two lamps shall be proved alight to enable the associated aspect to clear to proceed. In other cases, the proving shall be such as to ensure that there is no ambiguity about the routing from the signal.

### 3.5.4 Current rail gap indicators

- 3.5.4.1 Current rail gap indicators shall be used at current rail section gaps to indicate to train operators if the traction current in the next section is off. The indicator shall consist of three lamps with red lenses in a triangular arrangement.
- 3.5.4.2 Rail gap indicators shall be positioned at or before the commencement of current-rail sections in the direction of travel.
- 3.5.4.3 Where a route contains elements of another traction section, a current rail gap indicator shall be mounted on or adjacent to the signal and be appropriately selected for that route.
- 3.5.4.4 At locations where the sighting distance of the rail gap indicator is restricted a rail gap repeater shall be provided.
- 3.5.4.5 A current rail gap repeater shall use a similar arrangement to the rail gap indicator but be fitted with yellow lenses.
- 3.5.4.6 Where a sub-station gap occurs between stations, a co-acting rail gap indicator shall be provided at each platform which has a signalled route to the rail gap.

### 3.5.5 'A' sign

- 3.5.5.1 A semi-automatic signal which under certain circumstances may be treated as an automatic signal shall be provided with an illuminated 'A' sign.

|              |                                                                                                                                                                                                        |
|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Note:</b> | 'A' signs would typically be provided at sites which are normally left in through running mode, and where the interlocking of the through routes is secured, for example by the use of a 'King lever'. |
|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

- 3.5.5.2 The 'A' sign shall be situated beneath the signal concerned and shall display the letter 'A' when illuminated and be extinguished when the signal is operating as a semi-automatic signal.

### 3.5.6 Tunnel siding yellow warning lights

- 3.5.6.1 In addition to other protective measures, yellow warning lights shall be installed at 15 metre nominal intervals in tunnel sidings where there is no automatic means of protection against collision with a fixed obstruction.

### 3.5.7 Permanent speed restriction signs

- 3.5.7.1 Permanent speed restrictions shall be signed in accordance with Standard S1004, Signage for Operational Purposes.
- 3.5.7.2 The requirement for the maximum permissible speed to be shown on the sign in miles per hour or in kilometres per hour shall be determined by LU Operations.