Semaphore And Mechanical Signalling

Synopsis:
Principles for controlling Signalling Equipment mechanically.

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# Semaphore And Mechanical Signalling

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Part A

Issue record
This standard will be updated when necessary by distribution of a complete replacement.
Amended or additional parts of revised pages will be marked by a vertical black line in the adjacent margin.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Date</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>July 97</td>
<td>New standard.</td>
</tr>
</tbody>
</table>

Responsibilities
Railway Group Standards are mandatory on all members of the Railway Group* and apply to all relevant activities which fall within the scope of each individual’s Railway Safety Case. If any of those activities are performed by a contractor, the contractor’s obligation in respect of Railway Group Standards is determined by the terms of the contract between the respective parties. Where the contractor is himself a duty holder of a Railway Safety Case then Railway Group Standards apply directly to the activities described in his Railway Safety Case.

*The Railway Group comprises Railtrack and the duty holders of Railway Safety Cases accepted by Railtrack.

Compliance
The provisions of this Railway Group Standard are mandatory for design and implementation work undertaken on schemes for which the Signalling Scheme Plan is approved on or after 6th December 1997. Retrospective action is not generally required in respect of existing layouts. Railtrack shall however consider the need to meet the requirements of this standard if there is, on or after the 6th December 1997, a material change to the usage of a semaphore/mechanical signalling installation (e.g. a significant change to the train service pattern) or other material change to circumstances, which in itself does not require any change to the signalling installation.
Railtrack shall consider the need to meet the provisions of this standard for alterations effected on or after 6th December 1997 to Signalling Scheme Plans approved prior to 6th December 1997.
The provisions in this standard for the use of retroreflective semaphore signals may not be used until equivalent provision is made in Railway Group Standard GK/RT0031, Lineside Signals and Indicators.

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In authorising this standard, Railtrack PLC makes no warranties, express or implied, that compliance with all or any of Railway Group Standards is sufficient on its own to ensure safe systems of work or operation. Each user is reminded of its own responsibilities to ensure health and safety at work and its individual duties under health and safety legislation.
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Telephone: 00 35903 or 0171 830 5903 (BT)
Facsimile: 00 35776 or 0171 830 5776 (BT)
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Part B

1 Purpose
To define the principles specific to the safe control and routing of trains by means of Semaphore Signals and Mechanical Signalling Equipment.

2 Scope
This standard applies to all signalling installations employing semaphore signals and to all installations where the interlocking and/or the movement, detection and locking of points is performed mechanically.

3 Definitions

Backlight
A small white (aperture) light provided at the back of the lamp case of a semaphore arm or ground disc signal which is obscured by the movement of the semaphore arm or ground disc from the horizontal position. This is to enable the signaller to:
- observe the movement of the signal arm from the horizontal
- observe that the signal is lit.

Converse Locking
The provision of locking between functions to ensure that conditions cannot be broken down, i.e. if 1 locks 2, then 2 must lock 1. This form of locking is provided automatically by a mechanical interlocking.

Indication Locking
A form of locking whereby the full travel of the lever is inhibited until the operation of the points is complete and detection is obtained. The lever’s function is achieved when the full travel of the lever is reached.

Lever Frame Interlocking
A term used for any device, either mechanical or electrical, which ensures that only those levers which allow train movements to take place with safety can be operated in combination.

Slotting
A means of implementing multiple controls e.g.
- a Distant arm placed below a Stop arm such that it cannot be OFF when the Stop arm above it is ON, or
- a signal operated from two or more signal boxes or ground frames.

4 Principles

4.1 General
One stop signal shall be provided on each line controlled by a signal box for each permitted direction of travel. Additional stop signals may be provided where required for operational reasons. A distant signal or arm shall be provided at least minimum signal spacing from the first stop signal on each line and for each direction of travel. Distant signals or arms shall only be capable of clearing when all related stop signals on that line reading in the same direction have been cleared. See Railway Group Standard GK/RT0035 for details of signal positioning.
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4.2 Lever Frame Interlocking

Interlocking shall be provided to meet the requirements of Railway Group Standard GK/RT0060. If the interlocking is provided by other than mechanical means, it shall replicate the characteristics of mechanical locking described herein e.g. converse locking shall be provided.

Distant levers shall be so interlocked that they cannot be pulled until the levers of all of the related Stop signals have been pulled.

Signal and point levers shall be so interlocked that the signaller cannot clear a signal for the movement of a train unless the points have been set in the proper position for it to pass and are bolted as necessary. It shall not be possible to clear two opposing signals on the same line at the same time unless specifically requested by Railtrack e.g. where signal boxes switch out on single lines. It shall not be possible to move any points which are required to be set for the train until the signal has been replaced.

