

Category 2 Standard

S2504 Signalling interlocking (Formerly E7054) systems

Issue No.: A3

Issue date: March 2012
Review date: March 2017

MAYOR OF LONDON

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1 Purpose

- 1.1 This standard defines the requirements for signalling interlocking systems used by London Underground.

2 Scope

- 2.1 This standard does not cover specific application design or configuration issues, which shall be described in the Systems Requirement Specification or other associated project documents.
- 2.2 For the purpose of this standard, the interlocking system shall mean the interconnected vital and non-vital sub-systems which provide the following functions:
- a) interpretation of inputs from, and provision of outputs to, trackside equipment;
 - b) acceptance of commands from, and delivery of indications to, the various control systems and panels to which it is attached.

- 2.3 This document replaces E7054 A2.

3 Requirements

3.1 Safety considerations

3.1.1 Safety of signalling interlocking systems

- 3.1.1.1 Signalling interlocking systems shall be considered to be systems of Integrity Level 4 as defined in BS EN 50128 and BS EN 50129, and the requirements of this standard shall be followed at all stages throughout the system lifecycle.

3.1.2 Consequential effects on other systems

- 3.1.2.1 Signalling interlocking systems interface to vital signalling systems of Integrity Level 4 (to BS EN 50128), which have the onus of maintaining safe operation. Wherever there is a possibility that the vital signalling system could be stressed by the signalling control system as it attempts to set routes, a means of preventing this situation shall be included in the functionality of the signalling control system. A test mode shall be provided to allow the interlocking to be deliberately stressed to ensure that it functions correctly under these conditions.
- 3.1.2.2 The interface provided by the signalling control system to the vital signalling system shall be specified such that, in the event of a failure, it is impossible for voltages to be applied to the vital signalling system sufficient to cause it to malfunction or for the vital signalling function to cause the signalling control system to malfunction.

3.1.3 Health and safety

- 3.1.3.1 All equipment shall be constructed, installed and wired to conform to safety legislation and regulations, including those listed in Section 6.1.
- 3.1.3.2 The equipment shall not contain any material which may constitute a health hazard to staff, contractors or customers.
- 3.1.3.3 All materials used in the construction of equipment to be installed in underground or enclosed environments shall comply with standard 1-085, Fire safety performance of materials.

3.2 Systems and quality assurance

3.2.1 Systems assurance

- 3.2.1.1 The System Requirements Specification shall require the contractor to prepare a Systems Assurance Plan for each signalling interlocking system before it is designed and manufactured. The Systems Assurance Plan shall set out the contractor's approach, procedures and schedules for the conduct of Safety Engineering, Reliability Engineering and Maintainability Engineering. Human Factors Engineering is an integral part of systems assurance and shall be considered and reflected within the Systems Assurance Plan.
- 3.2.1.2 The Systems Assurance Plan shall comply with the requirements of BS EN 50126-1, BS EN 50128 and BS EN 50129.

3.3 Functional requirements

3.3.1 Introduction

3.3.1.1 General requirements

- 3.3.1.1.1 The interlocking system, a vital signalling system of Safety Integrity Level 4 (as defined in BS EN 50126-1, BS EN 50128 and BS EN 50129), has three principal functions.
- a) It shall control all vital signalling functions in areas of converging or diverging routes, including signals, point mechanisms, and ATP/ ATC facilities, such that no conflicting train movements occur, and protection is provided from following trains.
 - b) The system shall have the ability to interchange vital information with interlocking systems associated with adjacent areas of control.
 - c) It shall have the ability to interchange non-vital information with a central control system, with other interlocking systems in adjacent areas, and with local control panels, as required.
- 3.3.1.1.2 An interlocking system can be constructed in one of three ways.
- a) a configured solid state interlocking system, which is the type preferred for future interlocking systems.
 - b) an arrangement of interconnected vital relays, with additional diverse equipment to enhance safety levels, as necessary.
 - c) a mechanical lever frame with interconnected vital relays.
- 3.3.1.1.3 All relays used in interlocking systems shall comply with BR 930 or BR 960 series specifications, as appropriate. Relays shall be keyed mechanically to prevent insertion of the wrong relay type. Locking circuits and speed calculation circuits shall only use contacts of primary devices, or their direct repeaters. The number of different relay types used in a system shall be kept to a minimum.
- 3.3.1.1.4 Processor based interlocking systems shall contain duality, either by employing two independent systems in a dualled arrangement, or by using a '2 out of 3' voting arrangement.
- 3.3.1.1.5 Facilities for fault logging, fault finding and system interrogation shall be provided for processor-based systems. The fault logging shall include diverse equipment for recording of system processor states for the inputs and outputs. Portable plug-in

devices used for system interrogation and fault finding shall not have the potential for causing a wrong side failure.

- 3.3.1.1.6 Each interlocking site shall be capable of operating in either automatic control mode, or by local operation.

