REQUIRED OPERATIONAL CAPABILITY
FOR
INTERLOCKING SYSTEMS

FOR THE USE IN

PASSANGER RAIL AGENCY OF SOUTH AFRICA (PRASA)

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1. SCOPE

The interlocking secures and protects a route for a train to be safely traversed and makes the route available for other trains after the train movement has taken place.

The interlocking is the part of the signalling system that acts as a safety buffer between the requests of the train control officer and the actual control of the outside signalling elements like point-sets and signals.

Interlocking systems are used to increase the capacity and facilities of a railway line without reducing the safety level of the line.

The purpose of this document is to define the operational, performance, design, and development requirements for an interlocking.

1.1. Advantages of Hybrid Interlocking Technology:

The advantages by doing the non-vital functions with a computer are as follows:

1.1.1. Flexibility in the user interface technology and methods used.

1.1.2. There exist options to do functions like ATR, ARC, remote control and train describer with the same computer system because of the information that is needed for these functions already being available in the device.

1.1.3. A reduction in cost compared with other geographical relay based Interlocking systems.

1.1.4. The advantages by doing the vital functions within relay technology are as follows:

1.1.4.1 The methods used to do fail-safe vital functions in relay technology are well known.

1.1.4.2 No expensive and time consuming software safety and functional verification and validation are required.

1.1.4.3 Vital interfaces to outside signalling elements are relative robust.

1.1.4.4 Relay technology is well established.

1.1.4.5 Using relays and contactors as switching elements of larger currents over tail cables to elements/objects generate less heat than solid state switches.

1.1.4.6 The safety functions that detect wrong side failures and negate them by forcing fail-safe states are normally simply consisting of proving the normal state of the relays before, during or after the train movement.

1.2. The advantages of using electronic interlocking Technology:

1.2.1. The main interlocking and the outside area controllers are connected by medium-independent fail-safe data transmission systems (FSDTs). All the multi-core copper main cables in relay-based systems are eliminated. Optical fibre and in most cases even radio networks can be used as medium for these FSDTs. Redundancy with alternative routes, optical loops or even dual optical loops is possible to improve the network availability.

1.2.2. The multi-core copper main cable runs needed with central architecture Free wired, "Spur" based, and Hybrid relay interlocking systems are eliminated. This has the following advantages:

1.2.2.1 The cost of the multi-core copper cables running for kilometres, especially at Freight railway stations, is saved.

1.2.2.2 The cost of immunisation of copper cables parallel to AC electrified railway lines against induction, when large currents are drawn in the overheads for moving heavy loads, is saved. The optical fibre normally utilised for the Fail-Safe Data Transmission (FSDT) system is not electrically influenced by the overhead currents.

1.2.2.3 When the optical fibre is hanged on the overhead masks or the FSDT system utilises a radio transmission medium and distributed local power is available at the distributed interlocking housings, trenching cost can be saved.

1.2.2.4 The intrinsic value of optical fibre is less than that of multi-core copper cable and therefore will not be so lucrative to steal as multi-core copper cable.

1.2.2.5 When multi-core copper cable runs are stolen the signalling system or part of it may be out of service for months while the multi-core copper cables are sourced, installed and re-tested. During this time the operating method that is fallen back onto is less effective (causes train delays), higher risk for driver and/or TCO making mistakes (higher risk for train accidents) and a bigger and more stressful workload for the drivers and TCO.

1.2.3. The implementation of LED cluster signals becomes easier. The reason for this is the advantage of proving that the LED cluster is displaying a light output can be done outside and then via optical fibre transferred to the EI safety core.

1.2.4. The integrity/safety level of the call, detection and proving circuits are improved:

1.2.4.1 Short circuits between cores and earth in multi-core cables that can, with common power supplies, bypass relay contacts in the interlocking are eliminated.

1.2.4.2 Earth leakage detectors that had to be set to unacceptable tripping levels because of insulation properties of outgoing multi-core cable deteriorating with aging is eliminated.

1.2.5. The vital detected states of the elements (Aspect displayed on signal, points-set detection, section occupied or not, etc.) are available in closer proximity to the real elements, this information has test/maintenance advantages.

1.2.6. More operating and diagnostic information about the states and error states of the real element outside are available to the TCO and maintenance technician. Error states can be easily logged and tallied.

1.2.7. Scale economic advantages exist with the safety platform's hardware used for the main interlocking and area controllers. With larger interlocking systems more elements do not require more hardware in the main interlocking and the same applies to the area controllers up to the I/O capacity limit. When a central safety core/electronic interlocking is used with only object controllers outside, a whole railway line with a number of stations can be done with the same electronic interlocking. The high availability of the communication backbone is essential in this central interlocking architecture; even interruptions of seconds are not acceptable.

1.2.8. When an object oriented, geographical and true speed signalling electronic interlocking is used a number of hardware safety core platforms connected together can be used to control a big station, up to the maximum number limited by the safety case. When the areas controlled by each safety core are correctly chosen availability advantages can be realised. Faster real time access times to vital I/O, object controllers and elements can be realised when less of these are controlled/monitored by a hardware safety core with shorter scan times.

1.2.9. The building space required to house a large interlocking is significantly reduced when using electronic interlocking systems compared even with hybrid interlocking systems. When a central electronic interlocking architecture is used only apparatus cases/rooms to house the object controllers remains outside.

1.2.10. When a globe or cluster of an aspect fails the object controller/interlocking safety core in electronic interlocking systems switches the signal to a lower aspect or to the default aspect if a lower aspect is not available. With most relay based interlocking systems this situation would result in a dark signal being displayed until the signal is cancelled/normalised.

1.2.11. When an object orientated safety program is used. Once the objects and their governing rules are defined in the program and were verified and validated, all elements in an applied approved electronic interlocking will have the same functionality if applied in accordance with the test cases. If the functionality of an element (object) is later changed, the new functionality is tested and approved on one element (object) and this ensures that all elements of this type will have the new functionality in the future. Retrofitting of already installed stations are also quite simple.

1.2.12. When an expert system program with generic-rules that acts on PROLOG-facts for specific applications are used for generating the necessary Boolean equations. Once the generic governing rules have been created, verified and validated for all test cases the expert system applying these rules on a specific set of PROLOG-facts, at a specific application, will ensure all elements in an applied approved electronic interlocking system will have the same functionality, if applied in accordance with the test cases.

1.2.13. The configuration of the electronic interlocking for a specific station can be automated with e.g. a CAD file as input to an Expert-shell program file, generating the PROLOG-facts as input to the Expert systems.

1.2.14. The electronic interlocking has got integrated vital remote control functions that are needed for the emergency operations that override the interlocking.

1.2.15. The verification and validation of the functionality of the electronic interlocking is done by simulation together with some real hardware interfaces to real elements.

1.2.16. The testing of the electronic interlocking-configuration for a specific station is simplified by simulating the elements. The balk of the safety checking/testing of VDU/remote control controls and indications, the safety core configuration, module addressing, labelling, wiring up to outgoing panel (OP) from object controllers, etc. are done on the factory floor. Only correspondence checking/proving of tail cables to real elements, power supply settings and settings influenced by power supply levels need to be done outside on the real installation. This helps to reduce commissioning time.

1.2.17. Support systems like “Event Loggers”, “Fault Analyses Tools”, “Configurable Management Information Systems”, “Version Configuration Control Systems”, etc. are included in the electronic interlocking application bundle.

1.2.18. The element controllers have vital processing power and some of the real time interlocking functions can be done by these track side element controllers. This reduces the processing workload of the main interlocking increasing the number of elements that can be handled.

1.2.19. When in the future the technology involved in “Communication Based Authorisations Systems” (CBA) matures, these electronic interlocking systems can still be retained by redefining the objects and governing rules. The step to CBA from wayside signalling is quite small if the electronic interlocking is geographic, object oriented and true speed signalling (maximum speeds set in the objects with integers coupled to distinct speeds).

1.2.20. If the interlocking software is object orientated or rule based, the implementation of modifications to station layouts is simplified. To add or remove elements is as simple as:
a) adding or removing the associated data blocks and fixing the element link list, or
b) changing the input data PROLOG-facts to the Expert systems.

2. APPLICABLE DOCUMENTS

The following specifications, standards and drawings of the exact issue shown form a part of this specification to the extent shown herein. In the event of conflict between the referenced document and this specification, the contents of this specification shall be considered a superseding requirement.

2.1. PRASA and Transnet documents.

2.1.1. Required Operational Capability for Axle Counter Systems for PRASA

2.1.2. URS for Level Crossing Protection System for PRASA.

2.1.3. URS for Level Crossing Protection Crossing Interface for PRASA.

2.1.4. PRASA Catalogue of Indications for Interlocking

2.1.5. The Train Working Rules of PRASA.

2.2. Interface Control Documents ICDs.

2.2.1. URS Universal Foreign Interlocking to EI Interface for PRASA Application.

2.2.2. User Requirement Specification for EI interface to a Siemens Key Release Instrument for the use in Passenger Rail Agency of South Africa (PRASA)

2.3. Standards.

2.3.1. Code 736i for type N and C signalling safety relays.

2.4. CENELEC standards:

2.4.1. EN 50121-4 Railway applications – Electromagnetic compatibility (EMC) – Signalling and communications.

2.4.2. EN 50125-3 Railway applications – Environmental conditions for equipment – Signalling and communications.

2.4.3. EN 50126 Railway applications – The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS).

2.4.4. EN 50128 Railway applications – Software for railway control and protection systems.

2.4.5. EN 50129 Railway applications – Safety related electronic systems for signalling.

2.4.6. EN 50159-1 Railway applications – Signalling and communications – Safety-related communication in closed transmission systems.

2.4.7. EN 50159-2 Railway applications – Signalling and communications – Safety-related communication in open transmission systems.

3. GENERAL REQUIREMENTS

3.1. Safety approval

3.1.1. The EI must be approved by a reputable railway safety authority/independent assessor accredited by CENELEC such as the "Deusche Bundes Ampt"; "Office of TÜV; etc. as complying with a Safety Integrity Level 4 (SIL4) as described in the CENELEC Standard EN 50126 - Railway applications – The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS).Chapter 4.2.14 "Fail-safety requirements" applies.

3.1.2. The safety case for all the components: Interlocking safety core processing; Element controllers/vital I/O; FSDTs and Configuration tools/procedures/control/databases must be supplied with calculations of probabilities of wrong side failures per component where applicable, so that overall calculation of safety level for a specific installation can be calculated.
The sum of all the probabilities of wrong side failures of all the components in one signalling installation that can be simultaneously actively involved in train movements must be lower or equal to SIL 4.
The time period for which these probabilities were calculated must also be stated so that necessary replacement period of the system, to stay within the safety case, is clearly known.

3.1.3. Letters of approval for all components will be given to PRASA Technology Management and examples of above-mentioned overall calculation of safety level for a specific installation.

3.1.4. Generic interlocking core software, after approval/validation, must not be able to be modified during application configuration by unauthorised persons. There must exist safety precautions in hardware or software to prevent mismatched software to hardware to be loaded, being it configuration or version differences.

3.1.5. A software configuration program must exist with which it is possible to compare at program line level/configuration level and determine the configuration or version differences referred to above. This configuration control program must also act as a configuration control of the programs of already installed installations.

3.2. Reliability approval

3.2.1. An availability figure must be calculated for a pilot installation in South African environmental conditions over a period of at least one year for final approval.

3.2.2. If a single processor is used for the electronic safety platform the option of a hot standby second processor must be possible.

3.3. System definition:

The system consists of a user interface where requests are fed in and indications are displayed. The user interface is connected via a serial communication channel to one central or more station interlocking systems that interlocks and controls the different outside signalling elements via various vital interfaces. The PRASA Catalogue of Indication document must be used.

3.4. Interface Requirements:

3.4.1. The main interlocking and the outside Field Element Controllers must be connected by medium-independent failsafe data transmission systems (FSDTs) (Distributed topology).

3.4.2. The EI must be able to interface with adjacent free wired interlocking systems the following interlocking systems:

3.4.2.1 Route based relay interlocking system,

3.4.2.2 Spoorplan type geographic based relay interlocking systems,

3.4.2.3 Hybrid interlocking systems with non-vital functions in PLC logic and vital functions/interfaces in geographic based relay circuitry

3.4.2.4 and other electronic interlocking systems (Siemens Sicas S7). See User Requirement Specification in item: 2.2 Interface Control Documents ICDs above.

3.4.3. It must be possible to interface to the existing non-vital remote-control systems. If the EI can interface to a failsafe remote control and VDU display system, it will be an advantage in handling the emergency command interlocking override functions.

3.4.4. The EI must be able to communicate via a non-vital serial bus with either the Siemens Simatic S7 PLC or the GEC Alspa PLC.

3.4.5. The electronic interlocking of two adjacent stations must be able to be connected through a serial vital channel connecting the interlocking systems in effect together or/and a standalone absolute line block (see item 4.2.9).

3.4.6. The element controllers/interfaces for all elements used on PRASA/TFR lines must either exist or it must be possible to be developed. Tail cables between object controllers and elements are still acceptable but if these cables can be shortened or even eliminated, it would be a big advantage:

3.4.7. The interfacing to the various types of the following objects/elements utilised in PRASA/TFR signalling/authorisation systems must be possible:

3.4.7.1 Signals

a) 3 Aspect, Multi-aspect: flashing or multiple globes in some instances with route or turnout indicators.

b) LED Cluster based 3 Aspect, Multi-aspect: flashing or multiple light units in some instances with route or turnout indicators.

c) The flashing must be vitally and continuously monitored to be 1 Hertz – 500 mil-seconds on (with a tolerance not more than 700 mil-seconds) and 500 mil-seconds off (with a tolerance not less than 300 mil-seconds)

d) The vital detection (SIL4) of which aspect is currently displayed on a signal and continuously monitored. This is used in aspect steering, flank/head protection, dark signal detection and non-vital indications.

e) Degrading to a lower aspect or basic default aspect when called aspect fails (distant signal's default aspect is yellow). Detection when a lower aspect than was called is displayed. Detection when a specific globe/LED cluster has failed. (See Annexure B).

f) The continuous proving of one light of an aspect being displayed in the activation of a second light in the aspect. For example the first yellow in the activation of the second yellow with a double yellow aspect, the first yellow in the activation of the green aspect with a green over yellow aspect, the red aspect with the activation of the B-signal/C-signal/U-signal and the removal of the turnout/route indicators when the aspect fails.

g) Detection when signal has been hardware or software initiated passivated and requires technical intervention before rendered

operational again.

h) Filament proving and switching when applicable.

i) Day-night switching of the signal aspects would be a distinguishing feature.

3.4.7.2 Points-sets

a) Three wire or two wire AC immune 110Volt DC and/or 380 3Φ 50Hz AC throw power.

b) Single and Double slips.

c) Electrically and mechanically compounded sets.

d) Points-set detection with positive mid-stroke detection (SIL 4).

e) Crank handle manual operation with Crank Key mechanism installed on the points-set.

f) Local control panels for local control points-sets in local control shunting areas.

g) Emergency points throw with high integrity emergency function initiation.

h) Diamond crossings.

i) Key release for Key points, Power keys and Auto shunting – see URS ICD under Item 2.2.

j) High speed turnouts with multiple drives/machines with positive mid-stroke detection.

3.4.7.3 Level Crossing Protection Controller (LCPC).

3.4.7.4 The Level Crossing Protection Controller must be approved against Required Operational Capabilities for Axle Counter PRASA train operation and PRASA URS for LCPS.

a) Stand alone LCPC with its own train detection triggering system starting protection sequence with only full protection in place confirmation to the interlocking.

b) Stand alone LCPC with interlocking request starting protection sequence and with full protection in place confirmation to the interlocking.

c) The interlocking interfaces directly to the normal objects/elements that a LCPC consists of with the functionality described in "URS for Level Crossing Protection Controllers for PRASA".

3.4.7.5 Train detection

3.4.7.6 The axle counter system must be approved against Required Operational Capabilities for Axle Counter PRASA train operation.

a) Track sections with and without points-set. Track sections with multiple points-sets.

b) Track sections over diamond crossings, double slips and single slips.

c) The approved train detection systems that must be interfaced to are:

i) Axle Counters by serial communication fail safe data transmission (FSDT).

ii) Three detection state must be reported to the train control system, occupied, unoccupied and undefined/disturbed.

iii) Reset Inhibition indication of the Axle counter must be reported to the interlocking VDU.

iv) The emergency Reset Restriction removal command and Axle counter section reset command shall be provided from the interlocking VDU.

d) Track circuits:
Jeumont; ML; DC-tracks, etc.

e) When the interlocking has two adjustable delay times after which the train detection system has respectively indicated the section occupied and vacant before the interlocking reacts respectively to the section occupied and vacant state, it will help to reduce the effect of bobbing track circuits, varied response times of adjacent different train

detection systems and a fast short train on sequential train normalisation.

3.4.7.7 Fail Safe Data Transmission – (FSDT) systems:

a) If the EI can be utilised as a cost effective stand alone FSDT system to transfer the necessary bits over optical fibre to eliminate the existing copper block lines between stations between the Mk1, 1b and 1c block units, it will be a distinguishing feature.

b) If the EI's line block can be utilised to eliminate the above mentioned block units it will even be a better solution.

c) The EI must be able to interface with failsafe parallel I/O with the following FSDTs already approved:

i) The FSDT part of the Siemens AzSM(R) and AzS350U.

ii) The FSDT part of the Frauscher ACS2000 axle counter systems.

iii) Thales Vital 21 FSDT system.

3.4.7.8 Cab Signalling.

a) The step to Cab signalling/CBA becomes seamless when the electronic interlocking's safety core and configuration/tools are:

i) Object Orientated.

ii) Geographically based.

iii) True speed signalling with discrete speeds allocated to integers in the objects.

b) When the electronic interlocking's safety core and configuration/tools are route oriented and control sheet based it is not suited to control Cab signalling/CBA.

3.4.7.9 Train protection.

a) Automatic train-stop.

b) Automatic train protection.

c) Non vital driver vigilant systems.

3.4.7.10 Information systems

a) Remote accessible management information systems.

b) Remote accessible maintenance diagnostic and information systems.

c) Remote accessible technical performance analysis tools.

3.4.8. The hardware structure of the EI must be modular with the safety platform, used for the main interlocking and area controllers, equipped with a local Fail Safe Data Transmission (FSDT) bus connecting microprocessor modules, interfaces to FSDT field busses, voting modules, element controllers, etc together. This is important to enable obsolete and re-engineered modules to function together and in so doing the life span of the interlocking system is lengthened. The addition of new element controllers (new element or element interface) or field bus interface (new field bus) is simplified.

3.4.9. The need exists at existing Relay and Hybrid interlocking systems to eliminate the existing multi-core copper main cables and incandescent lamps while retaining the relay or hybrid interlocking. The functionality of this is described in "Required Operational Capability for Distributed Element Control System (DECS) for TFR Relay/Hybrid Interlocking systems to Eliminate Copper Main Cables" – BBD5569 version 1 of January 2009.

3.5. It must be possible to build into the generic software of the EI PRASA's/TFR's signalling philosophy, principles and signal aspects.

3.5.1. The software must be geographic and generic rule based or geographic and object orientated.

3.5.2. Software route based and functionally/control sheet based written will not be considered.

3.5.3. This is required to reduce testing time at commissioning and later modifications.

3.5.4. This is required to reduce the number of people with expert knowledge involved in a station commissioning to ensure the safety level and standardisation.

3.5.5. The geographic and object orientated software is preferred because it simplifies modifications to functionality (modify one generic program) or infrastructure (removing elements by removing relevant data blocks of elements and updating link lists) changes.

3.6. The life cycle cost of an electronic interlocking (EI) must be less than an equivalent hybrid interlocking.

3.7. The EI must have a PC based graphical configuration tool to enable the configuration of an interlocking for a specific station layout and control sheet.

3.7.1. When the configuration of the EI for a specific station can be automated by a program using the output files of the Front sheet/Element connection diagram of a CAD program it will be a distinguishing factor.

3.7.2. The debugging of the configuration of the EI for a specific station can be automated by a program, but not the final verification/validation tests.

3.7.3. When the debugging testing of a configured EI for a specific station can be automated by a program it will be a distinguishing factor. The final commissioning configuration checking and tests must be done manually by competent persons.

3.7.4. If the EI includes an event recorder with play back facilities it would be a distinguishing feature.

3.8. Maintenance and Diagnostic tools:

3.8.1. The EI must have a maintenance terminal that can be remotely accessible (Ethernet network) PC based diagnostic system with which the variable state and fixed configured state of any element (Object) at any station at any given moment can be monitored. Query files to monitor and log one or more elements (Objects) for a prescribed time period must be able to be set up.

3.8.2. The EI must log all hardware and software initiated passivations and any other event that caused a component to revert to a fail-safe state and requires a safety requirement/function to get the specific component operational again.

3.8.3. The logging of most of these events to retentive memory is required to ensure that the event will be retained after a power failure when the necessary safety requirement/function to get the specific component operational again has not yet been activated when the power failure occurred.

3.8.4. The EI must log all communication failures occurring on the FSDTs between the main interlocking and all area controllers or other adjacent interlocking systems.

3.8.5. Diagnostic programs logging the faults that occurred before the component element/object went to a fail-safe state (hardware or software passivated) is essential to eliminate some of these faults that causes unnecessary train delays.

3.8.6. If the EI includes an event recorder with play back facilities it would be a distinguishing feature.

3.8.7. SPAD detection and logging of conditions when SPAD occurred can help in determining severity of SPADs, false SPADs, etc.

3.8.8. Logging of right-side failures will assist in determining reliability/availability performance of EI system in South African conditions, which is needed for final approval of EI.

4. Operational Requirements:

4.1. User interface (Panel or VDU controls and indications):

The PRASA Catalogue of Indications for Interlocking document shall be used to indicate or display all the necessary indications of the interlocking elements or Signalling System Indications to the HMI/VDU.

4.1.1. Read all requests of the train control officer:

4.1.1.1 Translate route and overlap requests by the TCO into defined/configured routes and overlaps.

4.1.1.2 Set defined routes and overlaps as requested by TCO. Reject conflicting and opposing route requests to existing set routes, overlaps.

4.1.1.3 Automatic calling of predefined default routes and overlaps.

a) When only one route and/or overlap exist they must be selected automatically when the signal is called.
b) When the route is selected, and the signal is called without selecting an overlap or next route the default defined overlap must automatically be selected.
c) When the route is already selected and alternative overlaps are possible, the selection of an alternative overlap or next route with alternative coinciding overlap must first take place before the signal is called.