Where practicable, point-to-point locking may be provided to:
- simplify locking arrangements or
- provide trapping and flank protection.

4.3 Route Holding

A track circuit or other device shall be provided between the protecting signal and facing points to ensure that, after the signal has been passed, it shall not be possible to unbolt or move the facing points until the whole of the train has cleared them.

Levers operating Stop signals beyond trailing points, operated from the same signal box, shall, when worked, lock such point levers in either position. This is not required where the locking would unduly interfere with traffic movements for which there is adequate distance between the signals and points concerned, or another means of achieving route holding has been provided.

4.4 Signalling Aspect Sequences

Aspect sequences shall meet the requirements of Railway Group Standard GK/RT0032.

4.5 Signal Box Location

The signal box shall be positioned so that the signalling can be worked safely and in accordance with the Signalling General Instructions and Rules and Regulations. The signal box location shall be determined by whether there are level crossing gates or barriers to be operated by rodding. The box shall be adjacent to, or within 50 metres of, the crossing for ease of operation and so that the signaller has a good view of the road traffic.

If the position of the signal box is not governed by a level crossing, then it shall be placed so that the furthest points to be worked mechanically on
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either side of the box are not more than the maximum distance allowed, see Appendix A.1.

4.6 Integrity
The integrity of semaphore and mechanical signalling is dependent on:
• construction from approved equipment
• installation and testing to correct practice and technique
• regular inspection, maintenance and testing

The exposure of parts of the semaphore and mechanical signalling system to the effects of the environment and weather and the use of mechanical force within the system creates risks not encountered in electrical systems. Railtrack shall ensure that these risks are controlled and that the required safety integrity is achieved by:
• the use of approved equipment
• the use of correct installation practice and techniques
• complete and thorough testing prior to introduction into service
• regular inspection, maintenance and testing as defined in the Signalling Maintenance Specifications or other approved Codes of Practice.

Periodicity of inspection, maintenance and testing shall be determined by consideration of frequency of use, age and robustness of the equipment type.

5 Points

5.1 Compensation
Compensation shall be provided to make the system tolerant to change in temperature where required.

5.2 Power Operated Points
There shall be controls to ensure that a signaller cannot clear a signal until the points have completed their movement. Where point detection is not proved in the signal controls, the point lever shall be provided with indication locking.

5.3 Lever Operated Points
These shall be locked such that they can only be moved when the levers for all signals which read over the points are normal.

5.4 Sealed Emergency Release
This shall be provided where failure of a track circuit will prevent the operation of a lever which is connected to a facing point lock or to mechanically operated points, either facing or trailing. The sealed release facility will be provided on the basis of one shelf mounted plunger per point and/or FPL lever that is controlled by track circuits. (Alternative mechanisms to sealed release/shelf mounted plunger may be used provided that the same functionality/integrity is achieved).
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The only control functions that shall be by-passed are:

- dead locking or
- route locking.

Under no circumstances shall other controls for interlocking or proving purposes be by-passed by the sealed emergency release.

The provision of a sealed release facility for points worked from ground frames is prohibited.

5.5 Manual Time Release

A manual time release may be utilised where time release of a track circuit is not provided, for circumstances where a signal has cleared and been restored and it is necessary to change the route.

This facility may also be provided where a signaller is unable to restore a signal lever after the passage of a train due to the failure of a track circuit or treadle where backlocking is provided.

In these circumstances, a time delay shall be determined, in accordance with Railway Group Standard GK/RT0063.

5.6 Facing Points

Facing points on passenger lines shall have apparatus to detect that each switch is in its proper position with relation to its stock rail and that the points are bolted, before the protecting signals can be cleared.

Mechanical facing points on passenger lines shall additionally have a bolt-lock through the front stretcher bar, with its bolt either controlled by means of a train detection device or facing point lock bar.

Facing point bolting details shall be recorded on the Signalling Plan.

If the points are equipped with a Facing Point Lock (FPL), the controlling lever (FPL lever) shall be locked in the LOCK (IN) position whilst the signal levers are not normal.