3.3.1.2 Automatic mode

- 3.3.1.2.1 This is where routing is based on the commands received from the control system.

3.3.1.3 Local operation

- 3.3.1.3.1 A local panel (Emergency Local Control Panel) for use by operations staff, and another type for maintenance technicians (Maintainer's Panel), shall be employed to provide the local control inputs and indications. An interface to each local panel shall be provided to enable direct control into, and indications from, the interlocking system. This control facility shall be totally independent of a central control system, and shall include a controlled manner of change-over between control panels. The Emergency Local Control Panel shall be sited remotely from the Signal Equipment Room, preferably in a Station Operations Room, while the maintainer's panel shall be located in the Signal Equipment Room.

- 3.3.1.3.2 The local panel shall provide controls and indications for two principal types of situation:

- a) The establishment, cancellation and holding of routes;
- b) An automatic 'through routing' facility, wherever possible, whereby the main-line straight routes shall be re-established automatically after the passage of each train.

- 3.3.1.3.3 The method adopted for interfacing the control system and local panels to the interlocking system shall include a controlled means of transfer between the possible points of control, with only one point in command of a site at any one time. A clear indication of the location which has control shall be given at all possible points of control. Default control shall lie with the central control centre, which shall enable control to be passed to one of the other sites, either upon request or in the event of failure. Control shall only be transferred to the central control centre by request following a failure.

3.3.2 Locking functions

3.3.2.1 General

- 3.3.2.1.1 Each interlocking system shall prevent sets of points from being positioned, and signal equipment from being set or ATP codes being given, in any way that could provide a path for trains to move into opposing or conflicting routes.
- 3.3.2.1.2 Routes through an interlocking shall not be cleared until all points in the route or associated sub-routes, including any additional points providing flank protection or trapping, are locked and detected in the required position.
- 3.3.2.1.3 Points shall be held locked until the train is proved to be clear of the route, or a pre-determined portion of the route, by use of a timing function, and by a diverse means of position detection where necessary to meet operational constraints.
- 3.3.2.1.4 The interlocking logic shall ensure, before attempting to set up a route, that the required route is free from direct or indirect locking. All points shall then be set to, be locked and detected in the required position for the route.



- 3.3.2.1.5 The establishment of a route shall enable vital signalling outputs to be set to a permissive state. A failure of a train detection circuit, other than a point track locking circuit, shall not prevent the points for a route from being correctly positioned in order for the remote secure sign to be used, where this has been provided.
- 3.3.2.1.6 Overrun protection shall be provided to ensure that should a train overrun a signal which conflicts with a set passenger route, the entry signals and ATP codes for the set route are immediately returned to the stop condition. However, the compromised route shall not be unlocked.
- 3.3.2.1.7 Locking shall make allowance, where required, for the passage of long works trains or one service train pushing another, such that normal establishment and release of the locking is not compromised.
- 3.3.2.1.8 At locations where a route may be set into a siding which does not have full speed protection, the route shall be locked for the main-line until the train has been proved to be stationary at the signal which controls the siding entrance.

3.3.2.2 **Approach locking**

- 3.3.2.2.1 Approach locking shall prevent changing of routes when a train is less than a service braking distance from the start of the route, or the driver has been given an indication that the route is established, such as a repeater signal for the signal at the start of the route. Approach locking shall be applied prior to issuing permission for any train to enter a route, and shall extend as far as the entry point to the route.
- 3.3.2.2.2 The approach locking distance shall, as a minimum, extend from the last point at which cancellation of the route would cause the route entry signal, whether a passenger or shunt signal, to be returned to the non-permissive state (termed 'replacing') with sufficient distance for a train to come to rest at the signal. This distance shall be calculated from the normal service braking characteristic for the rolling stock and an additional allowance for driver and equipment reaction time (taken as 6 seconds at present for manual driving). Alternatively, this distance shall be determined from the point at which an immediate alteration to the ATC signals, received by an approaching train, will not allow the train to stop under normal service braking before reaching the start of that route.
- 3.3.2.2.3 Release of approach locking shall occur after any of the following events.
- Occupation and subsequent clearance of the approach locking zone after the passage of a train through the zone. This shall be arranged to ensure that irregular release does not happen in the presence of either an intermittent train detection indication (occupied or clear), or an intermittent track circuit boundary failure.
 - If a route has not been fully set, and consequently the signal equipment and ATP code signals, or either of these two items, have not yet been in a permissive state.
 - The signal equipment or ATP code signal has been replaced to stop, and a train has not entered the approach locking zone.

Note: This requires protection.

- A prescribed time delay has expired whilst a train is present on the approach locking zone and the signal equipment or ATP code signal has been replaced to stop. A minimum time of 60 seconds shall expire to prove that the train is at rest.

- 3.3.2.2.4 The logic associated with approach locking shall be designed such that a train which follows another train, at the minimum allowable interval, does not erroneously maintain the locking applicable to the previous train. Additionally, the preceding train shall not cause a premature release of the locking for the following train.