4.1.1.4 Define and set of alternative routes between the same starter and destination signals.

4.1.1.5 Selecting between shunt and main signal/route request (AG/BG functions).

4.1.1.6 Initiate the temporary replacement to danger without unlocking any of the elements (RG function).

4.1.1.7 Key release request for Key points-sets (E-points-sets), power keys, auto shunting, local control, etc.

4.1.1.8 With all the following emergency commands “with higher integrity” means at least SIL2 level and “preferably vital” means SIL3 or SIL4 level as described in the CENELEC Standard EN 50126 - Railway applications – The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS).Chapter 4.2.14 “Fail-safety requirements” applies.

a) When the VDU/interlocking does not already make provision for higher integrity emergency functions and element specific bits are possible between the VDU and interlocking the following state machine/hand shaking sequence must be followed to ensure the necessary emergency command integrity:

i) The VDU must send an element specific selection control bit to the interlocking as the initiation of the emergency function. The interlocking must then respond with an element specific selection indication bit only after proving that only one of these types of elements is selected, this element is not already involved in an emergency function and none of the following element specific bits are already TRUE. The element specific indication bit will then uniquely identify the selected element to be involved in the emergency function on the VDU. With elements with more than one emergency function possible (signals, points-sets, etc.) these element specific selection control and indication bits can be shared between emergency functions.

ii) The TCO must then on the VDU again select the same element that is now uniquely identified right click and select the emergency function to be performed on this element. The VDU must then send an element and emergency function specific conformation bit to the interlocking. With the axle counter reset emergency function a window for the TCO to fill in its details (time and date stamped) is first opened and when the TCO has completed this, the mentioned conformation bit is sent by the VDU. The interlocking must then respond with an element and emergency function specific conformation indication bit only after proving that only one of these type of elements is selected, it is the same element as was selected during the selection phase, this element is not already involved in an emergency function and none of the following element specific bits are already TRUE.

iii) When the VDU receives this element and emergency function specific conformation indication bit it must open a window to log the TCO details (time and date stamped) with all emergency functions or the Chief TCO's details (time and date stamped) when busy with an axle counter reset emergency function. When the

TCO or Chief TCO (axle counter reset) has completed filling in the window and closed it the VDU must send out an element and emergency function specific control activation bit. When the interlocking receives this element and emergency function specific control activation bit it must after proving that only one of these type of elements is selected and confirmed, it is the same element as was selected and confirmed during the selection and confirmation phases, this element is not already involved in an emergency function and none of the following element specific bits are already TRUE activate the emergency function requested on the requested element and respond with an element and emergency function specific indication activation bit to the VDU. The VDU can abort the emergency function after receiving the element and emergency function specific indication activation bit from the interlocking.

iv) When the TCO wants to abort the emergency function at any time during the above described sequence he selects any other element and the VDU must remove all control bits already marked for the initiation of the emergency function. The interlocking must follow suite and abort emergency function initiation.

v) When during the sequence any proving on the interlocking side fails any indication bits already marked for the initiation of the emergency function. The VDU must follow suite and abort emergency function initiation.

b) Initiation of emergency functions, if a non-vital remote control is used, must conform to "Emergency CTC operations for the HR97 interlocking" no. BBB0187 latest version only when a desk and diagram is used where only one element specific bit exists and the key and common push button is only operation specific. The parallel ASCI message is brought in to increase the integrity under these circumstances

4.1.1.9 Blocking of a point set so that it cannot be electrically thrown and a conflicting route/overlap setting not possible, but route/overlap setting that requires points-set. The detection of the point set being blocked is also proven. Unblocking of such a points-set is an emergency command with higher integrity preferably vital and always recorded.

4.1.1.10 Blocking of a track section against traversal so that a route over it can't be set and signal reading over it cannot be cleared, as required for occupation purposes. Unblocking of such a track section is an emergency command with higher integrity preferably vital and always recorded.

4.1.1.11 Blocking of a signal to be used as a starter signal so that a route from this signal cannot be set and it cannot be cleared for any route that it will normally give access to. Unblocking of such a signal is an emergency command with higher integrity preferably vital and always recorded.

4.1.1.12 Blocking of a signal to be used as a destination signal so that any route leading up to this signal as destination signal cannot be called. Unblocking of such a signal is an emergency command with higher integrity preferably vital and always recorded.

4.1.1.13 Initiation of normal route/overlap cancellation that under certain conditions takes place immediately.

4.1.1.14 Initiation of emergency route/overlap cancellation, as required when route/overlap is in the final defined state, is an emergency command with higher integrity preferably vital and always recorded.

4.1.1.15 Initiation of emergency points throwing is an emergency function high integrity preferably vital and always recorded.

4.1.1.16 The reset of a cranking key release is an emergency function high integrity preferably vital and always recorded.

4.1.1.17 The reset of an axle counter section (traditional override reset) an emergency function high integrity preferably vital and always recorded.

4.1.1.18 Initiation of the release of an emergency signal high integrity preferably vital and always recorded.

4.1.1.19 Through routing for predefined routes

4.1.1.20 Automatic route calling in front or at the back of the train triggered by train detection.

4.1.2. Display all indications that reflect the state of the interlocking and outside equipment.

4.1.2.1 Point's detection, locking, blocking and route/overlap definition indicated in unoccupied and occupied state. It's a non-vital function.

a) Points-set element:

i) KRK: No detection AND/OR Associated crank key turned. When no detection on a points-set, the pivot UK OR with section occupied pivot TK must be flashing.

ii) TK (pivot): When axle counter/track circuit section over points-set's interface is faulty/passivated AND/OR occupied.

iii) When there are more than one points-set in the same track section and a route has been set through the track section not containing all these points-sets, only the points-sets in the route must display TK indications when the section becomes occupied. When no route exist through the track section all points-set TKs must be displayed.

iv) TK+: All TK conditions OR KLS request with section occupied AND having plus (right) detection (points-set has got call and detection correspondence and is being monitored) AND NOT KRK.

v) TK-: All TK conditions OR KLS request with section occupied AND having minus (left) detection (points-set has got call and detection correspondence and is being monitored) AND NOT KRK.

vi) UK: Set of Points belongs to an actual set/locked/define state route/overlap that is under processing AND has proven detection (points-set has got call and detection correspondence and is being monitored) and must be displayed until route/overlap is cancelled or points-set is normalised by train normalisation.

Points-set has a hand-call on AND has proven detection (points-set has got call and detection correspondence and is being monitored) and must be displayed until the hand-call is normalised.

vii) UK+: All UK conditions OR KLS request AND having plus (right) detection (points-set has got call and detection correspondence and is being monitored) AND NOT KRK.

viii) UK-: All UK conditions OR KLS request AND having minus (left) detection (points-set has got call and detection

correspondence and is being monitored) AND NOT KRK.

ix) When a route or overlap was set only the displayed UK's in the route or overlap must be turned to TK's whenever the track sections become occupied.

x) The pivot UK/TK and +UK/+TK or –UK/-TK indications (as described above) for all four points-sets involved in a double-slip must be displayed.

xi) The pivot UK/TK and +UK/+TK or –UK/-TK indications (as described above) for both points-sets involved in a single-slip must be displayed.

xii) A steady +UK or -UK must be generated when a plus or minus call (route, overlap or manual) with respective plus or minus detection is proven. A steady pivot UK is always displayed with a steady +UK or –UK indication except when a KLS request is received then only the relevant +UK/-UK is displayed on its own.

xiii) When a points-set has lost detection the last called requested UK+/- must flash blue (COPK/COMK) until the last requested detection has been proven.

xiv) When a hand-call is active on a points-set that has lost detection the above mentioned UK+/- flashing blue (COPK/COMK) must be removed until the hand call has been removed.

xv) LK (Points locked): When points-set is locked in Route AND/OR Overlap a white lock light is displayed.

xvi) When the points-set's associated crank handle has been released yet reset, the yellow arrows around point set icon must be displayws must be displayed.

xvii) FSK: When points-set is locked in Flank protection AND/OR Head Protection the same white lock light as above is displayed.

xviii) LFK/WBK: When a points –set is locked (route and/or overlap and/or flank) a steady lock indication must be generated. LFK: When this points-set was also blocked against traversal, this same lock indication must be flashing. With the removal of the

block on the points-set, the lock indication must change from flashing to steady.

The WBK can, instead of the LFK also be used for points-set blocked against traversal; it displays a purple block around the lock light of the points-set.

xix) WFK: When a derailer, catch points-set or run-away points-set is not detected in the protection direction or has lost detection the two red lights next to it must flash red.

xx) PASK: Hardware initiated passivation of the Points-set interface AND/OR Points-set's Track vacancy system (Axle counter/track circuit) interface. The points-set can not be used without technical intervention outside – red flashing light next to lock light is displayed.

xxi) PFK: Software initiated passivation (points-set trailed, etc) of the Points-set interface AND/OR Points-set's Track vacancy system (Axle counter/track circuit) interface. The points-set can not be used without acknowledging the fault in the safety core program – a steady red light next to lock light is displayed.

xxii) When any other fault mode is present (Lost detection, Not completing stroke, Machine not drawing current when called, etc) on the points-set except the above mentioned two (PASK AND/OR PFK) a steady yellow light is displayed next to the lock light.

4.1.2.2 Shunt and main signals cleared, at danger or dark.

a) Signal element:

i) RGK: [KLS request AND NOT a distance signal OR Signal called and did not clear OR B-signal on main signal called OR C-signal on main signal called OR U-signal on main signal called] AND Red aspect proven on signal AND NOT Red Aspect fault AND Actual aspect monitored (no other fault modes on signal).

A signal called until it clears OR C Signal OR B Signal called into a yard and route call on points-set providing protection out of the

yard is pending until the berth track of the signal becomes occupied.

ii) HDGK: Signal cleared to a running aspect higher than single yellow (flashing yellow/double yellow; flashing green/green over yellow and green) AND applicable aspect displayed proven on signal AND NOT applicable aspect fault AND actual aspect monitored (no other fault modes on signal).

iii) HGK: KLS request AND Distance signal OR Signal cleared to a single yellow running aspect only AND Yellow aspect displayed proven on signal AND NOT Yellow Aspect fault AND Actual aspect monitored (no other fault modes on signal).

iv) WGK: White light called AND white light displayed proven on signal AND NOT white light fault AND Actual aspect monitored (no other fault modes on signal).

v) BGK: Shunt/B-signal aspect called on signal AND shunt aspect displayed proven on signal AND NOT shunt aspect fault AND Actual aspect monitored (no other fault modes on signal).

vi) CGK: C-signal aspect called on signal AND 2nd yellow light displayed proven on signal AND NOT 2nd yellow light fault AND Actual aspect monitored (no other fault modes on signal).

vii) UGK: U-signal aspect called on signal AND U-light displayed proven on signal AND NOT U-light fault AND Actual aspect monitored (no other fault modes on signal).

viii) EGK: Emergency signal aspect called on a signal part of a multi-aspect multiple light aspect system AND Blue-light displayed proven on signal AND NOT Blue light fault AND Actual aspect monitored (no other fault modes on signal).

ix) ECK: LED clusters used no filament switching ECK permanent high.

When incandescent lamps are used with filament switching, the ECK of a signal is TRUE whenever all the lights constituting the aspect that is displayed are burning their main filaments AND when the signal has route/turnout indicators the route/turnout

indicator displayed is burning the required number of lamps. When the above requirements are not met the ECK must become FALSE and the red/yellow/green indication on the VDU, which one relevant at the time, will flash.

In some interlocking systems the ECK also becomes FALSE when the aspect displayed is a lower one than was called. For example: a single yellow when a double yellow was called; single yellow when a green over yellow was called; etc.

x) JK Cancellation delay time in progress at this signal: When an "Emergency route cancellation" is in progress at this signal OR When an "Emergency overlap cancellation" is in progress at this signal OR When delayed overlap normalisation is in progress at this not cleared destination signal with train normalisation.

xi) LK: Signal is the destination signal of a route AND/OR the start signal of an overlap in the defined state (white lock light at signal).

RSE: Signal is the destination signal of a set or locked route AND/OR the start signal of a set or locked overlap (yellow lock light at signal).

With interlocking systems where the initiation of route and overlap cancellation is at the destination signal, this LK identifies the signal where the cancellation must be initiated and the colour: yellow normal cancellation or white emergency cancellation, the cancellation possible.

LK: With some interlocking systems the signal elements in route and overlap are also locked when the start signal is cleared. White lock lights are displayed at the route start signal, opposing signal in the route, destination signal and opposing signal in the overlap.

xii) LGK: The signal is blocked against using it as a starter signal OR as a destination signal – purple block displayed around signal icon.

xiii) FGK: Software initiated passivation (software discrepancy/safety test has failed) of the signal interface. The signal can not be used without acknowledging the fault in the safety core program – a steady red fault light next to the signal is displayed.

xiv) PASK: Hardware initiated passivation of the signal interface AND/OR Red aspect/Basic aspect has failed. The signal can not be used without technical intervention outside – red flashing fault light next to signal is displayed.

xv) When any other fault mode is present (Lamp/cluster has failed and aspect has been degraded because of this, route/turnout indicator has failed with LED cluster aspects, etc) on the signal except the above mentioned two (PASK AND/OR FGK) a steady yellow fault light is displayed next to the signal light.

4.1.2.3 Crank key release indications:

a) Crank key element:

i) Crank Key released: When the crank key has been released by the TCO – the point detection monitored and yellow arrows around the points-set element indicated.

ii) Crank key released and Key turned IN: When the crank key has been released by the TCO and key has been turned – the points detection lost, last call indication and yellow arrows around the points-set element indicated.

iii) Crank key released and Crank Key turned OUT: The crank key has been turned out from out key instrument – the point detection monitored and yellow arrows around the points-set element indicated.

iv) When the crank key is out and the crank key release reset has been issued by the TCO– the crank released state is removed immediately, the yellow arrows around the point-set element indication removed and points detection indicated.

4.1.2.4 Track circuit element locked (direction if applicable) or blocked:

a) Track element:

i) TK: When axle counter/track circuit section interface is faulty/passivated AND/OR occupied.

ii) UK: Track section belongs to an actual set/locked/define state route/overlap that is under processing and must be displayed until route/overlap is cancelled or track section is normalised by train normalisation.

iii) BLK: The track section is blocked – no signal can be cleared/give access to this track section – Purple boxes around both direction arrows underneath track section icon are displayed.

iv) LDIK: The track section is part of a set route/overlap in the left (BA or II direction) – yellow arrow underneath track icon indicates the left direction.

RDIK: The track section is part of a set route/overlap in the right (AB or I direction) – yellow arrow underneath track icon indicates the right direction.

LK: The track section is part of a route/overlap that is locked/in defined state – the applicable yellow arrow indications mentioned above changes to white.

v) PASK: Hardware initiated passivation of the Track vacancy system (Axle counter/track circuit) interface. The track section will stay occupied without technical intervention outside – red flashing of both direction arrows underneath the track section icon are displayed.

vi) TFK: Software initiated passivation of the Track vacancy system (Axle counter/track circuit) interface. The track section will stay occupied without acknowledging the fault in the safety core program –steady red of both direction arrows underneath the track section icon are displayed.

vii) When any other fault mode is present on the Track vacancy system (Axle counter/track circuit) interface except the above mentioned two (PASK AND/OR TFK) a steady yellow of both

direction arrows underneath the track section icon are displayed.

4.1.2.5 Key Release indications:

a) Key Release element:

i) IN: The Key normal – black keyhole icon displayed.

ii) OUT: The Key has been removed/not normal – red keyhole icon displayed.

iii) Release: The release timer to release Key outside is running – white flashing keyhole icon displayed. When the time runs out and the Key was removed the keyhole icon turns red and when the Key was not removed the keyhole icon turns to black.

iv) PASK: Hardware initiated passivation of the Key release/detection interface. The Key will stay not normal/OUT without technical intervention outside – red flashing light next to the keyhole icon is displayed.

v) KFK: Software initiated passivation of the Key release/detection interface. The Key will stay not normal/OUT without acknowledging the fault in the safety core program –steady red light next to the keyhole icon is displayed.

vi) When any other fault mode is present on the Key release/detection interface except the above mentioned two (PASK AND/OR KFK) a steady yellow light next to the keyhole icon is displayed.

4.1.2.6 Overall-lock Block indications:

a) Block element:

i) Flashing yellow arrow at the departure station in the departure direction while the block is calling request.

ii) Flashing yellow arrow at the arrival station in the arrival direction while the block is calling request.

iii) Steady yellow arrow at the departure and arrival station when the block is locked at departure end of block.

iv) Steady white arrow when the block has been entered (track occupied, route lock inside the Absolute line block section.

v) There shall be emergency overall lock cancellation to cancel the Overall-lock when any track is down or faulty but not locked.

4.1.2.7 Level crossing indications.

4.2. Interlocking Functions:

4.2.1. Route and overlap definition:

4.2.1.1 Valid route and overlap determination (prevention of alternative non-valid routes or overlaps; overlap only valid if associated with a valid route).

4.2.1.2 No route or overlap prevention when one or more track circuits in the requested route are occupied or points-set/s is/are blocked in the required detection state.

4.2.1.3 Points-set in the trailed state-SM3 or other passivation states (stroke not completed-SM6, unauthorised cracking-SM5, or hardware passivation-SM0) must still allow route setting over them.

4.2.1.4 The OLDz function as the only valid overlap running into a yard.

Head protection for an overlap towards a non-signalled yard can only be obtained from a derailer on the rail, catch points and run-away points-set all head protecting against rail vehicles running out of the non-signalled yard. A signal reading out of the yard can never provide head protection for an overlap towards the non-signalled yard.

The setting of the route into the non-signalled yard, removing the above mentioned protection, must only be allowed when the berth track section of the signal reading into the non-signalled yard is proven occupied and the shunt or C-signal into the yard on this signal has been called.

4.2.1.5 Alternative route or overlap selection with alternative buttons.

4.2.1.6 Route selection to be able to reach a locked element with emergency route cancellation.

4.2.1.7 Allow route selection over key points not detected.

4.2.1.8 No route or overlap selection allowed over points sets with crank key released or Disabled state.

4.2.1.9 Translate the route and/or overlap request.

a) Determine points-sets and track sections involved.

b) Determine direction that points sets must be thrown.

c) Selection of alternative routes must be available.

d) Where only one route or/and overlap is available, these should be automatically selected with the clearance of the signal.

e) When the route is selected, and the signal is called without selecting an overlap or next route the default defined overlap must automatically be selected.

f) An overlap may not be called without the route up to it first being called.

g) The overlap setting shall be rejected if the is an existing overlap already.

h) A zero overlap may at any time be extended to a normal overlap if the conditions allow it.

i) The extension of zero overlap shall only be possible if the zero overlap is not yet established.

j) A normal overlap shall never revert to a zero overlap.

k) Where an overlap is requested into a protected non-signalled yard, the overlap must end in a points-set or derailer affording protection and not an opposing signal.

l) When the route is already selected and alternative overlaps are possible, the selection of an alternative overlap or next route with alternative coinciding overlap must first take place before the signal is called.

m) When manual overlap is set for a route without a type the main route overlap is set. When a B-signal is cleared it will not be shortened if B-overlap was shortened.

n) When a follow-on route already exist the setting of a manual coinciding overlap must be possible.

o) When a following route is called from the destination signal instead of an overlap, a coinciding overlap must be automatically established when the starter signal is cleared. When the following route is set after the overlap was cancelled, the coinciding overlap must be automatically established when the starter signal is cleared.

p) The definitions of a main aspect and a shunt aspect overlap for the same destination signal can differ, main route configured with overlap and B-route without.

q) Where no overlap is called and the destination signal is configured for a zero-overlap, this zero-overlap should be automatically selected with the clearance of the signal. Zero-overlap always default overlap.

r) Configuration to allow or disallow an opposing overlap to a zero overlap must be possible.

s) When a route is set for a C-signal into a non-signalled yard with more than one entry point from the signalled area the destination signal at the opposite end of the non-signalled yard of this set route for a C-signal is not allowed to be a starter signal of a route reading out of the non-signalled yard.

t) When a signal reading out of a non-signalled yard is a starter signal for a route reading out of the non-signalled yard it must not simultaneous be allowed to be the destination signal of a route for a C-signal reading into the non-signalled yard.

u) It must be possible to configure for a main route not to require an overlap to cater for the situation of a main route into a dead end with a permanent red signal as destination.

v) When a route has been entered (final defined state: yellow, blue or green) a manual overlap and coinciding overlap, by setting a following route must be set that immediately goes into the final defined. Not applicable to emergency route.

w) When a complex layout of point-sets are connected to the bases of a number of signals the following rules must be applied to make this problematic layout and problem signals (the signals with a points-set connected to its base) safe:

i) Any Route from the Problem Signal cannot be cleared until a

feeder Route with the Problem Signal as destination signal has already been set.

ii) When the feeder Route set to the Problem Signal as the destination has been cancelled the Problem Signal must be replace back to danger.

iii) The Aspect on the Problem Signal must be limited to the yellow aspect if the interlocking is not requesting most restrictive aspect than yellow.

4.2.1.10 Axle counter Reset of a section still locked in Route or Route and Overlap must be inhibited/restricted until locking is cancelled off.

a) Route being entered all the occupied axle counter sections must be Reset restricted irrespective of in-count inhibit is active or not.
b) When the emergency Route cancellation has been completed – the true in-count inhibit active or not must become apparent on each section occupied.
c) The train normalisation when axle counter sections are reset in the correct train movement direction will also be prevented.
d) The Route section must be declared vacant of trains before the Emergency Route Cancellation is done.

4.2.1.11 Check if all elements in route and/or overlap are available

a) No conflicting or opposing routes and/or overlaps.

b) None of the elements in the requested route and/or overlap already locked.

c) No track sections or points-sets blocked against traversal.
d) The starter signal of route not blocked to be a starter signal.

e) The destination signal of route not blocked to be a destination signal.

f) Intermediate shunt blocked as starter – allow route to be set over it.

g) When signal providing flank/head protection it cannot be used as a starter signal.

h) When points-set in the release for cranking state – route set over rejected.