The FPL lever in the lock position shall lock the point lever both ways (or normal or reverse where specified by Railtrack).
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#### 5.7 Detection

The following table summarises the detection requirements when a signal box or ground frame is manned for all relevant movements:

<table>
<thead>
<tr>
<th>Points ↓</th>
<th>Signal →</th>
<th>Running Signal</th>
<th>Shunt Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mech</td>
<td>Motor</td>
</tr>
<tr>
<td>Power Operated</td>
<td>Indication</td>
<td>Facing</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Locking</td>
<td>Trailing</td>
<td>O</td>
</tr>
<tr>
<td>No Indication</td>
<td>Facing</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Locking</td>
<td>Trailing</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Mechanically Operated</td>
<td>Facing</td>
<td>Mechanical Detn.</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Electrical Detn.</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Facing</td>
<td>Mechanical Detn.</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>- no FPL</td>
<td>Electrical Detn.</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Trailing Points</td>
<td>Mechanically or Electrically Detected</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>

O = Optional  
✓ = Detection mandatory  
X = Not permitted

The following table summarises the detection requirements when a signal box or ground frame is not manned for all relevant movements:

<table>
<thead>
<tr>
<th>Points ↓</th>
<th>Signal →</th>
<th>Running Signal</th>
<th>Shunt Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mech</td>
<td>Motor</td>
</tr>
<tr>
<td>Power Operated</td>
<td>Indication</td>
<td>Facing</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Locking</td>
<td>Trailing</td>
<td>X</td>
</tr>
<tr>
<td>No Indication</td>
<td>Facing</td>
<td>X</td>
<td>✓</td>
</tr>
<tr>
<td>Locking</td>
<td>Trailing</td>
<td>X</td>
<td>✓</td>
</tr>
<tr>
<td>Mechanically Operated</td>
<td>Facing</td>
<td>Mechanical Detn.</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Electrical Detn.</td>
<td>X</td>
<td>✓</td>
</tr>
<tr>
<td>Facing</td>
<td>Mechanical Detn.</td>
<td>✓</td>
<td>X</td>
</tr>
<tr>
<td>- no FPL</td>
<td>Electrical Detn.</td>
<td>X</td>
<td>✓</td>
</tr>
<tr>
<td>Trailing Points</td>
<td>Mechanically or Electrically Detected</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>

O = Optional  
✓ = Detection mandatory  
X = Not permitted
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6 Signals

6.1 Signal Operating Mechanism
The operating mechanism of a signal shall be designed such that failure causes the signal to return to its most restrictive aspect. Where necessary, repeating of the arm position shall be provided to ensure that the actual position of the arm is indicated to the signaller. Controls shall be provided to render any resultant risk to be as low as reasonably practicable.

6.2 Appearance
For details of the appearance of different types of semaphore arms and shunt signals, see Railway Group Standard GK/RT0031.

6.3 Arm and Light Repeating
Arm repeating shall be provided for:
- all distant signals;
- all signals more than 400 metres (440 yards) from the signal box;
- all power-operated semaphore signals;
- all signals controlling the entrance to single line block sections worked by any non-token system (unless protection by points is assured);
- all other signals (including banner repeating and shunt signals) which cannot readily be seen from the signal box.

Light repeating shall be provided for all signals which cannot readily be seen by the signaller, or by the signaller at another location.

Where a retroreflective signal arm cannot be observed by the signaller under all lighting conditions, an arm repeater shall be provided.

Where provided, the indications for the arm shall be “ON” and “OFF”. “WRONG” may also be indicated or may be implied by an absence of indications. See Appendix A.5.

6.4 Mechanical Slotting and Slot Repeating
If a signal is worked by two or more signal boxes, it shall be slotted. Each signal box shall have the means to replace the signal independently.

If a distant arm is mounted below the stop signal for another signal box, it shall be slotted by that Stop signal and any similar Stop signal ahead.

Where a distant arm is mounted below a stop signal of the signal box in rear, it must additionally be back slotted by any other stop signals of the rear signal box ahead of that distant arm.

If a distant arm is mounted below a stop signal which is not the last stop signal controlled by that signal box, the distant arm shall be repeated below all stop signals ahead.

Slot repeating shall be provided.
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6.5 Backlocked Signals
Signal levers shall be backlocked where required in order to prevent the release of mechanical locking in the frame until such time as it is safe to do so, for example when approach locked.

6.6 Lighting of Semaphore Signals
The lighting of semaphore signals shall be determined by Railtrack and may be:

- lit;
- retroreflective;
- not lit i.e. daylight working only.

Where the signal aspect light cannot be observed by the signaller and a light repeater is not provided, a backlight shall be provided. All semaphore shunting signals shall have backlights to indicate their presence.

6.7 Sequential Locking
Sequential locking is non-reciprocal and shall, where required, be applied to successive running signals, to enforce the replacement of one lever (and its associated arm where arm repeating is provided) before the lever controlling the signal in rear is free to be pulled.

6.8 Intermixing of Colour Light and Semaphore Signals
Intermixing of colour light and semaphore signals is permitted, but where this is done, consideration must be given to signal sighting and the risk of reading through.