3.3.2.3 Route locking

- 3.3.2.3.1 Route locking shall prevent movement of point mechanisms under or in advance of a train within a route which the train is traversing, and shall prevent the establishment of any conflicting routes. A route shall include the overlap of the last controlled signal in the route or alternatively, the farthest point that an ATO train could reach under any type of service braking failure scenario.
- 3.3.2.3.2 Route locking shall prevent simultaneous establishment of routes which would allow a train to move in opposite directions from the same location.
- 3.3.2.3.3 Route locking shall be released automatically when the train has either been detected as clear of the route (or a portion of the route) by two diverse detection mechanisms, or by a single detection mechanism and the expiry of a suitable time delay (a 15 second delay is used at present for passenger moves, and 4.5 seconds for non- passenger moves). One of the detection methods shall indicate when the front of the train is at least a train length beyond the last set of points in the route (or portion of route, as applicable) to be released. Guidance on train detection systems is given in E7055. A loss of detection of the train within the route shall not be sufficient to release the route locking.
- 3.3.2.3.4 Where appropriate, the route locking may be released through the transfer, termed hand over, of locking for points in the overlap of the signal in advance of the route entry signal, which were required for protection of the route.

3.3.2.4 Track locking

- 3.3.2.4.1 Track locking shall prevent movement of point mechanisms when a train is occupying the track section in which the points are located, irrespective of whether a signalled route over the points has been established.
- 3.3.2.4.2 The track locking distances for facing passenger moves, facing non-passenger moves, and trailing moves shall be based on the nominal speed of a train, when the rule for passing a signal at danger is applied, to allow completion of point movement prior to a train on approach to the points reaching any movable portion of that set of points.
- 3.3.2.4.3 If insufficient tracklocking distance exists, each train shall be proved to be at an appropriate speed before release of the track locking function occurs.
- 3.3.2.4.4 Track locking shall be accomplished through the use of track circuits or axle counters, as described in E7055 irrespective of the type of signalling system to be used.

3.3.2.5 Facing junction locking

- 3.3.2.5.1 All facing junctions shall be locked by a protecting signal or ATP code section, which is at least an overlap distance in rear of the junction.
- 3.3.2.5.2 If insufficient overlap distance exists, trains shall be proved to be at a speed consistent with the available distance before the locking can be released.

3.3.2.6 Traffic locking

- 3.3.2.6.1 Traffic locking shall be provided in areas of bi-directional signalling, and shall prevent a change in the direction of traffic, in any track section, unless the speed and location of all trains in the section and on the approach to the section are such that the change can be accomplished safely.
- 3.3.2.6.2 Traffic locking shall prevent the establishment of a route which is in conflict with the established direction of traffic, and shall prevent unauthorised movement of trains against the established direction of traffic.
- 3.3.2.6.3 Traffic locking shall allow for train reversing moves without the need for changing the established direction of traffic. The reversing train shall be permitted entry into the section, and exit from it, irrespective of the established direction of traffic. The reversing move shall be accomplished safely by a suitable combination of the traffic locking, route locking, and signal equipment or ATP speed authorisation systems.
- 3.3.2.6.4 A request to change the direction of traffic in a bi-directional section shall cause the signalling equipment or ATP speed authorisation within the section to bring all trains to a stop at suitable locations, the preferred location being a platform.
- 3.3.2.6.5 A time delay shall be initiated which holds the traffic locking until sufficient time has elapsed to ensure that all trains in the traffic section are stationary. This time delay shall be a minimum of 60 seconds, after which the traffic locking shall be released to allow traffic to be established in the reverse direction. If there are no trains in the traffic section, or in the approach locking zones for cleared routes leading into the section, the traffic locking shall be released immediately on request, however the logic shall guard against loss of train detection.
- 3.3.2.6.6 Traffic locking shall be changed by a specific command request. It shall not change automatically in response to a request for a reverse direction route.
- 3.3.2.6.7 All entry and exit routes shall be cancelled automatically. Manual cancellation or alteration to routes shall not be required to achieve reverse running.

3.3.2.7 Protection of locking

- 3.3.2.7.1 The interlocking logic shall be designed so that any intermittent operation of train detection circuits (for example caused by contaminated rails) shall not result in premature release of any locking feature.
- 3.3.2.7.2 The interlocking logic shall protect against false detection of train absence in interlocking areas in the following situations:
- for passenger moves, detection of train position beyond the limits of the interlocking, or a minimum time delay of 15 seconds after clearance of the interlocking as a diversity factor;
 - for non-passenger moves, where headways are a critical consideration, the protection shall be as for a passenger move, except the minimum time delay shall be 4.5 seconds;
 - for non-passenger moves, where headway is not a critical consideration, a minimum time delay of 4.5 seconds following clearance of the interlocking can be used without the additional detection of train position.