4.2.1.12 Call points in the route and/or overlap in required direction (route and overlap setting).

a) Conflicting calls on a point set must be interlocked.

i) Manual calls must be interlocked.

ii) Conflicting route and overlap calls must be interlocked.

iii) Conflicting manual calls must be interlocked with route and overlap calls.

iv) If a conflicting manual call, route call or overlap call to the requested route call exist, the other points-sets in the requested route must not be thrown.

v) Route/overlap calls on points-sets can override flank and head protection calls.

b) There must be a distinction made between an individual manual, route, overlap and flank/head protection call on a points-set.

c) Point machines operation to be staggered, with the option to have a different staggering philosophy when the standby power is running.

d) Route and overlap calls stay until logic route and or overlap functions are released and with train normalization or cancellation until the element is unlocked.

e) The route and/or overlap calls must stay until either the points set has been traversed (train normalisation) or cancellation of the route and/or overlap has taken place.

f) The power to the points-machine must be disconnected after normal throwing time plus 6 seconds if no detection is made up (Default value 10 seconds).

g) Do not initiate points call when the track section associated with the points set is occupied.

h) Do not initiate points call when the crank key associated with the points set has been released.

i) No route or overlap prevention when one or more track circuits in the requested route is occupied.

j) Allow route setting over key-points not detected.

k) Allow route setting over points-sets blocked against throwing, if the points-sets blocked into the detection position required by the route**.**

l) When the call has been initiated and the associated track section becomes occupied the points set must complete its throw.

m) Where applicable, call a derailer or catch points in the position required to provide protection out of a yard or siding for the end of overlap (OLD function). (Head protection call).

n) The override of an already set flank/head protection call by route call shall be possible where flank/head protection can be shifted.

o) Power to the points-set machine must be disconnected as soon as detection is made.

p) The integrity of the points set position detection circuitry must be proved for each route request.

q) Do not allow route or overlap setting over points-sets with the associated crank key released.

r) When the crank key released the point set cannot provide flank or head protection.

s) When a normal overlap cancellation is running and route to this overlap is re-cleared the cancellation time must be stopped.

4.2.2. Flank protection:

4.2.2.1 Call points sets for flank protection for each of the points-sets set in route and/or overlap

a) All requirements regarding above route call apply.

b) Flank protection for running lines can be obtained either from a points-set or a red signal, however a red signal reading out of a non-signalled yard must never be used to provide flank protection.

Where the compounded set of a key-point is affording flank protection out of a non-signalled yard situated at the base of a signal, the signal must never be used to provide flank protection instead the key-points

detection and key normal should be used**.**

c) When double flank calls exist on a points-set or for any reason, other than an occupied flank track section, the points set cannot give flank protection (e.g. no detection, blocked against throwing in the opposite detection position) flank must be shifted out to the next available element/s which can provide flank protection.

i) The track section of the points-set with the double call or fault/blocked preventing it to provide flank/head-protection, is a flank track section if not part of one of the route sections as well or part of a different route moving away from where flank required.

ii) If the points-set track is part of a parallel route section, it must not act as a flank track section.

d) When a signal that is normally giving flank protection cannot provide flank protection (dark signal, etc.) the further seeking of flank protection at the base of the signal must not normally (as a rule) be allowed. In other words, the logical or real flank calling "Spur" must be stopped or have a configuration to be stopped when entering a signal on its head at its base. This will also ensure that destination track section do not become flank track sections (configurable). This will also ensure that potential start signals are giving flank protection. This will also ensure that in complicated stations the route and overlap setting is inhibited by flank- and head-protection locked points. This will also prevent flank protection calls proceeding to the adjacent station.

e) The shifting out of flank protection as more routes are pulled off and the shifting closer of flank protection as routes are normalised.

f) Proving the integrity of the flank protection for a point set in the route.

g) Facing points set in flank must obtain flank protection from both directions.

i) The track section of the facing points-set is a flank track section if not part of one of the route sections as well or part of a different route moving away from where flank required.

ii) If the points-set track is part of the route section, it must not act as a flank track section.

h) Flank protection must not be called over an occupied track section

unless when occupied because of a valid train movement away from where flank required. When flank protection already established and a flank track section forming part of this flank protection becomes occupied, the flank calls must remain.

Locking flank without proving vacancy of flank track section is not a problem if availability is not negatively affected.

i) When two points-sets in the same route put conflicting flank calls on the same points set, the flank call for the first points set in the route takes priority. (Only applicable when priority flank calls are implemented to resolve priority when double flank calls on the same points-set comes from the same route or overlap)

j) Initiation of flank calls (calls and locks on points-sets and logical calls on signals) must not proceed over track sections with any of the following conditions:

i) Undetected key points.

ii) Key release being given.

iii)Key removed.

k) Once flank protection has been established over this flank track section, and one of the above-mentioned conditions becomes valid, the flank must not be released. (The signal will be replaced but the flank is not released.) The existence of the condition may be reported in the diagnostics as reason for the signal replacing.

l) The override of a flank/head protection call by a route or overlap call (normally revised short overlap).

The shifted-out flank/head protection must first be proven before a point-set involved in flank/head protection is unlocked and called. (If a flank must be shifted out, for new route or different overlap, the new flank/head protection has to be proven first before the older flank/head protection can be released and the points-set used.).

m) Double slip with four points sets, when a logical diamond crossing is not used to connect them together, the two flank points are called to the non flank protection state (a technical solution to achieve the shifting out) to force the shifting out of flank protection. The logical diamond crossing solution is preferred.

n) The override of a flank call by another flank call is not allowed.

o) Flank call priorities will not be implemented on PRASA lines.

p) The flank protection for an emergency signal route and shunt signal overlap is called although not proven.

4.2.2.2 A configuration to allow or not to allow head protection shall be provided.

4.2.2.3 Proving flank/head protection for the route and/or overlap.

a) Flank/Head protection locking only with call/detection correspondence. (Sequence for flank locking: call the points-set, prove detection and lock it.).

b) The flank protection (detection and locking of points sets, red aspect of signal and vacancy of flank track sections) for each points set in the route and/or overlap (except derailers, catch-points and runaway points-sets) must be continuously proven for the duration of the route and/or overlap existence.

c) The head protection (detection and locking of points sets, red aspect of signal and vacancy of flank track sections) for each overlap must be continuously proven for the duration of the overlap existence.

This continuous positive proving of the detection of all the points-sets, vacant flank/head track-sections and the red aspect of signals that give flank/head protection, is vital – SIL4.

If steering is used to transfer the confirmation of this positive proving to the points-sets in the route or overlap, it can be done according to the last detected positions of the points-sets.

Derailers, catch-points, and runaway points-sets do not have a physical flank protection on the unused end.

d) When a track section not part of the route lying between that element/s affording flank/head becomes occupied, flank/head protection to the route is removed except if that track section is part of a parallel route in a diamond crossing element or a route set away from the route requiring flank.

e) The flank/head protection for an emergency signal route and shunt signal overlap is not proven.

f) Only after the points set in the route has been traversed, may the flank protection for it be released.

g) When the points-set in the route is unlocked by means of cancellation or train normalisation the flank protection for it may be released. The same applies to the overlap flank protection.

h) Blocked points-set with correct detection may give flank protection.

i) This applies both to blocked against throwing and blocked against traversal.

4.2.3. Locking and proving of route and overlap:

4.2.3.1 Lock all track elements in the required route and overlap.

a) Locking of the elements in route and overlap commences after the yellow route from start signal to destination signal has been set .

b) Points set must only be locked once called and detection correspondence has been proven.

c) A distinction between route and overlap locking must be made.

d) All track elements in the route and overlap must be locked in the direction of the train movement to prevent reverse end cancellation. (Train normalisation and TCO operation).

e) Two adjacent track elements must not be locked in opposite train movement directions.

f) No locking of elements in a route is allowed if one or more elements in the set route is already locked or blocked against traversal.

4.2.3.2 The fail-safe proving of the route definition and protection before a proceed signal aspect is displayed.

a) The steering of the fail-safe proving must be done according to the points-sets detection.

b) Proving the start signal normal (displaying a red aspect and not dark).

c) Proving that all the points in the selected route and overlap are called and detected in the correct position and are locked in the train movement direction. As required for main, shunt and goods-and-siding aspects respectively.

d) Proving that for a main aspect all elements in the selected route and overlap (points-sets, double slips, single slips, diamond crossings, etc.) have obtained their required flank protection.

e) Proving that for a shunt aspect all elements in the selected route (points-sets, double slips, single slips, diamond crossings, etc.) have obtained their required flank protection.

f) An emergency aspect needs no overlap, no opposing signal or flank proving in the route.

g) Proving that all track elements in the selected route and overlap are locked in the train movement direction. As required for main, shunt and goods-and-siding aspects respectively.

h) Where the selected overlap ends in an opposing signal, this signal must be proven normal (displaying a red aspect and not dark – head protection).

i) The destination signal must be proven normal (displaying a red aspect and not dark) or has proven the necessary interlocking for displaying a main proceed aspect.

   i) When the start signal is cleared to a main aspect the destination signal must not display a shunt aspect.

   ii) When the start signal is cleared to an emergency aspect the destination signal must not also display an emergency aspect but may be red, dark or display any proceed-aspect.

   iii) When the start signal is cleared to a shunt aspect the destination signal may be normal (displaying a red aspect and not dark) or display any proceed aspect.

j) The proving that the route and overlap track-sections are unoccupied. As required by a main, shunt and goods-and-siding aspect respectively.

   i) For a main aspect, all track-sections up to and including the end of

overlap element, must be continuously proven vacant.

ii) For a shunt aspect, all track-sections up to and including the end of route element, must be continuously proven vacant.

iii) For an emergency aspect, the track-section vacancy is not required.

iv) Shunting onto an occupied destination track-section (track-down-shunting) must be configurable. (The default is that track-down-shunting is not allowed. It depends on the need of the user.) In this case no overlap is required.

v) Simultaneous shunting from opposite directions onto the same occupied destination track-section not permitted.

vi) When the shunt signal has been cleared onto the occupied destination track section and the section becomes unoccupied (overlap required) the shunt signal must replace.

vii) When a shunt and/or C-signal is cleared into a not signalled yard/siding, the track sections up to the opposing signal reading out of the yard/siding must be proven vacant.

k) If key-points exist in the selected route or overlap, the points detection and key release instrument must be proven normal.

4.2.3.3 Clearing a signal onto a zero-overlap:

a) Zero-overlap route and signal release delay time activation:

i) When the normal route proving has taken place,

ii) Approach track-section leading up to zero-overlap route is occupied,

iii) and the signal leading up to the zero overlap has been called.

b) The locking of the zero-overlap at the destination signal must be established only time release delay has elapsed.

c) The vital time release delay for clearing of the start signal must be configurable between 10 and 90 seconds in 10 second increments.

d) The approach track-section must be continuously occupied for the full duration of the time release delay to clear the signal). If the track section in question becomes unoccupied before the time has elapsed, the release time delay must be stopped, and the route placed in final defined state by interlocking.

e) Prevention or the allowance of an opposing overlap having the zero-overlap signal as its opposing end of overlap signal, must be configurable.

f) A zero-overlap can at any-time be extended to a full overlap only if this is done before the release time delay has elapsed and the full overlap requirements are met.

4.2.3.4 Clearing a signal onto overlap into a protected yard (OLD (Overlap Derailer Unit) function):

a) The points-set or derailer at the end of the overlap must be locked and proved in the protection position as part of the overlap requirements.

4.2.3.5 Clearing a signal into a protected yard (OLD function):

a) The protecting derailer or runaway points-set must not be unlocked and called before:

i) The signal reading into the yard over the applicable points set has been called. and-

ii) The approach track-section of this signal must be occupied, and the train normalisation has taken place correctly up to this destination track section (confirming that a train has entered).

4.2.4. Train normalisation:

4.2.4.1 Train normalisation must be re-initiated at every start signal.

4.2.4.2 Replacement of start signal and approach locking:

a) The steering of the train normalisation must be done according to the

last called, detected and route locked positions of the points-sets.

b) When the berth-track-section of a cleared start signal is occupied and the signal is replaced to danger (e.g. because of any intermittent fault not affecting the route monitoring or changing the route into the first defined state), it must not be allowed to automatically re-clear again but can be re-cleared manually by the TCO.

c) When the berth-track-section of a cleared start signal is occupied and the king/after-track-section does not become occupied the start signal must be replaced whenever a track section in the rest of the route become occupied (route/overlap in the final defined state) and it must not be allowed to clear again until emergency route cancellation has been applied (this replacement does not apply to an emergency aspect).

d) When the berth-track-section of a cleared start signal is occupied for more than 3 seconds and it then picks up, the start signal must be replaced immediately and it must not be allowed to clear again until a cancellation of the route/overlap has been effected (applies to an emergency aspect as well).

e) When the berth-track-section of a cleared start signal does not become occupied, the start signal must be replaced whenever the king/after track sections in the route becomes occupied for 3seconds or longer and it must not be allowed to clear again until a cancellation on this start signal has been effected (this replacement does not apply to an emergency aspect).

f) When the berth-track-section of a cleared start signal is occupied for more than 3 seconds and the after-track-section becomes occupied the start signal must be replaced whenever a track section in the rest of the route become occupied and it must not be allowed to clear again until a cancellation on this start signal has been effected (this does not apply to an emergency aspect – the emergency replaces after berth track picking).

g) The above signal replacement requirements do not apply to automatic shunting (when shunt aspects on two opposing signals are cleared simultaneously for a route between yards not affecting the running lines, controlled by a shunting key, and the shunt signals are required to re-clear after every movement).

4.2.4.3 Sequential entering and departing of track-sections by a train must normalise (unlock) all elements in the route and overlap. With the normalisation of an element the respective flank protection for that element must be released.

a) A track section is considered as being occupied when it has been continuously in the occupied state for 0.5 second or more (track section entered). A track section is considered as being unoccupied when it has been continuously in the unoccupied state for 1.5 seconds or more (track section departed).

b) The complete sequence for a long train bridging the track section of the element in question is, previous track section occupied, track section of element in question occupied, next track section occupied, previous section unoccupied and track section of element in question unoccupied.

c) The complete sequence for a short train not bridging the track section of the element in question is, previous track section occupied, track section of element in question occupied, previous section unoccupied, next track section occupied and track section of element in question unoccupied.

d) Where multiple track sections exist between signals, even if not containing points-sets, the above sequences for train normalisations for long and short trains must be adhered to.

e) The complete train normalization of the route must also normalise the overlap couple to that route.

f) When multiple track sections without points-sets exist between the bases of two signals within station limits exist. The track section elements have to be unlocked with train normalisation, reverse normalisation of an opposing route or operator-initiated cancellation.

4.2.4.4 The overlap and/or parts of the route still locked cancels off immediately when it is proven that the train for which the route and overlap were originally required has exited the track section in the opposite direction (reverse normalisation).

a) When the previous destination signal is clear (pulled off) when the reverse normalisation takes place, only the route up to this destination signal must be normalised.

b) When the reverse normalisation of a destination section consisting of multiple track sections without points-sets takes place the individual track section element locks and the overall lock must be released.

4.2.4.5 The 90 seconds time delay cancellation of the overlap starts when the berth track of the destination signal, that must be at danger, becomes occupied and the train normalisation has taken place correctly up to the destination track section (confirming that a train has entered)

a) When the train-normalisation has broken off before the destination track section becomes occupied, the overlap 90 second delayed cancellation (N3-cancellation) must not start.

b) When the 90 second overlap cancellation has started and the destination track section becomes vacant again, the cancellation must stop and not be initiated again. Emergency cancellation is needed to cancel overlap.

c) When with a long train all the track sections in the route are still occupied when the destination track section becomes occupied, the overlap cancellation must start.

d) Train normalization of zero overlap locking as per normal overlap requirements above (90" time release after approach track-section of destination signal occupied).

e) When the destination signal is cleared before the 90" overlap release time has elapsed, the normalisation must be terminated, and the timer reset to zero (only when cleared signal's route is affected by the overlap cancellation). This override of the overlap release must be possible with main, shunt and emergency aspect clearing.

f) The overlap 90" overlap release normalisation must not start when the destination signal is cleared even when the aspect is dropped out when the berth track of the destination is occupied.

g) When the overlap 90" overlap release normalisation is already in progress when the destination signal is cleared the cancellation must be terminated. When the cancellation of the overlap does not interfere with the cancellation of the route of the cleared destination signal, the release normalisation does not have to terminate.

h) The overlap 90" overlap release normalisation must not start if the

first element past the destination signal is route locked. (This first element past the destination may be an element that got locked from a route setting attempt or a previous malfunctioning train normalisation.)

i) When a reverse move away from the still locked overlap is detected while the overlap 90” overlap release normalisation time is running, the overlap 90” overlap release normalisation must be stopped immediately.

j) When the destination is a yard and an overlap is required at the opposite entrance of the yard (goods and siding signal). The initiation of the N3 cancellation is when the last track section element in the route up to the non-signalled yard unlocks.

4.2.5. Cancellation:

The cancellation of routes and overlaps by the train control officer.

The 90” time release must be configurable between 10” and 240” in increments of 10 seconds.

4.2.5.1 The cancellation of normal and first define routes and overlaps (Normal cancellation - N1).

a) The normal cancellation is independent of the detection of the points-sets in the route.

b) When the approach track of the signal being cancelled is occupied or locked the cancellation takes place with a 90 seconds time delay (If the signal was at proceed it must be immediately replaced to danger at the start of the 90 seconds delay). If the approach track is unoccupied or unlocked the cancellation will take place without a time delay (immediate cancellation).

c) When the route and overlap have already gone into the state for example “first or final defined state” where 90 seconds time delay cancellation is required, this state cannot be reverted to the immediate cancel state.

d) Cancellation of elements must only take place up to and including the next signal that reads in the same direction (except for running shunts where the running shunt was not the start signal of the route).

e) Cancellation of route locked elements must only take place from the destination signal up to start signal of normal route or first define

route.

f) When the signal at the start of the overlap of another signal was cleared, and is then cancelled, only the part of the route not forming part of the coinciding overlap of the signal in rear will be cancelled after the 90” time delay.

g) The cancellation of a route shall be initiated at the destination signal of this route, the route and overlap associated with this destination signal (end of route and start of overlap) are both cancelled after the 90” time delay.

h) Cancellation of elements from the opposing direction to the locked route and/or overlap must not be allowed (wrong end-cancellation).

i) The override of the N1 (Normal cancellation) cancellation while the 90” time is running by re-clearing the signal must be possible.

i) The following sequences are mandatory:
AG ⇒ N1 ⇒ AG; BG ⇒ N1 ⇒ BG.

ii) AG (A-signal), BG (B-signal) C-signal is included in AG. NG (emergency signal)

iii) The following sequences are nice to have:
AG ⇒ N1 ⇒ BG; AG ⇒ N1 ⇒ NG; BG ⇒ N1 ⇒ NG.

iv) First defined state – level 1 command.

j) When a main or shunt signal is called but never clears, the N1 cancellation must stay enabled.

k) If a signal is replaced by any of the requirements as described in “Replacement of start signal and approach locking” above, the N1 cancellation must be disabled. When the signal is re-cleared the N1 must be enabled.

l) A N1 cancellation must not be allowed to unlock any elements that in final define state (this is needed to force a N2 cancellation when the train normalisation has broken down).

m) When cancellation of a route is initiated at the destination signal of this route, as is done in some interlocking systems, the route and overlap/zero overlap associated with this destination signal (end of route and start of overlap) are both cancelled.

n) Normal overlap cancellation when the start signal is still at proceed will be rejected, an RG function on the start signal must first be performed before the overlap can be cancelled.

4.2.5.2 Emergency cancellation always 90 seconds time delay (cancellation irrespective of locking direction and track section vacancy detection - N2 – emergency cancellation).

a) The emergency cancellation cancels routes in final define state, it's not limited by occupied track sections, in other words it will cancel underneath and past a train.

b) The emergency cancellation is dependent on the route locked direction.

c) The emergency cancellation is independent of the detection of the points-sets in the route.

d) Initiation of emergency cancellation, if a vital/non vital remote control is used, must ensure:

i) That the initiation only takes place on one signal per station at a time.

ii) That the initiation takes place on the intended destination signal.

iii) The identity of the person performing the cancellation is recorded.

iv) That the event and reason is recorded and secured before it is effected (for legal purposes).

v) That the event and reason is also recorded as an abnormal event in the diagnostic tool.

e) Initiation of emergency cancellation, if a non-vital remote control is used, must conform to "Emergency CTC operations for the HR97 interlocking" no. BBB0187 latest version only when a desk and diagram is used where only one element specific bit exists and the key and common push button is only operation specific. The parallel ASCI message is brought in to increase the integrity under these circumstances. The preferred initiation of emergency cancellation is to use element specific selection control bit/selection indication bit, conformation control bit/conformation indication bit and activation control bit/activation indication bit – see detailed description under item: 4.1.1.9.

f) Cancellation in the locked direction of elements must only take place up to and including the next signal that reads in the same direction. Cancellation in the opposing direction is allowed with a N2 but must terminate at the first opposing signal or where an opposing overlap does not end at a signal, at the last element of this applicable overlap (excluding this last element). Only when N2 from starter signal.

g) Zero-overlap locking cannot be unlocked by a N2 cancellation in the opposing direction.

h) It must be possible to change the overlap of a signal that has been cleared by cancelling the overlap (this includes a zero-overlap locking) with a N2 and after 90 seconds selecting a new overlap. The start signal is put back to danger immediately when the cancellation is initiated on the destination signal.

i) After the removal of a block on a points-set, the remaining lock on the points-set can only be unlocked by N2 cancellation or unblock emergency function.

j) After the removal of a block on a track section element, the remaining lock on the track section can only be unlocked by N2 cancellation or unblock emergency function.

k) Emergency overlap cancellation must be rejected if any part of the route still exists.

l) An Emergency cancellation (N2) must not be allowed to unlock any elements that in first define state (this is needed to force a N1 cancellation when the route is in normal or first define state).

4.2.6. Points-sets:

a) Points-set control and detection: The points-machine motor shall be 380 Volts, 50 Hertz 3 phase or Three wire or two wire (AC immune) 110Volt DC.

b) Plus and minus calls must be interlocked.

c) The detection circuit and throw cables shall be shall be superimpose.

d) Except when energised, the control cables to the machine shall be normally isolated from the points power supply.

e) Arrangements shall be such that the false operation of one relay or contactor cannot operate the points.

f) The points-set machine supply shall be disconnected at the element controller after a predetermined time (normally 10 seconds) should the machine not complete its throw, or immediately after it has reached the end of its stroke.