7 Levers

7.1 Position of Lever Frame
The levers in a mechanical frame shall be arranged in a straight line and numbered consecutively with the lowest number on the signaller’s left hand when facing the levers. The normal position of the levers shall be back in the frame and when pulled shall be reversed. The layout of the levers should be so arranged that pulling one lever between two adjacent levers which are reversed (pull-between) is avoided.

The preferred arrangement of the lever frame shall be such as to allow the signaller to have the best possible view of the line and all operations for which the signaller is responsible, with easy access to the windows where necessary.

7.2 Levers not operating external functions
When a lever ceases to operate an external function and:
- the lever and associated interlocking is removed, a ‘space’ is created in the lever frame
- the lever is retained but any associated locking is removed, the lever shall be designated a ‘spare lever’
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- the lever and associated locking is retained the lever shall be designated 'lever worked to maintain locking' or alternatively 'lever worked for interlocking purposes'.
- the lever is fixed and the interlocking retained for integrity of interlocking the lever shall be designated a 'fixed lever'. Note: Levers may not generally be fixed in the Reverse position.

Retention of levers with no external function to maintain interlocking shall be subject to risk assessment if they are to be retained for longer than 12 months. This risk assessment shall consider as a minimum:
- overall security of the mechanical interlocking installation, including existence of other levers worked or retained for the maintenance of interlocking.
- the risk of interference of the retained interlocking when servicing lever frame and interlocking and failure to test for the retention of this locking.
- the quality of records for the interlocking prior to the works removing the external function.
- the number of times the signaller requires to work the lever or the extent the signaller places reliance on the retained interlocking in relation to the number of operations of working levers.

The numbers of spare levers, fixed levers, levers worked to maintain locking and spaces shall be identified on the Signalling Plan, Signal Box Diagram and Locking Table.

7.3 Colours of Levers
All levers shall be painted in accordance with Railway Group Standard GK/RT0005 and shall be fitted with a lever number / pull plate describing the functions of the lever.

7.4 Short Lever Handles
Levers in a mechanical frame controlling electrical functions which can be worked with slight effort, such as those controlling colour light signals, power worked points and king levers, shall have shortened handles.

8 Locks and Keys

8.1 Electrical Locks
Electrical locks controlling lever movements shall generally be provided with economiser to reduce the current consumption and shall generally be provided with a force down feature. Note: force down shall always be provided when indication locking is provided.

8.2 Mechanical Locks
Where a lock is fitted to a mechanical lever frame, level crossing gates etc. to give a release by insertion and rotation of the appropriate key, the key when inserted into the equipment to be released shall be retained until the equipment is returned to normal. A common form of this lock is an Annetts lock, operated by an Annetts key.
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8.3 Keys
The withdrawal of a key from a locking frame shall ensure that the locking is effective for the particular function for which that key is used, e.g. release of ground frame, etc. A common form of key is an Annetts key.

9 Indications

9.1 Indications shall be provided to meet the requirements of Railway Group Standard GK/RT0025. The signaller shall have adequate view of the indications, which shall be adjacent to the operating device.

9.2 For mechanically operated points equipped with a separate FPL, the detection indication (where provided) shall incorporate the fact that the points are correctly bolted. For power worked points, the indication shall incorporate the fact that the point switches are detected in the controlled position and the FPL is engaged.

10 Hybrid Operation

10.1 Description & Use
Hybrid operation is the use of mechanical operation of signals and points and electrical operation of signals and points within the same signal box. Hybrid operation may be considered for use.

10.2 Risks
The use of hybrid operation creates special risks in that necessary signalling controls may be provided in the mechanical or electrical element, or duplicated (completely or partly) in the two elements, hence there is enhanced likelihood that necessary controls may be unintentionally omitted, or, by being duplicated, may produce increased failure and secondary hazard potential. Railtrack shall ensure that these special risks are controlled.
Appendix A - Guidance

The force available to move points, or pull signals OFF, manually depends on the strength of the signaller with the mechanical advantages of the operating lever, and the distance of the function to be operated from the signal box. The ease of working mechanical signalling will depend upon the route taken by the connecting rodding and wires, secure linkage with the mechanical locking frame is essential.

The risk of injury should be mitigated by reducing to a minimum the event of signal wire breakage or rodding disconnection by regular maintenance and replacement related to frequency of use.

10.1 Limits of Operation

Wire operation of a mechanical signal should be limited to 1,000 metres (1,100 yards). For any further distance consideration may be given to the provision of an alternative, e.g. colour light or power operation.