When the points-set has not complete its stroke and the 10 second timer has elapsed, it must be possible to keep on throwing the points-set to and throw until detection is obtained.

g) The circuit design must be such that it is possible to reverse the call on a set of points while the machine is still in mid-stroke.

h) The starting of point machines called for in a route shall be staggered sufficiently to avoid excessive demand on the power supply, but with the minimum delay to the route setting (normally 300ms), with the option to have a different staggering philosophy when the standby power is running.

The number of simultaneously running points-sets must be able to be set to a certain number. For standby power a different number can apply.

The staggering of multiple machines of the same points-set must also be possible with the same provisos as mentioned above.

i) It shall be possible to hand operate a set of points by means of a crank-handle.

j) Crank handle operation shall be initiated by the Crank key release operating method by utilising cranking key mechanism

k) A separate contact to detect unauthorised cranking shall be provided.

l) Do not initiate points call when the track section associated with the points set is occupied.

m) Do not initiate points call when the crank key released associated with the points set has been commanded.

n) When the crank key release is active, do not allow route or overlap setting, manual and flank calls on points sets associated with that crank key release.

o) The integrity of the points set position detection circuitry must be proved for each route request.

p) When the call has been initiated and the associated track section becomes occupied, the points set must complete its throw.

q) Provision must be made to throw a points-set with the associated track section occupied, when initiated with emergency operation.

r) Provision must be made to throw high speed turnouts with multiple drives.

s) Blocking of a point set so that it cannot be electrically thrown, this is logical blocking of the point-set not mechanical.

t) Blocking of a point set so that it cannot be traverse so that a route over it cannot be set, as required for occupation purposes. The integrity of the detection of the point set being blocked is also proven.

u) Through the points detection circuit it must be possible to detect when a points-set has moved without it being electrically thrown or manually cranked with a detected crank handle (points set trailed by a train or points-set not mechanically locking anymore and opening with vibration, etc).

   i) With positive mid-stroke detection where the detection circuit gives three detection states: PLUS (Right); MINUS (Left) and MID-STROKE the trailing/not mechanical locking state of a points-set can easily be detected.

   ii) When the “Points-set trailed” has been detected the points-set must be passivated and any further calls on the points-set must be rejected.

   The fault mode must be stored in retentive memory so that even

when power is lost the fault mode on this specific points-set must be retained and applied when power is restored.

iii) The trailing fault mode must only be allowed to be acknowledged when proven detected in the last called position. Special emergency throw command when in this trailed state.

iv) When the trailed fault mode still is valid and mid-stroke position or the opposite detection position of last called is still detected on the specific points-set the trailing fault mode must not be allowed to be acknowledged.

4.2.7. Signals:

4.2.7.1 Signal position types:

a) Home signal.

The first signal when approaching a station from an adjacent one that reads into the station, over track sections containing points-sets. When more than one possible route exists starting from this signal, the signal will be equipped with route indicators (three aspect signalling) or turnout indicators (multi-aspect signalling).

b) Intermediate home signal.

The first stop signal when approaching a station from an adjacent one that always reads onto a home signal.

c) Distant signal.

The first signal (not a stop signal) when approaching a station from an adjacent one that reads onto an intermediate home signal or a home signal. A white board with a black diagonal line is displayed on this signal. (Its default aspect is yellow, and it displays a green aspect if the intermediate home signal is displaying yellow or a higher aspect.)

d) Advance starter signal (block-signal).

The last signal reading out of a station into the track section between stations (block section). This signal never reads over track sections containing points-sets and opposing to an intermediate home signal if it exists. (It has a red and a green aspect.). The distant signal at the arrival

station must be proven to display a proceed aspect before the advance starter can clear and continuously monitored.

e) Starter signal.

The signal reading out of a station over the last track sections containing points-sets and reading on to the advance starter signal if it exists. When more than one possible route exists starting from this signal, the signal will be equipped with route indicators (three aspect signalling) or turnout indicators (multi-aspect signalling).

f) Intermediate shunt signal (running shunt).

i) A shunt signal positioned on routes between normal signals reading in the same direction.

ii) When a normal A-signal, B-signal, C-signal, U-signal and N-signal is cleared over this running shunt, it will display a running aspect (the normal A-signal, B-signal, C-signal, U-signal and N-signal aspects are not dependent upon this running aspect being displayed). The running aspect of the running shunt signal being displayed should not be proven in the signal aspect of the signal cleared over it.

iii) The intermediate shunt signal is not allowed to be used as a destination signal, only as a start signal for its shunt aspect.

iv) The intermediate home signal is not allowed to provide flank/head protection.

g) Miniature signal.

Due to clearance constraints within station areas miniature signals are sometimes used. These signals have the same functionality as normal signals except they may not be positioned on main lines and may not have a green aspect reading onto them. (Miniature signal is different to dwarf signal. – Dwarf signals, a normal signal target mounted on a short signal pole, is not allowed.)

h) Route signal (U-signal).

A route signal is a starter signal reading into a token-controlled line. A

route signal never reads onto a destination signal.

i) Repeat signal.
Where there is insufficient sighting distance for a signal, a repeat signal can be placed in advance of this signal repeating displayed proceed-aspects (red aspect not repeated). A white illuminated "X" is displayed on this repeat signal. (Only used on three-aspect-signalling. It is avoided if possible.)

j) Intermediate block signal (IBS-signal).

i) The intermediate block signal is used to divide a long track section between stations into shorter track sections to allow more than one train in the same direction into the section.

Depending upon the overall length of the complete section, more than one IBS-signal per direction may be used. Overall directional locking is required to force all the IBS-signals to be cleared only in the same direction and comes into effect when the section entry signal (advance starter or the starter signal if the advance starter does not exist) is cleared into the section. This overall locking must only be released once the train normalisation through the section has taken place past the opposing section entry signal at the destination station and all the track sections are unoccupied. This increases the throughput in the section. (Like advance starter signal: red and green aspect.)

ii) The IBS-signal normally has a distance signal reading onto it.

iii) Limited bi-directional auto block sections are possible with multiple IBS signals in the one direction and dummy block signals in the limited direction and by clearing the IBS signals automatically behind the train.

k) Automatic block signal (Auto-signal).

i) As for the intermediate block signal, but the signals can be placed into auto-mode whereby the signals will be automatically cleared behind the trains once all requirements have been met.

ii) The automatic signal is normally used on limited bi-directional lines in urban areas.

iii) The automatic-block signal has never got a distance signal reading onto it.

Signal aspect types:

l) Main signal (A-signal).

i) "A"-signal aspects include: Red, Yellow, Double yellow, Green yellow and green together with a route/turnout indicator where applicable. When the "A"-signal aspect fails (all filaments), the route/direction indicator if applicable, must be immediately removed.

ii) Full route and overlap requirements must be proven to clear a "A"-signal.

iii) Clearing of a "A"-signal onto a shunt aspect is not permitted, neither is the clearing of a destination signal to a shunt aspect allowed when the signal reading onto it has already been cleared to a "A"-signal aspect.

m) Shunt signal (B-signal).

i) The "B"-signal aspect consists of two white lights at 45° with the normal red light together with a route/turnout indicator where applicable. When the red light fails (main and auxiliary filaments) the shunt aspect must be immediately removed. When the "B"-signal aspect fails (all filaments), the route indicator if applicable, must be immediately removed.

ii) Allowing shunting movements onto an occupied destination track section must be configurable. In this case no overlap is required.

iii) Relaxed shunting does not require any overlap because of the slower train movement speed taking place under shunter supervision but never towards a main line, must be configurable.

iv) Clearing of a "B"-signal onto any proceed aspect is allowed.

v) When a "B"-signal is cleared into a non-signalled yard, even if both sides of this yard are connected to the signalled area, no overlap is required. (different to C-signals)

vi) With a two-position ground shunt signal, the red position is normally displayed. When a proceed-aspect is displayed the red position is not displayed and the above-mentioned red-light interlock therefore does not apply. (ground shunt signal).

This shunt signal is not allowed to be used as a destination signal, only as a start signal for its shunt aspect.

This shunt signal is not allowed to provide flank/head protection. Also applies to a intermediate shunt signal.

vii) Simultaneous clearing of opposing shunt signals onto the same occupied/unoccupied destination track section is not permitted.

n) Goods and siding signal (C-signal).

i) The goods and siding signal allows the train to move into an un-signalled yard or siding without shunter supervision. When both sides of this yard are connected to the signalled area, a normal "A"-signal overlap is required beyond the destination signal.

ii) In areas where three aspect signalling philosophy is applied the "C"-signal aspect consists of the red light and an additional yellow light mounted below the normal yellow light together with a route/direction indicator where applicable. When the red light fails (main and auxiliary filament) the yellow light must be immediately removed. When the "C"-signal aspect fails (both filaments), the route/direction indicator if applicable, must be immediately removed.

iii) In areas where multi-aspect signalling philosophy is applied the "C"-signal aspect consists of the red light and the second yellow light together with a turnout indicator where applicable. When the red light fails (main and auxiliary filaments) the second yellow light must be immediately removed. When the "C"-signal aspect fails (both filaments), the turnout indicator if applicable, must be immediately removed.

iv) When a signal reading into an un-signalled yard protected by an OLD- overlap, the OLD-protection may only be removed when the signal is called and the signal's berth track section is proven to be occupied by a train (train normalisation has taken place up to the berth track section in question).

v) Clearing of a "C"-signal onto a shunt aspect is not permitted, neither is the clearing of a destination signal to a shunt aspect allowed when the signal reading onto it has already been cleared to a "C"-signal aspect.

vi) The signal displaying the C-signal aspect may also be capable of displaying other main aspects for different routes. Because of this the C-aspect must only be displayed if proven that the correct route is selected.

o) Emergency signal (N-signal).

i) The emergency signal aspect consists of a red and a blue light or a flashing red light. When it consists of a red and blue light and the red light fails (main and auxiliary filaments) the blue light must be immediately removed.

ii) The emergency aspect is an electrical authorisation that applies to a specific train. The emergency aspect will only clear once the berth track section to the signal is occupied (even occupied because of a fault – fail-safe state).

iii) Only the detection and locking of the track section elements in the route are required and proven. (Points-sets detection and locking, track circuit element's locking, X-elements locking, double-slips and single slips locking, key points detection and key normal in route must be proven). Opposing signal red and next signal reading into the same direction not dark do not have to be proven. No flank/head protection, no route clear and no overlap need to be proven.

iv) An emergency aspect is not permitted to read onto another emergency aspect. The first one cleared will prevent the second from clearing.

v) When an emergency signal is cleared on a signal the route of this signal should be taken to the state as if a train has entered the route (final defined state). Normal route and overlap cancellation not possible anymore, only emergency route and overlap cancellation are allowed.

vi) When an emergency signal is not replaced by the train normalisation system (train detection system faulty) the emergency signal must be cancelled with a N2-cancellation.

vii) When a RG function exists (taking a signal temporarily to red for re-clearance at a later time) and performed on a signal cleared to emergency signal, this signal can only again be cleared to an emergency signal aspect.

viii) Emergency signal is not allowed to be cleared for a route entered by a train by a main or shunt signal aspect. The route and overlap must first be declared clear and cancelled by an emergency route/overlap cancellation after which a route can be set again, and the emergency aspect called and cleared on the signal.

ix) The emergency signal shall replace back to danger after 90 second time delay, if it did not normalise with birth track picking, or train.

p) Intermediate shunt signal (running shunt).

i) The running aspect (two vertical white lights) is displayed when a main signal has been cleared over the running shunt – the main signals aspect must be adhered to and the running shunt ignored.

ii) When vertical light or pivot light fails in the running aspect – the red light must start flashing at 1Hz - the main signals aspect must be adhered to and the running shunt ignored. The vertical light must be proven in the pivot light so that the pivot light on its own will never be displayed.

iii) The shunt aspect (two white lights at 45°) has the same requirements as “B”-signal aspect. When the shunt light fails the intermediate/ground shunt will change to its red aspect (two

horizontal lights). When the pivot light fails the intermediate/ground shunt will switch on the red light. The shunt light must be proven in the pivot light so that the pivot light on its own will never be displayed.

iv) The signal at danger displays two horizontal white lights. The red light must be proven in the pivot light so that the pivot light on its own will never be displayed. The only single light that will be displayed is the red light and means at danger stop.

q) Route signal (U-signal)

i) In signalled areas, a route signal aspect consists of a white illuminated "U" together with the normal red light and route/direction indicator. When the red light fails (main and auxiliary filament) the route signal aspect must be immediately removed. When the "U" light fails, the route/direction indicator, if applicable, must be immediately removed.

ii) The signal displaying the U-signal aspect may also be capable of displaying other main aspects for different routes. Because of this the U-aspect must only be displayed if proven that the correct route is selected.

r) Repeat signal (X-board) – only applicable to 3-aspect signalling.

i) The proceed-aspect displayed on the signal ahead is repeated on the repeat signal with an illuminated "X" (yellow or green).

ii) The red of the signal ahead is not repeated instead a dark signal with an illuminated "X" is displayed.

iii) A shunt aspect (B-signal), emergency aspect (N-signal), goods and siding aspect (C-signal) and a route aspect (U-signal) may not be repeated.

iv) If a home signal or starter signal is repeated and a route or turnout indicator is part of the displayed aspect, the route or turnout indicator is not repeated (only the proceed aspect).

v) The multi-aspects: double yellow and green yellow are already repeated so these aspects do not need to be repeated on a repeat

signal.

s) Automatic block signal (A-board).

i) It always displays an illuminated "A" with either a red light, yellow aspect or green aspect.

4.2.7.2 Signal aspect control:

a) Three aspect philosophy:

i) A yellow aspect is displayed if the next signal is at red, the next signal is cleared but not for a straight route (yellow aspect) or the route past the signal in question is for a turnout irrespective of the state of the next signal.

ii) On metro lines with three aspect-signalling home and starter signals are equipped with route indicators (a route indicator displayed on this signal for each possible route starting at this signal).

iii) On TFR lines with three aspect-signalling home and starter signals are equipped with turnout indicators. (only a left, straight and right indicator is displayed as applicable).

iv) The straight route indicator of a home signal must be proved in the green aspect of the intermediate home signal.

b) Multi-aspect philosophy is implemented in two formats:

i) With flashing aspects:
Aspect sequence listed from highest to lowest/basic/default aspect:

"Green" (D): Next signal cleared to at least Yellow (H) the route past this signal and the next signal is straight.

"Flashing green" (FD): Next signal cleared to at least Yellow (H) there is a medium turnout in the route of this signal or the next signal.

"Flashing yellow" (FH): Next signal cleared to at least Yellow (H) there is a slow turnout in the route of this signal or the next signal.

"Green + White" (DW): Next signal is displaying a Yellow + white aspect the route past this signal and the next signal is straight.

"Flashing green + white" (FDW): Next signal is displaying a Yellow + white aspect and there is a medium turnout in the route of this signal or the next signal.

"Flashing yellow + white" (FHW): Next signal is displaying a Yellow + white aspect and there is a slow turnout in the route of this signal or the next signal.

"Yellow" (H): The next signal is at danger Red.

"Yellow + white" (HW): The next signal is displaying a Red (R) aspect and between this signal and the next signal there is no braking distance.

"Flashing red" (FR): The points in the route are locked and detected but the route is not proven clear drive on sight.

"Red" (R) Basic danger aspect where a train must stop

ii) With Multiple light units:

Aspect sequence listed from highest to lowest/basic/default aspect:

"Green" (D): Next signal cleared to at least Yellow (H) the route past this signal and the next signal is straight.

"Green over 1st Yellow" (DH): Next signal cleared to at least Yellow (H) there is a medium turnout in the route of this signal or the next signal.

"1st Yellow + 2nd Yellow" (1H2H): Next signal cleared to at least Yellow (H) there is a slow turnout in the route of this signal or the next signal.

"Green + White" (DW): Next signal is displaying a Yellow + white aspect the route past this signal and the next signal is straight.

"Green over 1st Yellow + white" (DHW): Next signal is displaying a Yellow + white aspect and there is a medium turnout in the route of this signal or the next signal.

"1st Yellow + 2nd Yellow + white" (1H2HW): Next signal is displaying a Yellow + white aspect and there is a slow turnout in the route of this signal or the next signal.

"Yellow" (H): The next signal is at danger Red (R).

"Yellow + white" (HW): The next signal is displaying a Red (R) aspect and between this signal and the next signal there is no braking distance.

"Red + blue" (RB): The points in the route are locked and detected but the route is not proven clear drive on sight.

"Red" (R) Basic danger aspect where a train must stop

c) There are four basic rules governing the multi-aspect signalling steering:

i) **Rule 1**: When the next signal is cleared, the lowest limiting speed of this signals route and the next signals route must be displayed on this signal.

(For example: This route D + Next route D = D on this signal; This route FH + Next route D = FH on this signal; This route FD next route FH = FH on this signal; This route D + Next route FD = FD on this signal; etc.

ii) **Rule 2**: When the next signal is cleared AND according to Rule 1 a FH or FD must be displayed on this signal AND there is no handling distance between this signal and the next signal, the applicable FH or FD must be repeated on the signal reading on to

this signal.

iii) **Rule 3**: When there is or is not braking distance (no handling distance implies no braking distance) for the route from this signal to the next signal AND the next signal is at danger (R), a Yellow or Yellow + white (HW) respectively must be displayed on this signal (a Yellow aspect on this signal when this route, without braking distance, is selected is never possible).

iv) **Rule 4**: When the next signal is displaying a Yellow + white (HW) aspect a white light must be added to the aspect determined by Rule 1 displayed on this signal.

d) Multi-aspect philosophy: (part of the document M0110522472, A) The document STZ148-41F of 31 July 1977 still applies. Double yellow is replaced by a flashing yellow and a green yellow is replaced by a flashing green.

i) The aspects sequences as described in specification STZ148-41F of 31 July 1977 should be adhered to for TFR lines. The document covers only slow turnouts, if high speed turnout points-sets (1:20) are used; a green yellow aspect is displayed wherever a double yellow aspect is indicated in the document.

ii) When LED clusters are used the aspect sequences described in **Annexure A** below should be adhered to for TFR lines.

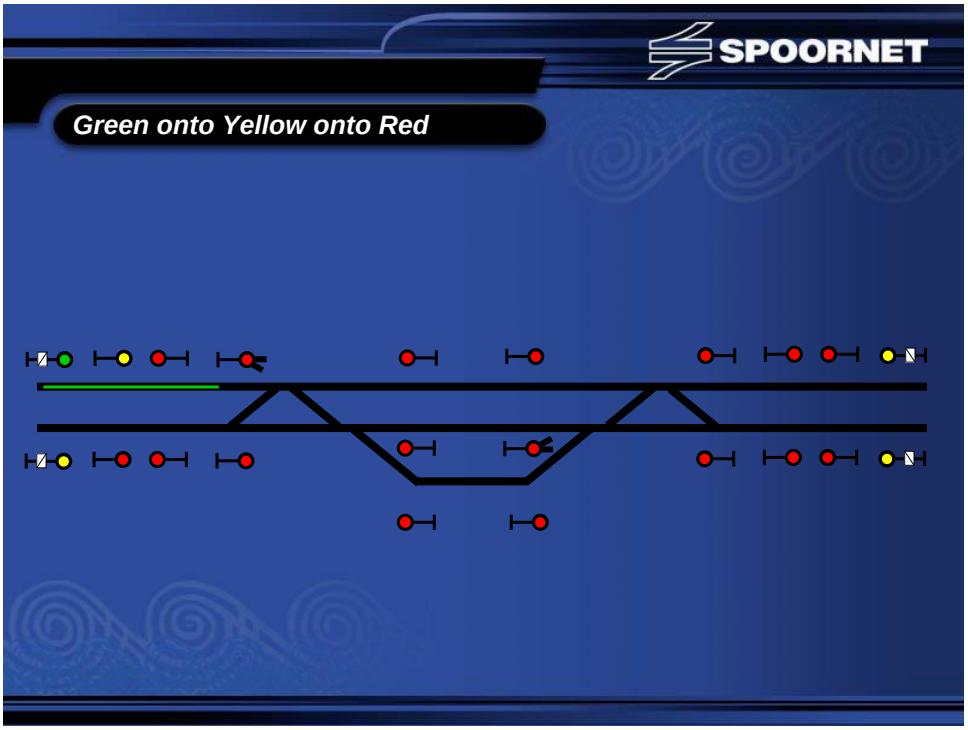
When the interlocking has the capability of switching to a lower aspect when an aspect fails, this degrading of the aspects must adhered to **Annexure B** below.

iii) The operating instructions for the aspects in **Annexure A** is described in **Annexure C**.

iv) For metro lines the flashing aspect sequences as described in document CSE-1152-002 Category E48 must be adhered to.

v) Home signals and starter signals are equipped with turnout indicators where applicable.

e) Multi-aspect philosophy illustrated as a simulation on a embedded PowerPoint presentation:



4.2.8. Miscellaneous operational functions:

4.2.8.1 Crank-handle control and disable state:

a) With the cranking the points-set releasing the crank handle hole sliding cover with a key:

i) The point-set must be put on release to crank mode by the TCO.

ii) When the key is turned and the released sliding cover is moved to the position that opens the crank handle hole, the key must not be allowed to be turn back and removed before the cover slide is not moved to the normal position.

iii) When the cranking activity is completed the personnel responsible for cranking have taken out the key the TCO can reset the crank release mode.

iv) When this Key is turned when points-set has plus or minus detection and is not in the Release to Crank-mode – Unauthorised Cranking #SM7 must be activated

v) Reset of point-set/s put in crank handle release state initiated per

points-set (Command-structure of crank handle reset stays the same).

vi) The reset of the release state however does not take time but is still an emergency function.

b) When the power of a Interlocking Module, Field Element Controller/s fails/ or communication is lost to Field Element Controller/s the points-sets associated with these Field Element Controller/s must all be put into the disabled state when the power or communication restored and after re-integration push button operated. The common power fail reset command that these points form part of must then be operated to reset these points-sets disabled state.

i) There must be then a 90 seconds time delayed reset before unlocking the disable points

ii) No route setting allowed over this disabled state.

4.2.8.2 Key Instrument release, key points and shunting keys:

4.2.8.3 The Key Instrument release must be approved against URS for Key Instrument Release for PRASA train operation.

a) The key must be detected normal (CR activated, SL relay down and the key-points detected for the main line).

b) When a track section containing key-points is locked in route and/or overlap and is unoccupied, the key release for that set of key-points is prohibited (with the track section only occupied but not locked the release is possible).

c) When the compounded set of the key-points is affording flank protection out of a non signalled yard to a main line points set locked in route or overlap, the key release for that set of key-points is prohibited.

d) The release when successful must be maintained for a prescribed time (10 to 30 seconds) to allow the key to be removed. An indication must be given during the time that the key-release is active (key detection not normal), after the time has elapsed the key detection will return to normal (key not removed – no indication) or the key detection will stay not normal (key was removed), indicate key out indication.

e) When the key is not detected as normal, no signal authorised movement towards, over or from that track section is allowed (Signal cannot be cleared towards, over or out of track section containing the key-points).

f) When a specific route between two non signalled yards is selected and a shunt signal cleared from one yard to the other and the shunting key removed, the opposing shunt signal is automatically cleared and the train normalisation inhibited/normal and emergency cancellation as well. The normal requirements for a shunt signal into yard must be proven for the first shunt signal. When the shunting key is replaced the second shunt signal is also replaced and train normalisation for the first shunt signal will take place as normal (Automatic shunting).

4.2.9. Stand alone “Absolute Line Block” between stations/interlocking systems

The “Absolute Line Block” between stations/interlocking systems normally at both stations consists of an O-track section as berth track to an advance starter signal. An intermediate home signal as opposing signal to the advance starter signal with a A-track section (after/king track) between them and a distant signal reading onto the intermediate home signal, placed at braking distance from it, with a track section, which can be kilometres long, between the bases of the two intermediate home signals. When track circuits are used in this kilometre-long section track there may be multiple track sections because of the length limitation on track-circuits.

A main aspect or shunting aspect on the starter signals out of the station with the advance starter-signals as destination signals or shunting limits is possible when the section track between the stations are not occupied and or when not occupied not locked towards the station where the main or shunting aspect on starter signal is cleared, or if occupied it must be locked away from the station where the shunting past starter signal will take place (train movement direction away) and for the main aspect the overlap track, normally the ATPR track section has already been cleared by the train moving away from the station.

When the section track between stations is occupied without any knowledge of the train movement direction a main or shunting aspect on the starter signals at neither of the stations are allowed.

When distant signals exist at both stations, no aspect steering between stations are necessary. When this is not the case aspect steering between stations must be done.

The distant signals may overlap, but that does not influence the configuration since the distant signal is not a spoor element but is called directly from the intermediate-home signal and in EI where it is a spoor-element it is a different spoor to the main-signal

spoor that is only dependant on the aspect displayed on the intermediate-home signal that it is reading onto.

Diagram 1: Absolute Line Block

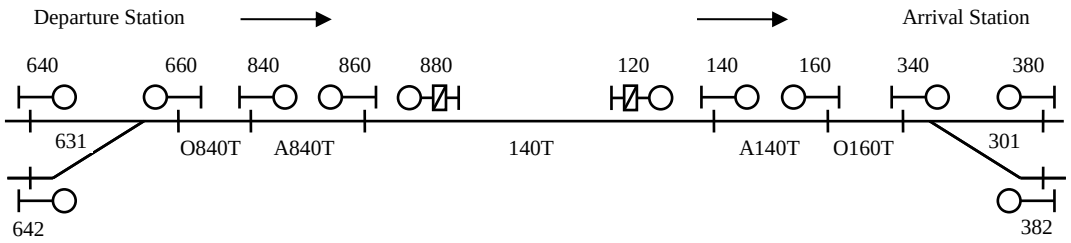


Diagram 2a: Absolute Line Block with dummy/logical block signals:
With other layouts where the section track is shorter and no shunting out of the station is required, the intermediate home signals and distant signals are still physical signals, but dummy/logical advance starter (block) signals are used.

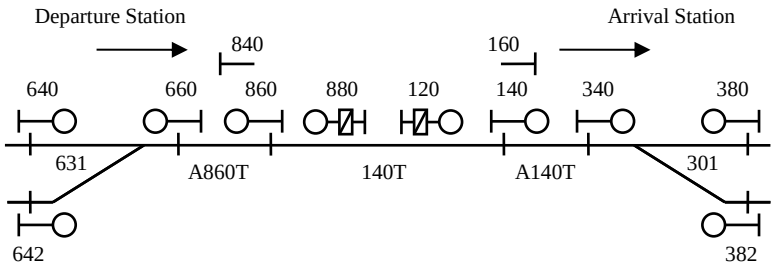


Diagram 2b: This layout also exists with physical block signals without any track sections between the block/advance starter signals and their respective opposing intermediate home signals, as indicated below:

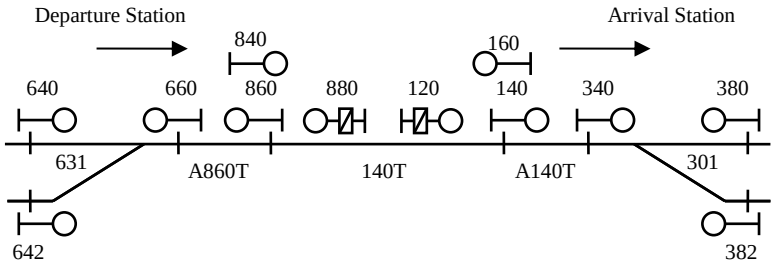


Diagram 3: Absolute Line Block with dummy/logical block signals and overlapping intermediate home signals:

With other layouts where the section track is even shorter the intermediate home signals overlap with no distant signals, with dummy/logical advance starter (block) signals each respectively at the opposite station's intermediate home signal.

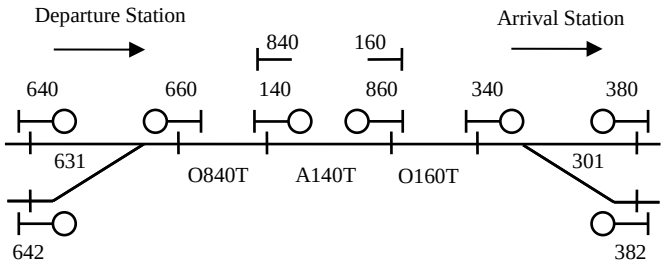


Diagram 4a: Absolute Line Block with no intermediate-home signals and dummy/logical block signals with no automatic 90 second overlap normalisation at the arrival station when the home signal at the arrival station is at danger:

With other layouts where no shunting out of the station is required, the distant signals are still physical signals reading onto the home signals with no intermediate home signals and dummy/logical advance starter (block) signals are used.

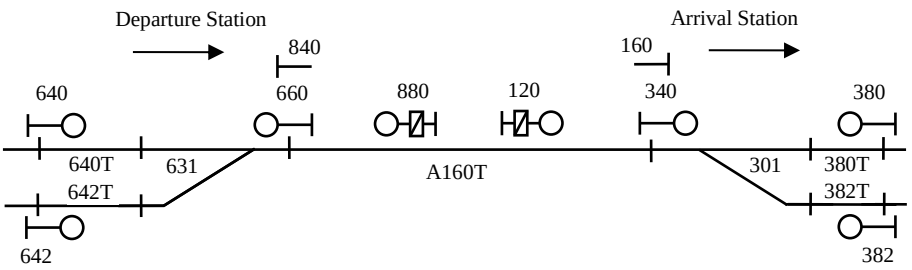
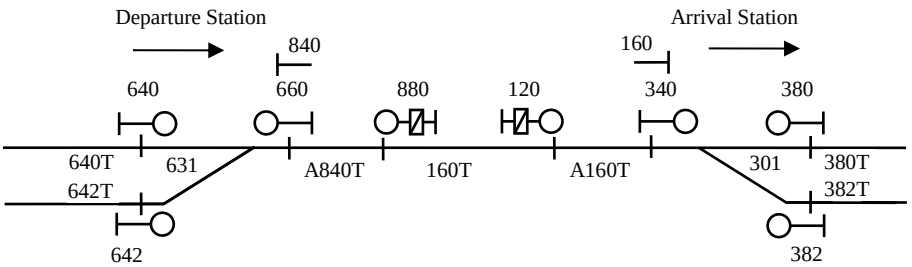


Diagram 4b: Absolute Line Block with no intermediate-home signals and dummy/logical block signals with automatic 90 second overlap normalisation at the arrival station when the home signal at the arrival station is at danger:

With other layouts where no shunting out of the station is required, the distant signals are still physical signals reading onto the home signals with no intermediate home signals and dummy/logical advance starter (block) signals are used.



4.2.9.1 Set of "Absolute Line Block" between stations/interlocking systems:

a) Send from departure station non-vital request to adjacent arrival station to enquire if arrival station is ready to receive a train (Request for line clearance – block calling lines Spoorplan blocks). This request

must not be sent if the block and applicable elements are not normal at the departure station.

i) At arrival station checks that, if applicable, no shunting out of the arrival station onto the same line in the opposite direction to the line block movement is in progress.

ii) At the arrival station check that the part of the route here and the overlap is available: unlocked and clear from trains.

iii) At the arrival station check that the distant signal, when applicable, is not a dark signal and in Diagram 3 the intermediate-home signal of the arrival station, that is the destination signal of the starter signal, is not dark.

iv) At the arrival station check that the opposing section entry signal: Diagram 1and 2b the opposing block/advance starter signal; Diagram 2a and 4 the opposing starter signal at the arrival station dependant on the state of the points at the arrival station; and Diagram 3 the overlapping intermediate-home signal of the adjacent station.

v) At the arrival station check that there is no "Block as starter signal" placed on the intermediate home or home signals as applicable.

vi) At the arrival station check that all the applicable elements are normal, the train-normalisation of the last train has taken place completely or it was cancelled properly when the train normalisation did not take place.

vii) At the arrival station check that there is no "Block for traversal" placed on the A-track section, O-track section or W631/W301 points-sets (Diagram 2 and 4).

viii) Check that in layout Diagram 4 there is no opposing overlap set from a starter to home signal. The overlap from the home signal to the appropriate starter signal is required for the line block.

Simultaneous entry into the station with this layout is mandatory because of the overlaps of the line block not normalising with the train arrival at the home signals.

b) When the appropriate checks mentioned in item a) above are proven successful the arrival station can respond with a readiness declaration to the departure station (first sweep of the Spoorplan blocks).

c) The departure station can then offer the train for departure by set/reserve route, lock and monitor route and send request to arrival station to set/reserve, lock and monitor part of route and overlap as applicable (second sweep of Spoorplan blocks).

When the "Absolute line block" forms the fringe between two separate CTC centres or TCO control areas, manual confirmation from the arrival station's TCO must first be obtained before the block is set up and cleared. The automatic block calling, in other words, by doing a AG on the starter or advance starter signals, must be disabled. In Spoorplan terms only the "long method" clearing the block by doing a BPBR and PBR on the opposing block signal at the arrival side must be allowed. This long method must always be available even between stations where automatic block calling is enabled.

When an axle counter is used for the long section track under these circumstances, both TCOs must be involved in resetting the axle counter section after a failure.

d) The vital proving that must take place before the advance starter signal or intermediate home signal (when dummy/logical block signals exist) can be cleared at the departure station (arrival station when overlapping intermediate home signals exist) are as follows:

i) At the departure side the same proving as for a normal main signal and route.

ii) At the arrival side the part of the route and the overlap is proven as for a normal main signal, route and overlap.

iii) The distant signal, if applicable, must be proven yellow or any other higher running aspect but not a dark signal.

iv) In case Diagram 1 no shunting out of the arrival station onto the same line in the opposite direction to the line block movement is already in progress or shunt signal on the starter signals for this

move has already been cleared.

In cases Diagram 3 and 4 not an opposing overlap from a starter signal to the applicable home signal has been locked.

e) The advance starter signal, intermediate home signal or starter signal (when dummy/logical block signals exist) will now be cleared at the departure station (arrival station when overlapping intermediate home signals exist).

The continued vital monitoring of the relevant variables must now take place until the train normalisation or cancellation has taken place at both stations.

4.2.9.2 Train normalisation/cancellation of the "Absolute Line Block" between stations/interlocking systems:

a) Sequential train-normalisation into the block section and out of the block section must be done to proof the train completeness. If the train-normalisation still takes place passed the block and intermediate-home signals irrespective if the applicable signal's globe/cluster has failed, it will be a distinguishing factor.

b) When the train-normalisation has broken down through the block cancellation at the arrival side block must have no effect and cancellation at the departure side block must forced 90 second timed delay.

c) When the long section track section uses track-circuits as train detection system and is, because of the limitation on the length of track-circuits, cut in to multiple track sections, the sequential train-normalisation of each track section must be properly done and when this train-normalisation over mentioned track sections breaks off, the train-normalisation of the block at the arrival sides must also not take place.

d) When the line block has been set-up and advance starter cleared the initiation of the cancellation of the line block must only be allowed from the departure station with normal route cancellation (N1) that is limited by track occupancy. Under no circumstances must the emergency route cancellation (N2) be allowed to be used over the fringe from the one to the other station.

e) When the approach track of the section entry signal is occupied (Diagram 1: O840T/O160T; Diagram 2 and 4: the berth track of the

appropriate starter signal; Diagram 3: O840T/O160T) the block must only cancel after a 90 second delay time and if the after/king track of this section entry signal has not become occupied within the 90 second delay time it may be allowed to cancel at the end of the 90 second delay time.

f) When the after/king track of this section entry signal (Diagram 1: A840T/A160T; Diagram 2: 631T/301T; Diagram 3: A140T and Diagram 4: 640T/642T/380T/382T as applicable) has become occupied within the 90 seconds delay time the cancellation function must be stopped because the cancellation at both stations of the block are no longer allowed.
In this situation the normal initiation of the block cancellation must be inhibited.
This inhibition must be maintained until the train has cleared Diagram 1: A840T, 140T and A140T or in other words past the opposing advance starter signal at the arrival station (cleared the block section).
This inhibition must be maintained until the train has cleared Diagram 2: 631T, O840T, A140T, O160T and 301T or in other words past the appropriate opposing starter signal.
This inhibition must be maintained until the train has cleared Diagram 3: A140T or in other words past the opposing intermediate home signal.
This inhibition must be maintained until the train has cleared Diagram 4: 640T/642T/380T/382T as applicable, 631T/301T as applicable and A160T or in other words past the appropriate opposing starter signal.

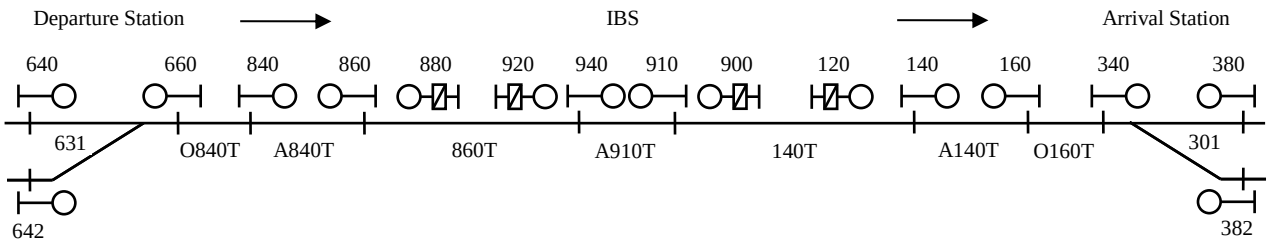
4.2.10. Intermediate Block Signals (IBS) to divide a long single line section into two "Absolute Line Block" sections between stations/interlocking systems

The Intermediate Block Signals (IBS) normally exists of two opposing advance starter/block signals placed at overlap distance apart with each a distant signal reading onto it placed at breaking distance from its block signal with "Absolute Line Block" systems to both adjacent stations/interlocking systems normally at both stations consists of an O-track section as berth track to an advance starter signal. An intermediate home signal as opposing signal to the advance starter signal with a A-track section (after/king track) between them and a distant signal reading onto the intermediate home signal, placed at braking distance from it, with a track section, which can be kilometres long, between the bases of the two advance starter signals.

When one of the block signals at the IBS station is a dummy/logical signal the long section between departure and arrival station is only divide in two sections in the

direction where a physical block signal exists at the IBS station (two trains can be send into this section behind each other in this direction) and not in the other direction where a single block section exist between the departure and arrival station (only one train at a time can be send into this section in this direction). The same specifications for cancellation, describe below, holds for both sections.

Diagram 5a: Intermediate Block Signals



4.2.10.1 Set of an "Absolute Line Block" through "Intermediate Block Signals" between stations/interlocking systems:

a) Send non-vital request from departure station to adjacent IBS station that relays it to the adjacent arrival station to enquire if arrival station is ready to receive a train.

i) At arrival station checks that, if applicable, no shunting out of the arrival station onto the same line in the opposite direction to the line block movement is in progress.

ii) At the arrival station check that the part of the route here and the overlap is available: unlocked and clear from trains.

iii) At the arrival station check that there is no "Block to be used as starter signal" placed on the intermediate home or home signals as applicable.

iv) At the arrival station check that there is no "Block for traversal" placed on either the A-track section or O-track section.

b) When the appropriate checks mentioned in item a) above are proven successful the arrival station can respond with a non-vital readiness

declaration to the IBS station that will relay this to the departure station.

c) The departure station can then offer the train for departure by set/reserve route, lock and monitor route and send request to IBS station to set/reserve, lock and monitor part of route and overlap and relay request to arrival station to set/reserve, lock and monitor part of route and overlap as applicable.

d) The vital proving that must take place before the advance starter signal can be cleared at the departure station are as follows:

i) At the departure side the same proving as for a normal main signal and route.

ii) At the IBS station the arrival side the part of the route and the overlap is proven as for a normal main signal, route and overlap.

iii) At the IBS station the distant signal must be proven a yellow or green aspect but not a dark signal.

iv) At the arrival side the part of the route and the overlap is proven as for a normal main signal, route and overlap.

v) The distant signal must be proven yellow or any other higher running aspect but not a dark signal.

vi) No shunting out of the arrival station onto the same line in the opposite direction to the line block movement is already in progress or shunt signal on the starter signals for this move has already been cleared.

e) The appropriate block signal at the IBS station and the advance starter signal at the departure station will now be allowed to clear. The continued vital monitoring of the relevant variables must now take place until the train normalisation or cancellation has taken place at all three stations.

4.2.10.2 Train normalisation/cancellation of the “Absolute Line Block” between departure station/interlocking to IBS station/interlocking and IBS station/interlocking to destination stations/interlocking:

a) When the line blocks have been set-up from the departure station to the IBS station, IBS station to arrival station and the appropriate block

signal at the IBS and advance starter at the departure station have cleared the initiation of the cancellation of the line block must only be allowed from the departure station with normal route cancellation (N1) that is limited by track occupancy. Under no circumstances must the emergency route cancellation (N2) be allowed to be used over the fringe from the one to the other station.

b) When the approach track of the section entry signal at the departure station is occupied (Diagram 5: O840T/O160T) the block must only cancel after a 90 second delay time and if the after/king track of this section entry signal has not become occupied within the 90 second delay time it may be allowed to cancel at the end of the 90 second delay time.

c) When the after/king track of this section entry signal (Diagram 5: A840T/A160T) has become occupied within the 90 seconds delay time the cancellation function must be stopped because the cancellation at all three stations of the block are no longer allowed. In this situation the normal initiation of the block cancellation must be inhibited.
This inhibition must be maintained until the train has cleared Diagram 5: departure station: A840Tand 860T; IBS station A910T and arrival station: 140T and A140T or in other words past the opposing advance starter signal at the arrival station (cleared the block sections at IBS and arrival station).

d) When the train has cleared the block section between the departure station and IBS station by going past the applicable opposing block signal (Diagram 5: G940 0r G910), the block between the departure station and IBS station can be cleared in the same train movement direction for a train to follow the one in the section between the IBS station and the arrival station.

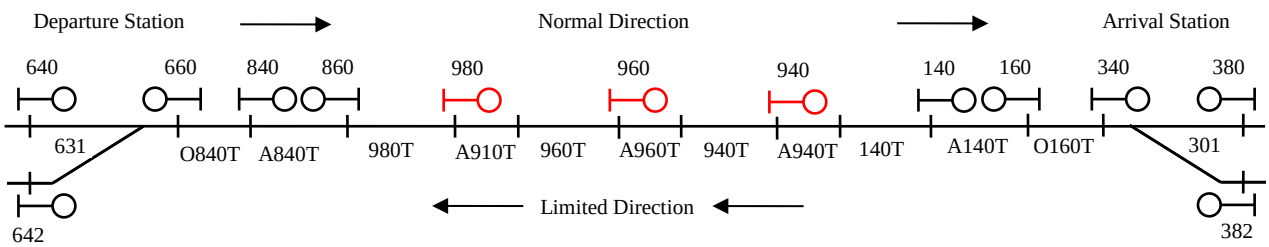
4.2.11. Auto Block Signals (ABS) to divide a long single line section into multiple sections between stations/interlocking systems and the block signals of each sub section is automatically cleared when its route and overlap become available with aspect steering between block signals reading onto each other (red marked signals in Diagram 5b)

The Auto Block Signals (ABS) normally exists of multiple IBS systems, as described above, without distant signals at the IBS signals, on the same single line section with normal “Absolute Line Block” systems to both adjacent stations/interlocking systems

normally at both stations consists of an O-track section as berth track to an advance starter signal. An intermediate home signal as opposing signal to the advance starter signal with a A-track section (after/king track) between them (no distant signals at destination stations). IBS signals become Auto-block signals.

When the ABS is limited bi-directional a number of auto-block signals exist in the one direction with no opposing auto-block signals only the destination station's advance starter signal as an opposing signal. The long single line section between departure and arrival station is only divide in multiple sections in the direction where the auto-block signals exist (multiple trains can be send into this section behind each other in this direction) and not in the other direction where a single block section exist between the departure and arrival station (only one train at a time can be send into this section in this direction). A single line section can therefore be divided with auto-block signals into a different number of sections in the two overall directions.

Diagram 5b: Auto Block Signals (ABS)



Each auto-block signal's route contains a A-track that must be overlap distance length and a route track that must be long enough that the trains will clear the A-track at the back if it has arrived at the next auto-block signal, so that a following train can be allowed to pull up to this auto-block signal.

An overall block direction must be set between the two destination-stations to set the train movement direction and the direction in which the auto-block signals will clear.

Once overall direction between the two destination-stations has been set, routes and overlaps can only be set and locked in the same direction.