Manually worked points should not exceed 320 metres (350 yards) rodding run from the lever to the furthest point end.

10.2 Adjustments

Signals - adjustments to the signal wire travel should only be carried out at the signal box end, due to effects upon point detectors and risk of the signal arm showing "OFF" when it should be "ON" due to the wire being tight.

Signals which are backlocked should be adjusted so that the arm returns to the ON position when the lever is in the backlocked position in the frame.

Wire adjusters should be provided at operating floor level for use by the signaller when signals, not running through mechanical detectors, are a considerable distance from the signal box, for example Distant signals.

The wire between intermediate devices, e.g. mechanical detector, gain stroke lever or ground mounted slotting device, must be capable of adjustment.

Weights and springs should be selected for purpose to ensure that:

- signal wires are never taut with the lever normal and the signal on,
- the balance lever returns to the fully ON position,
- the lever operates in reasonable balance, Normal to Reverse (and vice versa).

Mechanical Points - adjustments of throw should be achieved at the extremity of the rodding run by an adjustable crank.

Expansion should be controlled by means of compensation, which should be provided in rodding runs longer than 32 metres (35 yards) to avoid the need to adjust points, etc., for changes in temperature. Compensators should be fixed in the rodding run in such a position that the expansion or contraction of the rod in
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tension is equalised by the expansion or contraction of the rod in compression by which means the overall operating length of the rod remains constant.

10.3 Detection
Mechanical detectors (up to a maximum of four) should be maintained with a clearance of 2.5mm (3/32") on each side of the signal slide. The clearance between the notch face of the signal slide and nearest blade should not exceed 13mm (½") for any detector at 23 metres (25 yards) or less from the signal. This clearance, however, may be increased on detectors at distances more than 23 metres (25 yards) from the signal to allow for the effect of temperature changes in the wire between the signal and detector. Where two or more detectors in a wire run control the same signal, the detector nearest the signal should have the normal clearance and the other detectors should have clearances progressively increasing to the maximum of 50mm (2") at the last detector if it is more than 183 metres (200 yards) from the signal. The increase of signal slide clearance should be at the rate of not more than 25mm (1") per 92 metres (100 yards) of wire run.

10.4 Spare Levers
When a new lever frame is installed, at least 10 per cent of the total number of levers in the frame should be kept as spare, distributed as evenly as possible through the frame, preferably in groups of three levers to cater for future signalling. Spare levers are not required at Ground Frames.

10.5 Arm, Slot and Light Repeating
All lit Distant arms should be repeated in the box from which they are supervised.

A single indicator may be used to repeat the lights of a group of signals, but separate indicators are necessary for signals on different lines.

Repeater may be combined on the same circuit, where appropriate, such as:
"ASR" (Arm and Slot repeater) should prove that the arm is in the 'ON' position,
"ALR" (Arm and Lamp repeater),
"SLR" (Slot and Lamp repeater),
"ASLR" (Arm, Slot and Lamp repeater), should indicate that the indications are on the same circuit.

10.6 Mechanical Slotting
Mechanical slotting is achieved by balance levers on the signal post and arranged so as to ensure that the signal arm can only be moved to the OFF position after the last controlling lever has been pulled in the signal box and is restored to the ON position by the first controlling lever to be replaced.
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Back slotting is a means of ensuring that an outer distant arm cannot be OFF when:
- the inner distant arm is ON or
- an intervening stop signal worked from another box is ON.

The response of the arm and of the slot lever in the ON position, and of the slot lever in the OFF position should be suitably repeated and indicated.

10.7 Signal Arm Position Proving

Contacts used for proving signal arms ON should break when the arm is 5 degrees or more from the horizontal. Contacts proving signal arms OFF and controlling signal indications should make when the arm is not less than 35 degrees from the horizontal.

Contacts used for proving signal arms OFF and controlling AWS equipment should be made before the OFF indication contact. The contact should make at 25-30 degrees and break again at a maximum of 65 degrees from the horizontal unless agreed by Railtrack.

Signal Arm Adjustment

10.8 Backlighting

Backlight blinders should be adjusted to obscure the backlight of the lamp when the signal arm is 5 degrees or more from the horizontal position.
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References

HMRI Railway Safety Principles and Guidance
Part 2 Section D: Guidance on Signalling (HSE).

GK/RT0031 Lineside Signals and Indicators.
GK/RT0032 Lineside Signal Aspect Sequences.
GK/RT0035 Layout of Signals.
GK/RT0037 Signal Sighting.
GK/RT0060 Interlocking Principles.
GK/RT0063 Approach Locking and Train Operated Route Release.