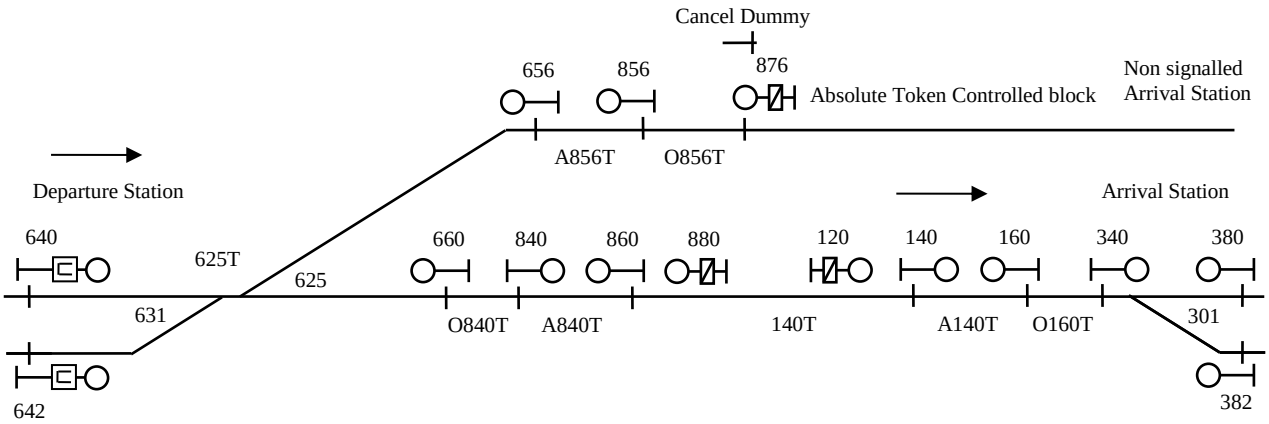
The overall block direction between stations can only be cancelled when all the track sections between the advance starters of the two stations are vacant and all locked routes and overlaps in the overall direction have been cancelled. When the overall direction is cancelled it can be set in the opposite direction.

The set, lock, train normalisation, proving and cancellation of individual auto-block signals route and overlap and the replacement of the auto-block signal take place as normal signals already described above.

Shunt aspects on the destination stations starter signals are only allowed when the last auto-block signal's route (route track) is locked in the same direction as the shunt movement (occupied or not) or not locked and not occupied.

4.2.12. The access via route signals (U-signals) from a colour light signalled station to an absolute token controlled block section:

Diagram 6: U-signals reading from colour light signalled station to absolute "Token" controlled block section:



4.2.12.1 Clearing U-signal aspects on the starter signals when travelling to the "Token" controlled absolute block section:

a) The route from the applicable starter signal (in example G640 or G642 in Diagram 6) must be set and an AG function activated on the applicable starter signal.

i) The selection between the display of a U-aspect or a normal main

aspect will be done by the route selected towards the "Token" controlled line or colour light signal controlled line respectively

ii) The U-aspect is only allowed to clear when all the elements in the route (in the example W631, W625, A856T and O856T in Diagram 6) were normal, clear/vacant and unlocked (train normalisation traversing these elements were last successful or elements were cancelled after train normalisation has failed), before the AG function was done).

iii) When wrong end emergency route cancellation is allowed on the opposing dummy AND/OR the intermediate home signal G856 while either of the starter signals G640 or G642 is cleared to a U-signal aspect, the applicable starter signal must replace to danger when the 90 second time delay of the cancellation starts.

iv) When a normal (N1) or emergency (N2) route cancellation is done on either of the starter signals G640 or G642 with the applicable route selected to G656 as opposing signal, the cancellation must take place up to and including the last track section O856T.

v) The opposing signals must also be proven in their default states and not dark (in the example G656 red, intermediate home G856 red and distant signal G876 yellow in Diagram 6).

vi) The sequential train normalisation must be proven up to and including the last track section on the "Token" controlled line (in example O856T in Diagram 6).

4.2.12.2 Clearing the intermediate home signal when travelling from out of a "Token" controlled absolute block section towards a colour light signalled station:

a) When the route and overlap for the intermediate home signal has been selected the intermediate home signal can be cleared.

i) When the intermediate home signal is cleared the berth and after track sections (in example O856T and A856T in Diagram 6) must both be locked towards the station even when the berth track (O856T) is already occupied (train has arrived) before the intermediate home signal is cleared.

ii) When the interlocking cancellation in the interlocking is from the

signal forward, a logical dummy signal must be created to cancel the intermediate home's berth track section when locked towards the station. When the cancellation of routes in the interlocking is initiated at the destination signals the home and intermediate home signals will suffice to cancel the berth and after track sections of the intermediate home signal when locked towards the station.

iii) When wrong end emergency route cancellation (N2) is allowed and done on the opposing starter signals G640 or G642 depending on the last route selected, the home signal, intermediate home signal and distant signal, when all cleared, must replace to their default aspects at the start of the 90 second delay time and all elements in the route/overlap will be cancelled with the elapse of the 90 second delay time.

iv) When cancellation on the destination signal G656 is done (N1 or N2) the home signal, intermediate home signal and distant signal, when all cleared, must replace to their default aspects at the start of the 90 second delay time. With destination signal cancellation interlocking systems all elements in the route/overlap will be cancelled with the elapse of the 90 second delay time. With cancellation from signal forward interlocking systems the home signal G656 route and intermediate home signal G856 overlap will cancel after the 90 second delay time.

v) When the intermediate home signal G856 is cleared, regardless of the home signal cleared or not, G856 must be replaced to danger and the two track sections A856T and O856T cancelled.

vi) The sequential train normalisation must start at the berth track section of the intermediate home signal when entering the station from the "Token" controlled line.

vii) When braking distance exists between the intermediate home signal and the home signal the intermediate home signal can be cleared on its own.

viii) Aspect steering, where applicable, must be done from the home signal to the intermediate home signal.

5. Physical characteristics.

If secondary relays (type C relays described in UIC code 736I) are used in the design they must be housed in the units and mounted on the racks described in specifications: CSE 11MH-002; CSE 11Q4-005; CSE 11Q5-005.

5.1.1.1 The system must be maintainable using the present maintenance capabilities.

a) The installation, fault finding, adjusting procedure as well as first line maintenance must be possible using a Multi-meter with similar specifications as the FLUKE model 75.

b) The relay units must be plug-in type, so that repairs and modifications can be performed at a central workshop, where the unit must be thoroughly tested according to the typical circuit and sealed after the integrity was proven. If any specialised test instrument or computers and software are needed in the workshop to facilitate repairs to the system and testing thereof, then it must be supplied with the system.

c) The system programmer software or other software running under DOS/Windows/other operating system on a PC must be able to monitor and present in a graphical format the status of the interlocking, outside signalling and user interface (locally or remotely via modem).

d) A switch able test point on the relay unit racks must be provided to enable the technician to pick up the opposite polarity to the voltage he is testing for on the rack or unit terminals.

e) Plug-in modules must be provided with protective containers in which the modules can be transported over rugged dirt roads using light delivery vehicles.

f) Mean time to repair must be: MTTR ≤ 120 minutes/fault. See paragraph 2. for definition of maintainability.

g) Mean time between interlocking failures must be: MTBF ≥ 1 1500hours/100 elements of the interlocking and will become proportionally shorter with more elements. See paragraph B. for reliability definitions.

5.1.1.2 The following must be accepted as definitions for Reliability, Maintainability, Availability.

a) Reliability :

i) MTBF = Mean time between failures:

ii) MTBF: It's the average time elapsed between failures causing the system to fail to a safe condition and being unavailable as it's unable to perform one or more of the functions as laid out in this specification [1], [2].

iii) A constant failure rate is accepted after the initial burn-in period of six months.

iv) $\mathbf{MTBF} = \frac{1}{\lambda}$ [1], [2],.

v) In the interlocking system the MTBF figure is given as a time period per 100 elements of the interlocking, the time period increases proportional if the interlocking has more than 100 elements and decreases proportional if the interlocking has less than 100 elements. The following are considered as elements: track circuits; axle counters; signals and point sets.

vi) The failure rate for equipment failures of this system must be: $\lambda \leq$ 1.0 faults/100 elements of system/2 months (MTBF $\geq$ 1500 hours).

vii) The probability for a right side failure is then $\lambda = 1/1500 = 6.67 \text{ X } 10^{-4}$.

b) Maintainability:

i) Maintainability is the probability that a device will be restored to operational effectiveness within a given period provided that the maintenance action is performed in accordance with prescribed procedures [1].

ii) Maintenance action rate μ is the number of maintenance actions that can be carried out on the system per hour [1].

iii) MTTR = Mean time to repair, is the average time taken to perform a maintenance action and is the reciprocal of μ [1].

iv) $\mathbf{MTTR} = \frac{1}{\mu}$

v) For this system the MTTR ≤ 120 minutes/fault.

c) Availability:

i) The steady state availability of a single system (simplex system) which is maintained and in continuous operation is defined as:

ii) $$\mathbf{A} = \frac{\mathbf{MTBF}}{\mathbf{MTBF} + \mathbf{MTTR}}$$ [1], [2].

iii) Whereby the MTTR-value in our case must also include the repair time, the fault reporting time and the travelling time.

iv) That's why availability is not specified other than with above-mentioned MTBF and MTTR values.

5.1.2. Environmental conditions.

5.1.2.1 The system must be capable of withstanding the following lightning discharges in the area:

a) The equipment must be capable of withstanding transversal and longitudinal voltage spikes of 10 kilovolt peak, 20 µseconds wide with a rise time of ≥ 8 µseconds between cores and on single cores respectively, leading from the equipment.

b) The environmental conditions, both natural and man-made, that the item must be able to withstand during transportation, installation and operation - See specification no. CSE-1154-001 Category E48.

5.1.3. Transportability.

If sealed safety units are used, they must be robust enough to be transported with a light delivery vehicle on a gravel road between the central workshop and the site. If this is not the case transporting holders must be designed to ensure that no damage to them will occur while in transit.

5.1.4. Portability.

5.1.4.1 If sealed safety units are used, they must be of the plug-in type secured by a single bolt and they must not weigh more than 50 Kilograms.

5.1.4.2 If sealed safety units are used, the different units must have different coding pins (metal pin ≥ 5mm in diameter) to prevent units being plugged in at wrong positions.

5.1.5. Fail-safety requirements.

5.1.5.1 Fail-Safety:

a) A safe system is one that has an acceptable probability of failing to a predicted (safe) state. A system can be made to be safe in a number of ways. Three main categories of safe systems are : [1]

i) Inherently safe systems where a "guaranteed" mechanism (e.g. gravity) is used to force the system into its predicted default (safe) state under failure conditions [1].

ii) Safety by checking uses techniques of continuous checks on the relevant circuitry. If any failure occurs, it must be detected by this testing and the system must then revert to a safe state [1].

iii) Safety by redundancy is achieved by using more than one system to achieve the same function. The outputs of these multiple systems are compared and/or used to form a composite output before any control can take place [1].

Normally safe systems are made up of combinations of the above techniques [1].

b) The measuring of fail-safety in our case is:

i) MTBWSF = Mean time between wrong side failures

$$\mathbf{MTBWSF} = \frac{1}{2}\frac{(\mathbf{MTBF})^2}{\mathbf{t}}$$

This equation is derived from the MTBSF = Mean time between system failures for a duplex redundant system, namely:

$$\mathbf{MTBSF} = \frac{1}{2}\frac{(\mathbf{MTBF}_{\mathbf{simplex}})^2}{\mathbf{MTTR}}$$ (See reference [1] for the deduction)

Where the MTTR is replaced with t = the mean time until the first fault is detected and negated. This replacement is based on the principle that a system may be regarded as fail-safe when two independent faults, each with a low fault probability, have to take place simultaneously before a wrong side failure occurs. A Wrong side failure = a failure of the system that can potentially cause a train accident.

c) In our case MTBWSF $\geq 100 \times 10^6$ hours equivalent to a $\lambda_{WS} = 1 \times 10^{-8}$ /hour (SIL 4 –as described in the CENELEC Standard EN 50126 -

Railway applications – The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS). Chapter 4.2.14 “Fail-safety requirements” applies.

d) Assume the following:

i) There are no design errors that will cause a failure that cannot be detected [1].

ii) Failures in subsystems are independent [1].

iii) All first failures, if undetected, will cause an unsafe operation of the system [1].

iv) Any subsequent failure will render the first failure and itself undetectable or cause the system to be unable to revert to the safe state [1].

e) Reference Sources:

i) [1] An Introduction to Electronic Safety by G.B.Paverd, March 1988-Chapter 2.:Reliability, Maintainability, Availability and Safety.

ii) [2] Electronic Equipment Reliability by J.C.Cluley - Chapter 1,3,4

f) When an electronic interlocking system is used, the software to realise the safety requirements shall be implemented using the architecture, methods, tools and techniques described in CENELEC standard: “Railway applications; Communications, signalling and processing systems; Software for railway control and protection systems” EN50128:2001 to ensure conformance to “Software Safety Integrity Level 4” SWSIL4 level as described in the for mentioned document.

g) When an electronic interlocking system is used, the process for acceptance and approval of the whole system as described in the CENELEC standard: “Railway applications; Safety related electronic systems for signalling” ENV50129:1999 shall be adhered to, to ensure conformance to “Safety Integrity Level 4” SIL4 as described.

5.1.6. Flexibility and expansion.

5.1.6.1 The interlocking must be of a geographical modular design so that changes to the station layout can be accommodated with ease.

5.1.6.2 The use of safety units to interface to and control each signalling element outside is recommended because the safety is then built into the system and does not depend on the planning and testing of each station.

5.1.7. Materials.

Not applicable.

5.1.8. Electromagnetic radiation and susceptibility.

The system must be immune against electromagnetic interference found in a "Relay Room" next to the railway line, described in Specification CSE-1154-002-E48, Appendix 2. [B.M. Steyn].

5.1.9. Nameplates and marking.

Any relays, fuses, safety units, in/output card addresses, clip-on rails and terminal blocks must be clearly labelled to facilitate fault finding and modifications.

5.1.10. Workmanship.

5.1.10.1 Thermal strippers must be used where single strand insulated wire is used.

5.1.10.2 Wire wrapping techniques is not acceptable in any safety circuits.

5.1.10.3 PC-board mounted relays are not acceptable in any safety circuits

5.1.11. Interchange ability.

5.1.11.1 If plug-able safety units are used, the same type of unit must be interchangeable between stations equipped with this Interlocking.

5.1.11.2 If secondary relays (type C relays described in UIC code 736I) are used in the safety units, provision must be made to accommodate both the SEL relays from Thales and the K50 relays from Siemens and the two versions of safety units must be interchangeable.

5.1.12. Item security.

5.1.12.1 The safety units must be sealed with a lead seal over a steel wire by the manufacturing company after the full safety test was performed. This company takes responsibility for the safety of this unit until the seal is broken.

5.1.12.2 If any modification is done to the unit in the central workshop, the unit must be given a full safety test again and sealed by a TFR seal. TFR now takes responsibility for the safety of the unit.

5.1.13. The following documentation must be supplied with the system (see Procedure No.CSE-1134-001 Category E98).

5.1.13.1 Synopsis sheets.

5.1.13.2 Material lists; General assembly drawings; Detail drawings.

5.1.13.3 Block diagram; circuit diagrams; Wire running lists.

5.1.13.4 A description of the interface between the PLC and the relay part of the interlocking as well as the interface between the interlocking and the outside equipment.

5.1.13.5 The mechanical relay unit coding; The mechanical PC board coding.

5.1.13.6 Procurement/Purchase specifications.

5.1.13.7 PC Board net list circuit diagram; PC Board layout files on disk; PC Board component identification.

5.1.13.8 Engraving/Silk-screening drawings; Label details.

5.1.13.9 Operator manual, Training manual.

5.1.13.10 Maintenance manual with procedures and schedules (time scales included) and fault-finding trees.

5.1.13.11 Detail functional description.

5.1.13.12 Reasons for inclusion of relay contacts.

5.1.13.13 Hardware program strapping.

5.1.13.14 Planning Guidelines.

5.1.13.15 Quality and safety assurance instructions.

5.1.13.16 Test and commissioning procedures.

5.1.13.17 Safety, Reliability and Maintainability Analysis - for example FMECA-analysis.

6. QUALITY ASSURANCE PROVISIONS

6.1.1. Safety quality control during manufacture of safety units and the full safety test of each safety unit: The responsibility is with the approved signalling company that won the as and when contract for manufacture of safety units.

6.1.2. Full safety and functional test according to the control sheet (outside equipment simulated): The responsibility is with the approved signalling company that won the contract for the specific project and the TFR approved testing engineer.

6.1.3. Correspondence test and final commissioning: The TFR approved testing engineer- See specification: Testing of Signalling installations no. CSE-1155.500 Category N48.

6.1.4. All the requirements and characteristics are demonstrated on a full functional model.

6.1.5. Safety analysis is also done on this same full scale model.

Not applicable.

7. PREPARATION FOR DELIVERY

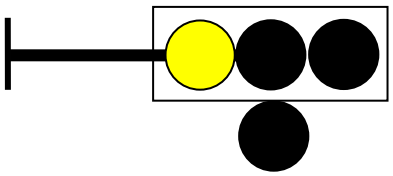
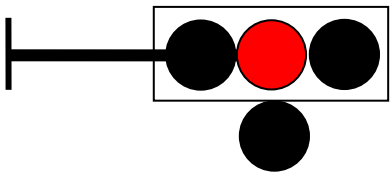
Not applicable.

8. Annexure A

8.1. TFR Multi-aspect Steering sequences:

Legend:

R = Red Aspect
H = Yellow Aspect
FH = Flashing Yellow Aspect
FD = Flashing Green Aspect
D = Green Aspect
SU = Straight Route; 1:12 Slow turnout; 1:20 Medium turn out.
NB = No Breaking Distance
NH = No Handling Distance
X = Don't care State
0 = State False
1 = State True

Case no.	Applicable Signal									Next Signal								
1																		
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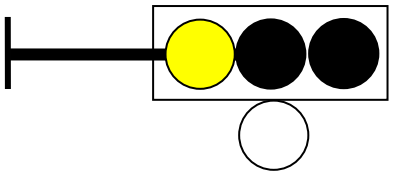
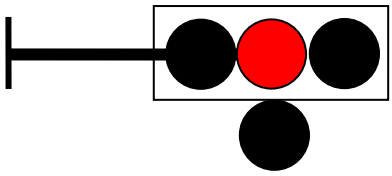
2																		
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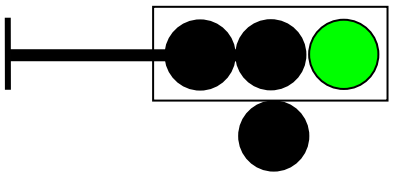
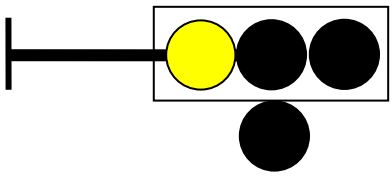
3																		
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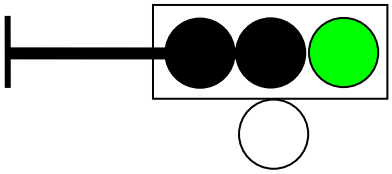
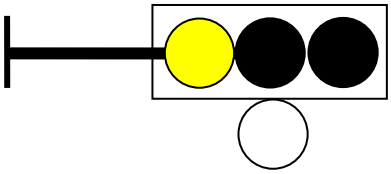
Case no.	Applicable Signal									Next Signal								
4																		
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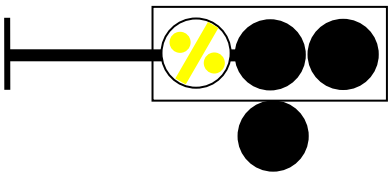
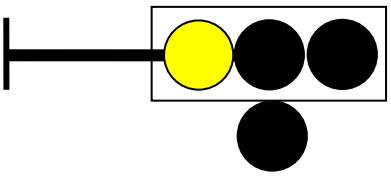
5a																		
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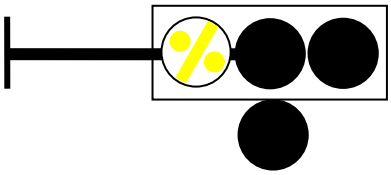
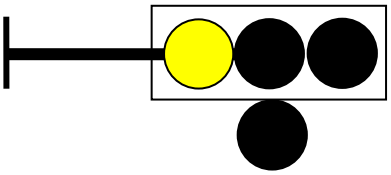
5b																		
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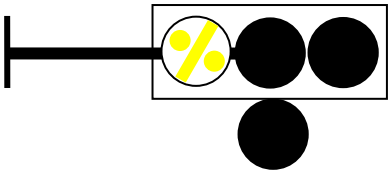
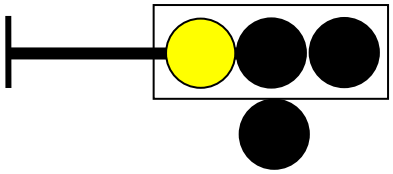
Case no.	Applicable Signal									Next Signal								
5c																		
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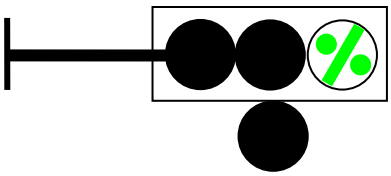
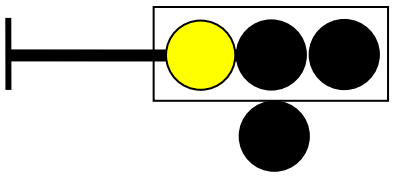
6a																		
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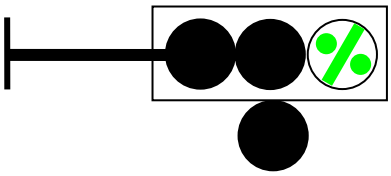
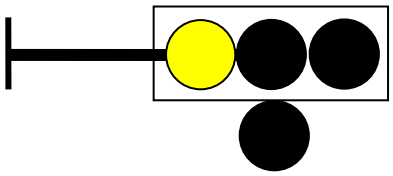
6b																		
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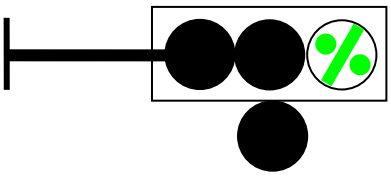
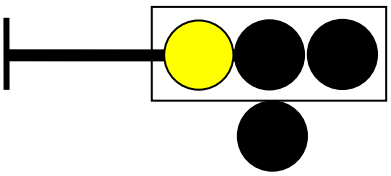
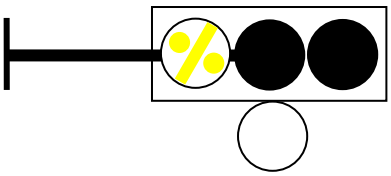
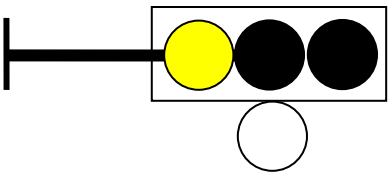
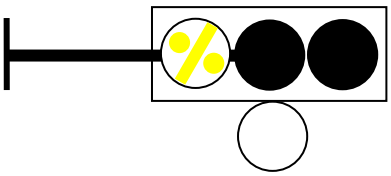
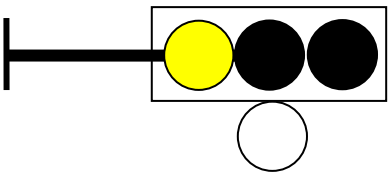
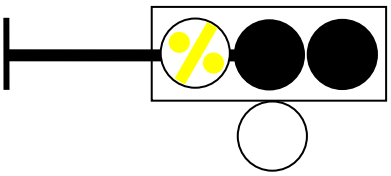
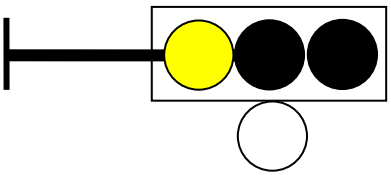
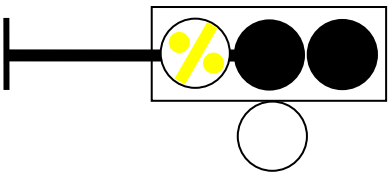
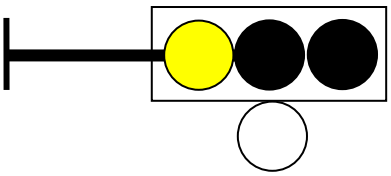
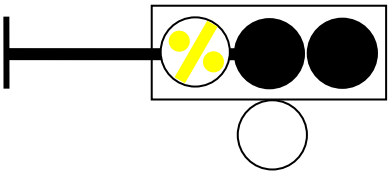
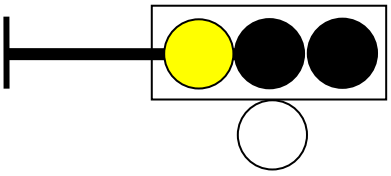
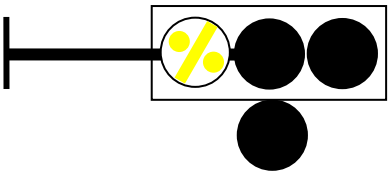
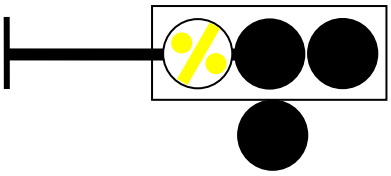
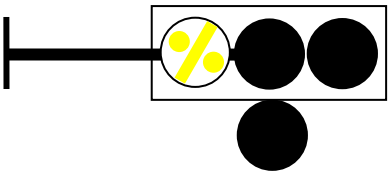
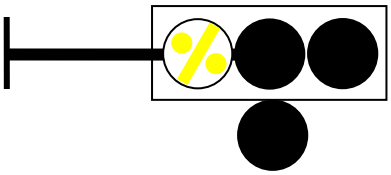
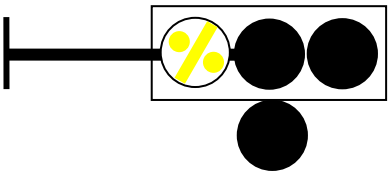
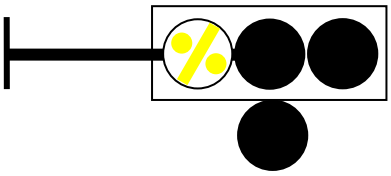
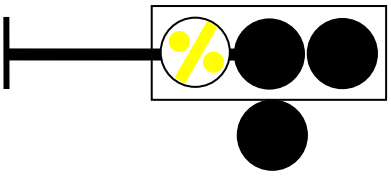
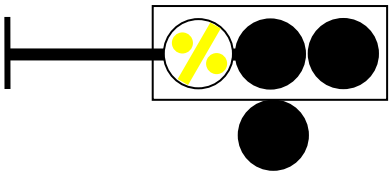
	0	0	0	1	0	0	1:20	X	X	0	1	0	0	0	0	1	0	0

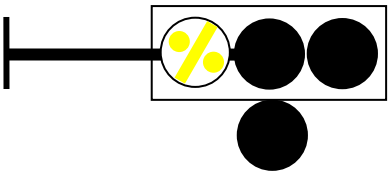
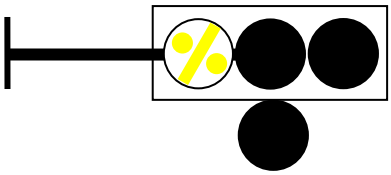
Case no.	Applicable Signal									Next Signal								
6c																		
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	0	1	0	0	1:20	X	X	0	1	0	0	0	0	1:20	0	0
7a																		
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	1	0	0	1	1	X	X	0	1	0	0	0	1	1:12	1	0
7b																		
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	1	0	0	1	1:20	X	X	0	1	0	0	0	1	1:12	1	0

Case no.	Applicable Signal									Next Signal								
7c																		
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	1	0	0	1	1:12	X	X	0	1	0	0	0	1	1	1	X
7d																		
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	1	0	0	1	1:12	X	X	0	1	0	0	0	1	1:20	1	X
7e																		
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	1	0	0	1	1:12	X	X	0	1	0	0	0	1	1:12	1	0

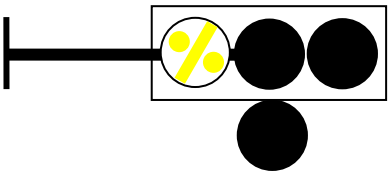
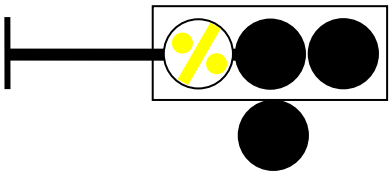
Case no.	Applicable Signal									Next Signal								
8a																		
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	1	0	0	0	1	X	X	0	0	1	0	0	0	1:12	0	X
8b																		
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	1	0	0	0	1:20	X	X	0	0	1	0	0	0	1:12	0	X
8c																		
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	1	0	0	0	1:12	X	X	0	0	1	0	0	0	1:12	0	X

Case no.	Applicable Signal	Next Signal
8d		

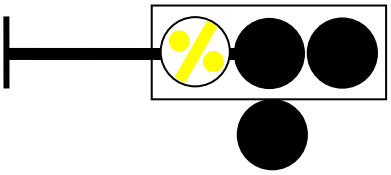
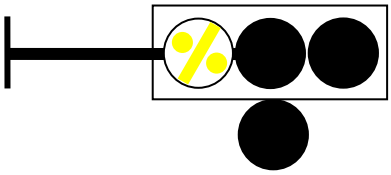
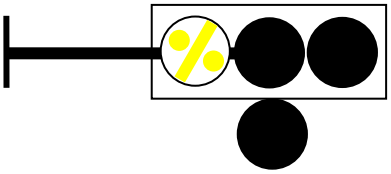
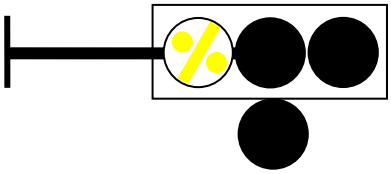
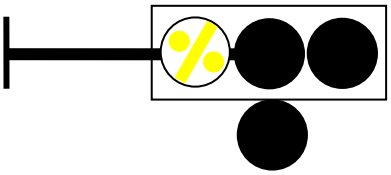
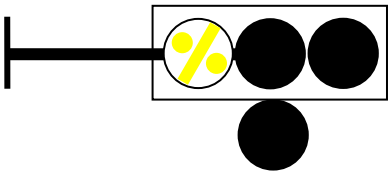
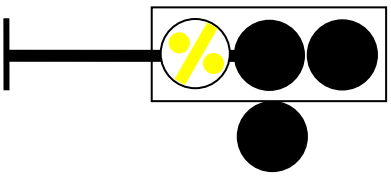
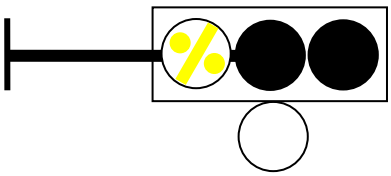
R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	1	0	0	0	1:12	X	X	0	0	1	0	0	0	1	0	X

8e		

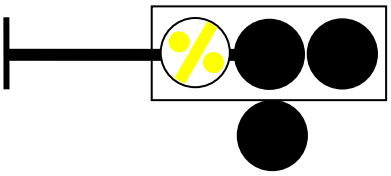
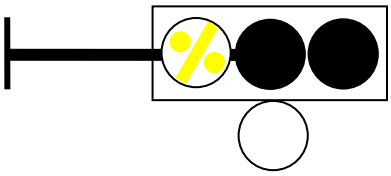
R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	1	0	0	0	1:12	X	X	0	0	1	0	0	0	1:20	0	X

8f		

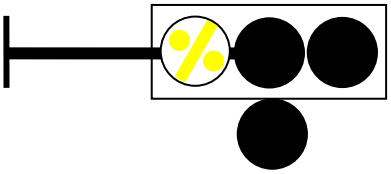
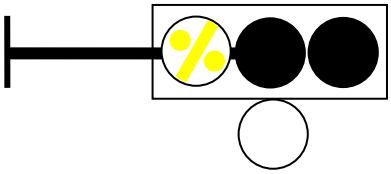
R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	1	0	0	0	1	X	X	0	0	1	0	0	0	1	1	1

8g																		
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	1	0	0	0	1	X	X	0	0	1	0	0	0	1:20	1	1
8h																		
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	1	0	0	0	1:20	X	X	0	0	1	0	0	0	1	1	1
8i																		
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	1	0	0	0	1:20	X	X	0	0	1	0	0	0	1:20	1	1
9a																		
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH

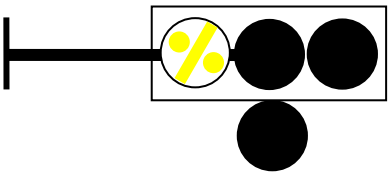
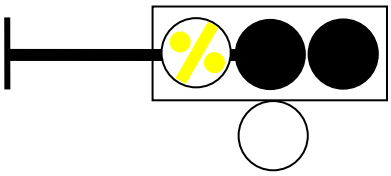
	0	0	1	0	0	0	1	X	X	0	0	1	0	0	1	1	1	1

Case no.	Applicable Signal	Next Signal
9b		

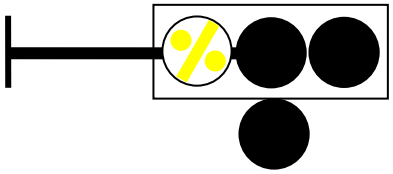
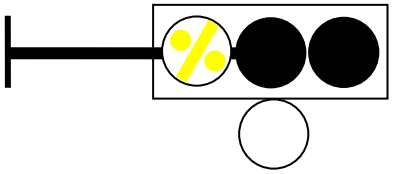
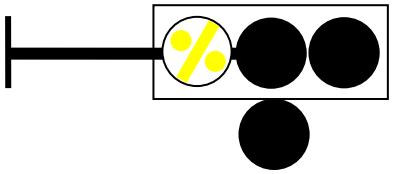
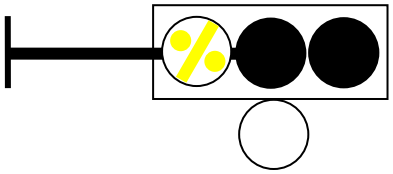
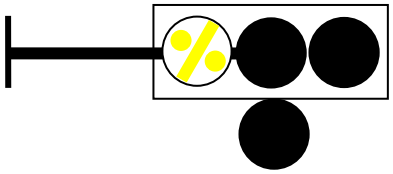
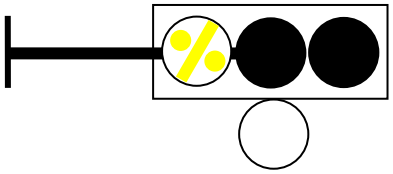
R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	1	0	0	0	1	X	X	0	0	1	0	0	1	1:20	1	1

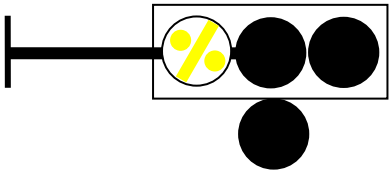
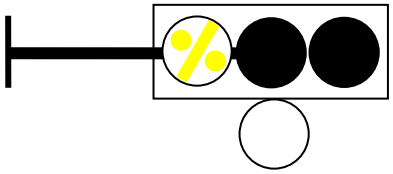
9c		

R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	1	0	0	0	1:20	X	X	0	0	1	0	0	1	1	1	1

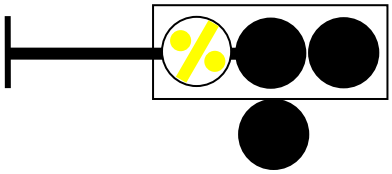
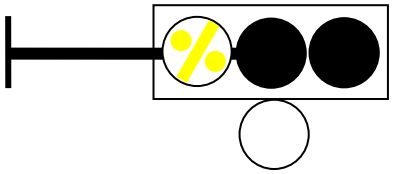
9d		

R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	1	0	0	0	1:20	X	X	0	0	1	0	0	1	1:20	1	1

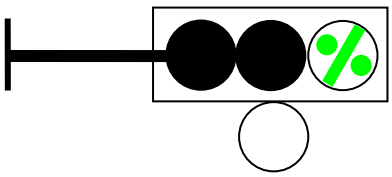
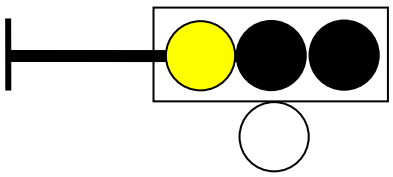
Case no.	Applicable Signal									Next Signal								
9e																		
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	1	0	0	0	1	X	X	0	0	1	0	0	1	1:12	X	X
9f																		
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	1	0	0	0	1:20	X	X	0	0	1	0	0	1	1:12	X	X
9g																		
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	1	0	0	0	1:12	X	X	0	0	1	0	0	1	1:12	X	X

Case no.	Applicable Signal	Next Signal
9h		

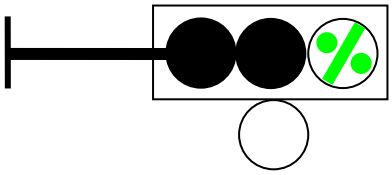
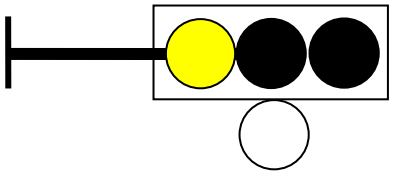
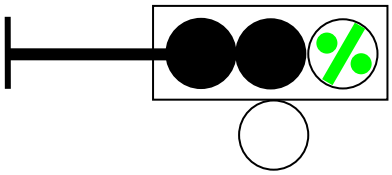
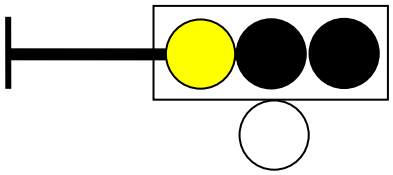
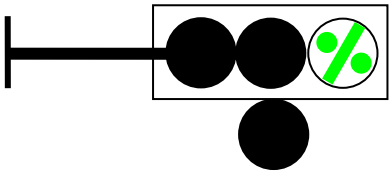
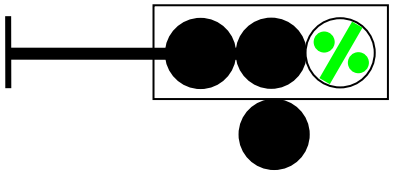
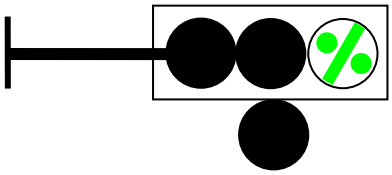
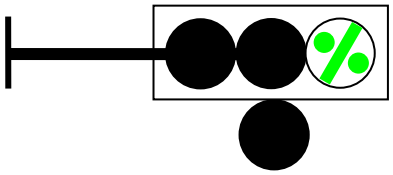
R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	1	0	0	0	1:12	X	X	0	0	1	0	0	1	1	X	X

9i		

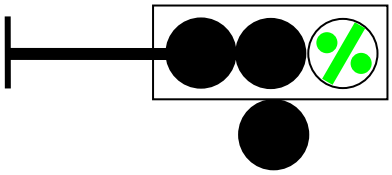
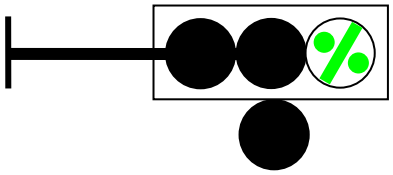
R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	1	0	0	0	1:12	X	X	0	0	1	0	0	1	1:20	X	X

10a		

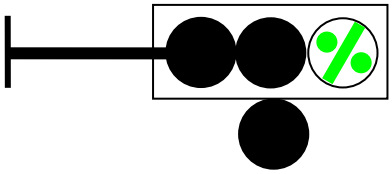
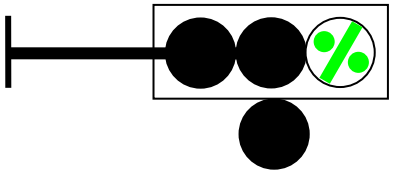
R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	0	1	0	1	1	X	X	0	1	0	0	0	1	1:20	1	0

10b																		
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	0	1	0	1	1:20	X	X	0	1	0	0	0	1	1:20	1	0
10c																		
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	0	1	0	1	1:20	X	X	0	1	0	0	0	1	1	1	0
11a																		
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	0	1	0	0	1	X	X	0	0	0	1	0	0	1:20	0	X
11b																		

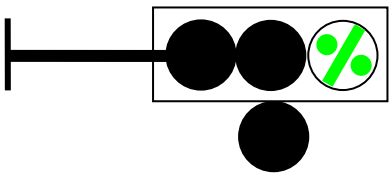
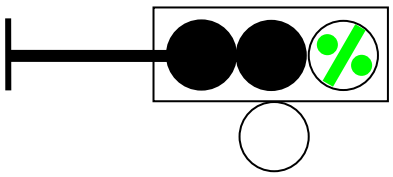
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	0	1	0	0	1:20	X	X	0	0	0	1	0	0	1:20	0	X

Case no.	Applicable Signal	Next Signal
11c		

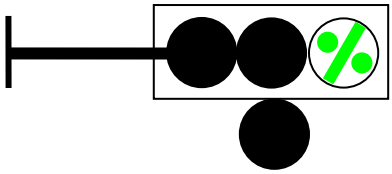
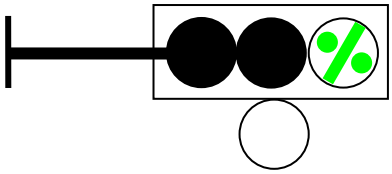
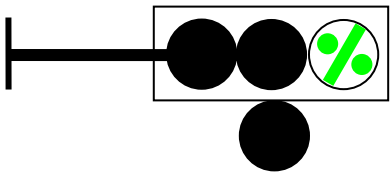
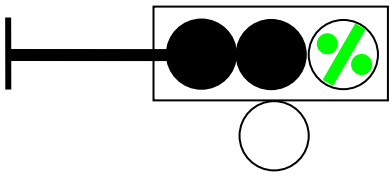
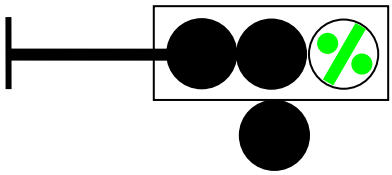
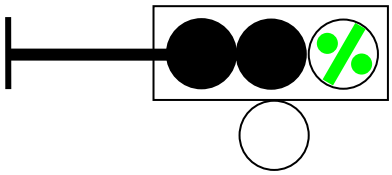
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	0	1	0	0	1:20	X	X	0	0	0	1	0	0	1	0	X

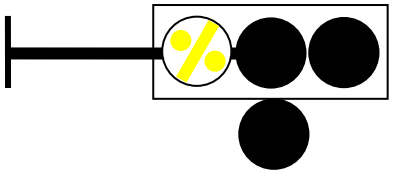
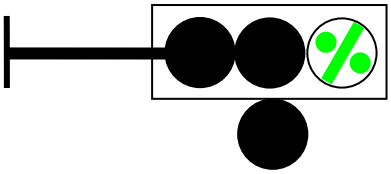
11d		

	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	0	1	0	0	1	X	X	0	0	0	1	0	0	1	1	1

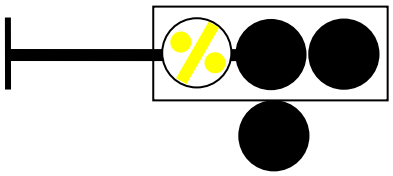
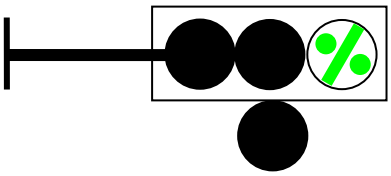
12a		

	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	0	1	0	0	1	X	X	0	0	0	1	0	1	1	1	1

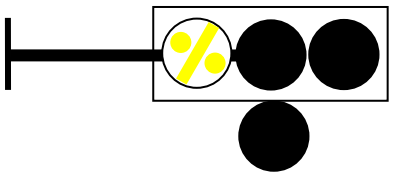
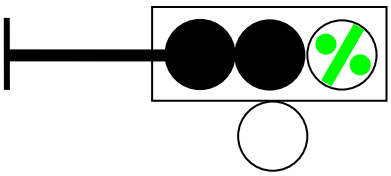
Case no.	Applicable Signal									Next Signal								
12b																		
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	0	1	0	0	1	X	X	0	0	0	1	0	1	1:20	X	X
12c																		
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	0	1	0	0	1:20	X	X	0	0	0	1	0	1	1:20	X	X
12d																		
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	0	1	0	0	1:20	X	X	0	0	0	1	0	1	1	X	X

Case no.	Applicable Signal	Next Signal
13a		

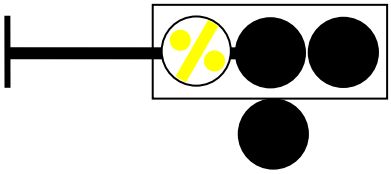
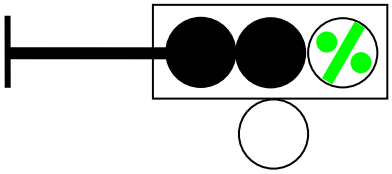
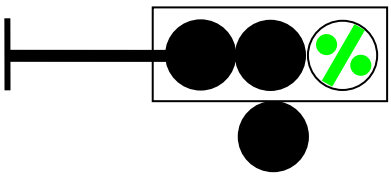
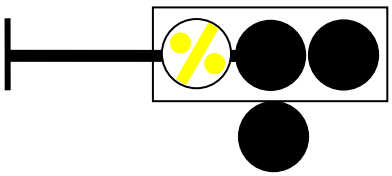
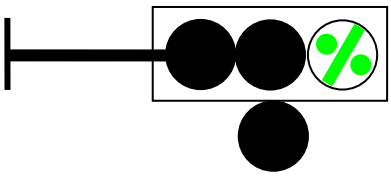
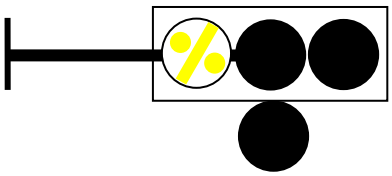
R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	1	0	0	0	1:12	X	X	0	0	0	1	0	0	1:20	X	X

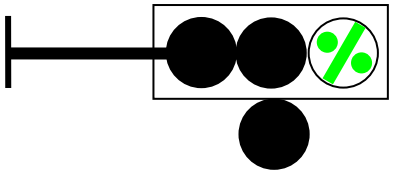
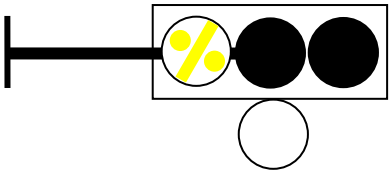
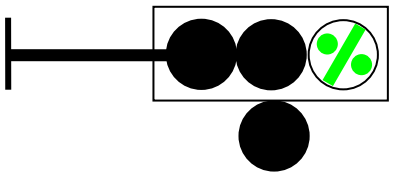
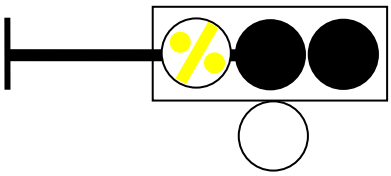
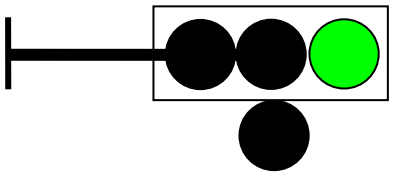
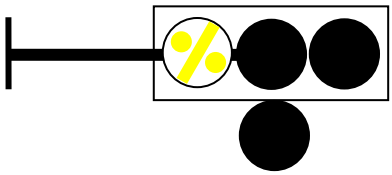
13b		

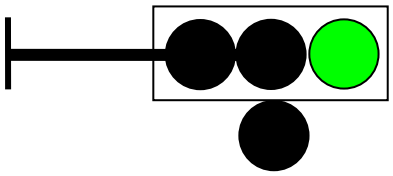
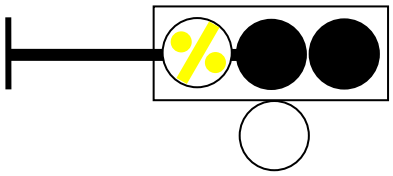
R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	1	0	0	0	1:12	X	X	0	0	0	1	0	0	1	X	X

14a		

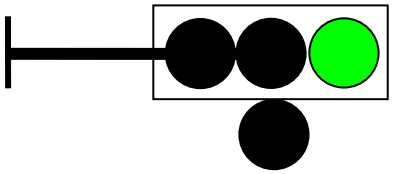
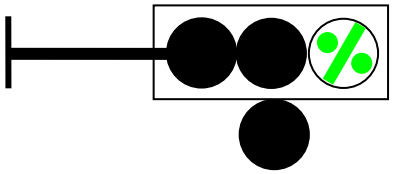
R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	1	0	0	0	1:12	X	X	0	0	0	1	0	1	1:20	X	X

Case no.	Applicable Signal									Next Signal								
14b																		
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	1	0	0	0	1:12	X	X	0	0	0	1	0	1	1	X	X
15a																		
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	0	1	0	0	1:20	X	X	0	0	1	0	0	0	1	X	0
15b																		
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	0	1	0	0	1:20	X	X	0	0	1	0	0	0	1:20	X	0

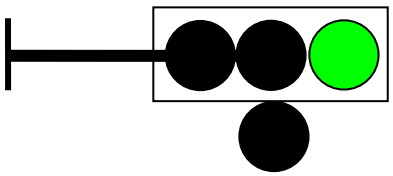
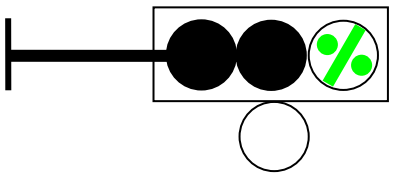
Case no.	Applicable Signal									Next Signal								
16a																		
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	0	1	0	0	1:20	X	X	0	0	1	0	0	1	1	X	0
16b																		
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	0	1	0	0	1:20	X	X	0	0	1	0	0	1	1:20	X	0
17																		
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	0	0	1	0	1	X	X	0	0	1	0	0	0	1	X	0

Case no.	Applicable Signal	Next Signal
18		

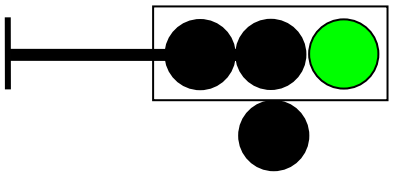
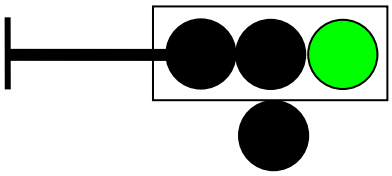
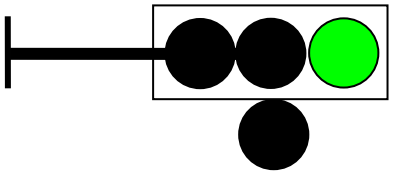
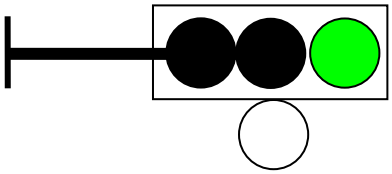
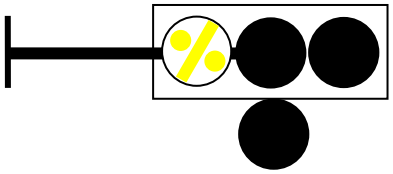
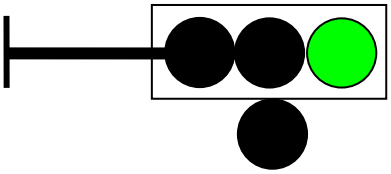
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	0	0	1	0	1	X	X	0	0	1	0	0	1	1	X	0

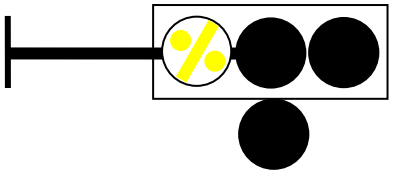
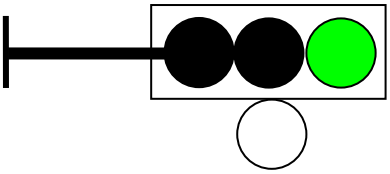
19		

	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	0	0	1	0	1	X	X	0	0	0	1	0	0	1	X	0

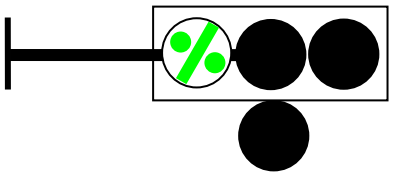
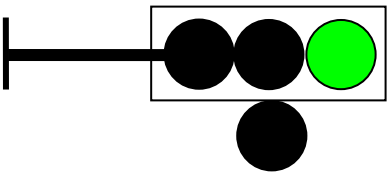
20		

	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	0	0	1	0	1	X	X	0	0	0	1	0	1	1	X	0

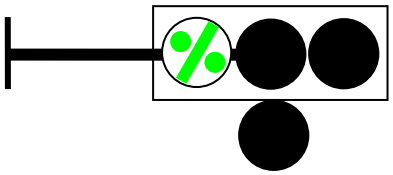
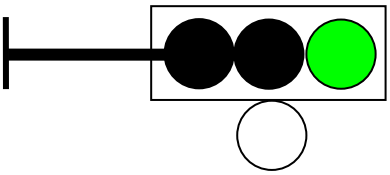
Case no.	Applicable Signal									Next Signal								
21																		
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	0	0	1	0	1	X	X	0	0	0	0	1	0	1	X	0
22																		
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	0	0	1	0	1	X	X	0	0	0	0	1	1	1	X	0
23a																		
	R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
	0	0	1	0	0	0	1:12	X	X	0	0	0	0	1	0	1	X	X

Case no.	Applicable Signal	Next Signal
23b		

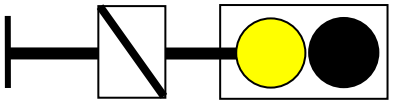
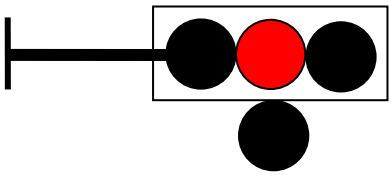
R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	1	0	0	0	1:12	X	X	0	0	0	0	1	1	1	X	X

24a		

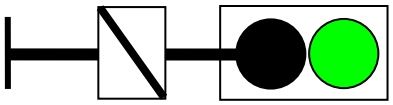
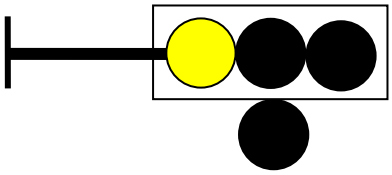
R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	1	0	0	0	1:20	X	X	0	0	0	0	1	0	1	X	X

24b		

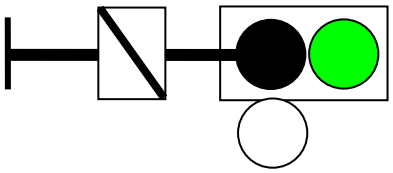
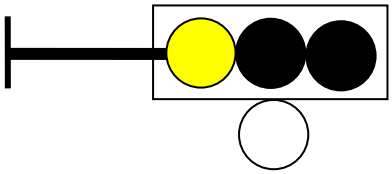
R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	1	0	0	0	1:20	X	X	0	0	0	0	1	0	1	X	X

Case no.	Applicable Signal	Next Signal
25		

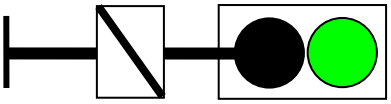
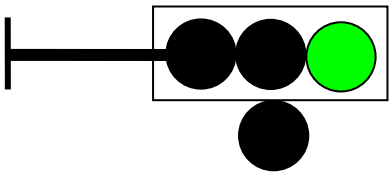
R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	1	X	X

26		

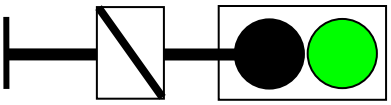
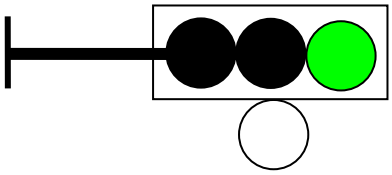
R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	1	0	0

27		

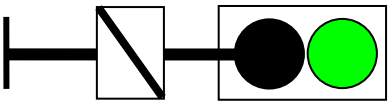
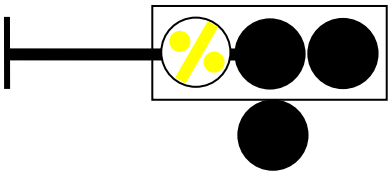
R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	0	0	1	1	1	0	0	0	1	0	0	0	1	1	1	0

Case no.	Applicable Signal	Next Signal
28		

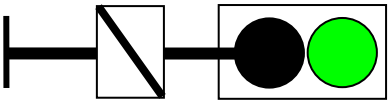
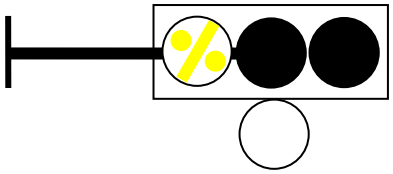
R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	1	X	0

29		

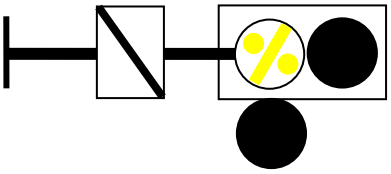
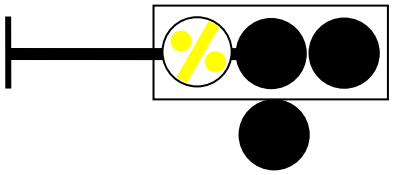
R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	0	0	1	0	1	0	0	0	0	0	0	1	1	1	X	0

30		

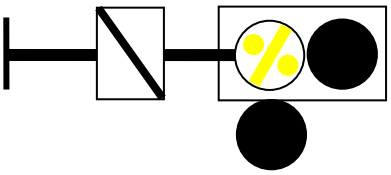
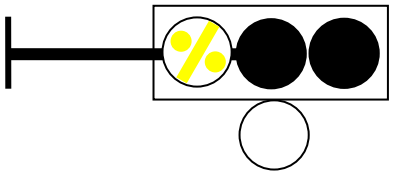
R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	1	X	0

Case no.	Applicable Signal	Next Signal
31		

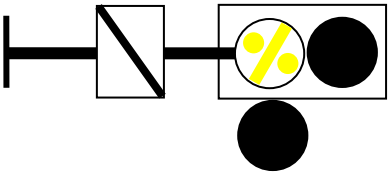
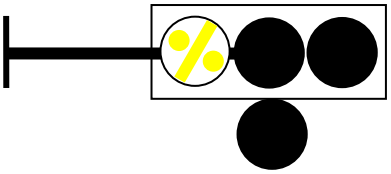
R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	0	0	1	0	1	0	0	0	0	1	0	0	1	1	X	0

32a		

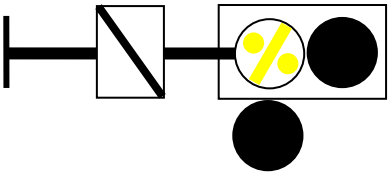
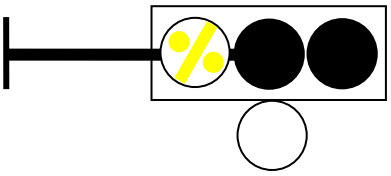
R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	1	0	0	0	1	0	0	0	0	1	0	0	1	1	1	1

32b		

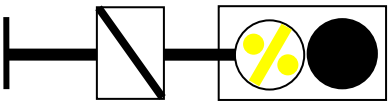
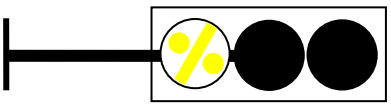
R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	1	0	0	0	1	0	0	0	0	1	0	0	1	1	1	1

Case no.	Applicable Signal	Next Signal
32c		

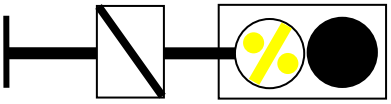
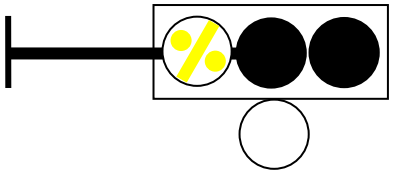
R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	1	0	0	0	1	0	0	0	0	1	0	0	1	1:20	1	1

32d		

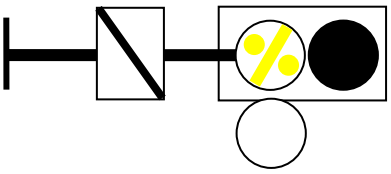
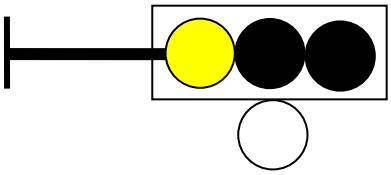
R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	1	0	0	0	1	0	0	0	0	1	0	0	1	1:20	1	1

32e		

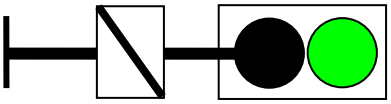
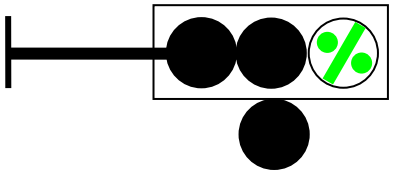
R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	1	0	0	0	1	0	0	0	0	1	0	0	1	1:12	0	0

Case no.	Applicable Signal	Next Signal
32f		

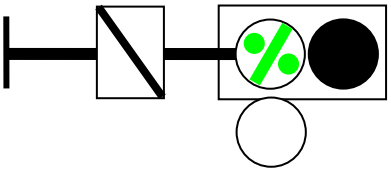
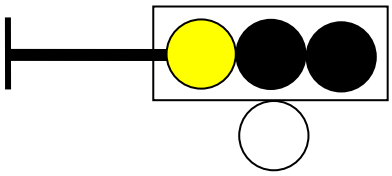
R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	1	0	0	0	1	0	0	0	0	1	0	0	1	1:12	0	0

33		

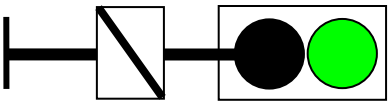
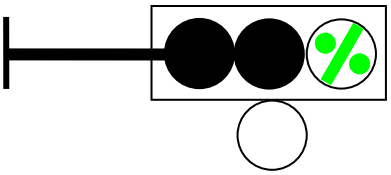
R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	1	0	0	1	1	0	0	0	1	0	0	0	1	1:12	1	0

34		

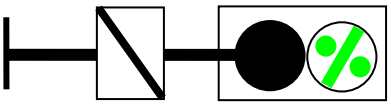
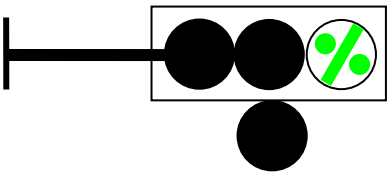
R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	1	X	0

Case no.	Applicable Signal	Next Signal
35		

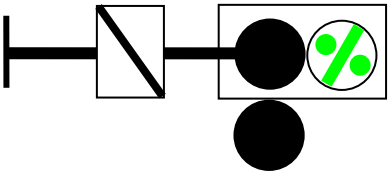
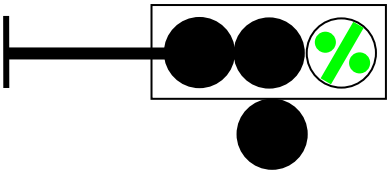
R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	1	0	1	1	1	0	0	0	1	0	0	0	1	1	1	0

36		

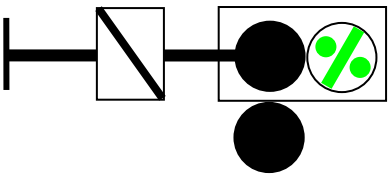
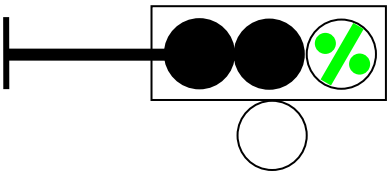
R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	0	0	1	0	1	0	0	0	0	0	1	0	1	1	X	0

37		

R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	1:20	0	0

Case no.	Applicable Signal	Next Signal
38		

R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	1	1	1

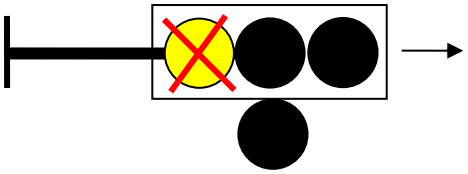
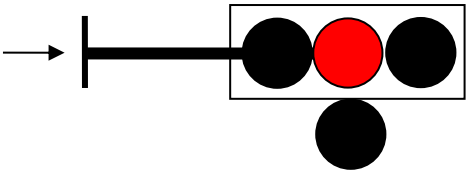
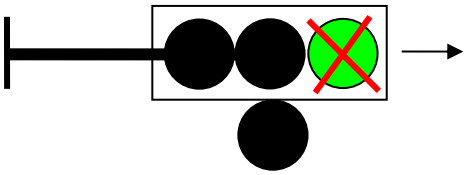
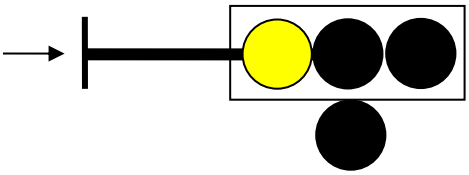
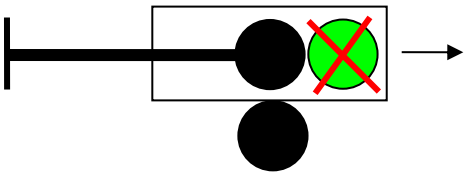
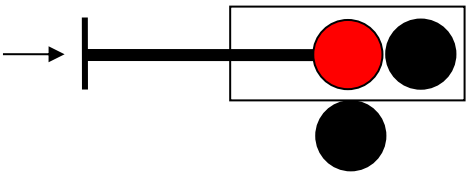
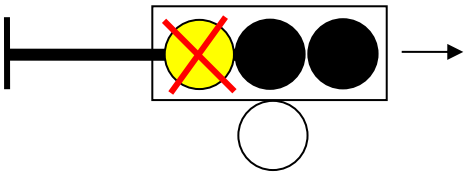
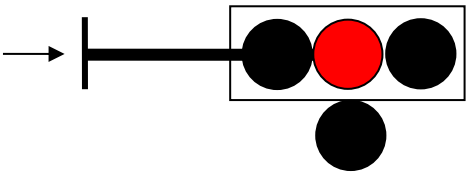
39		

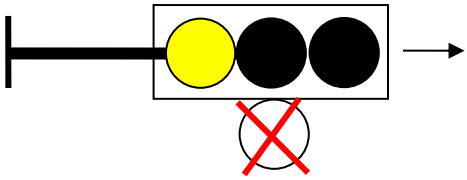
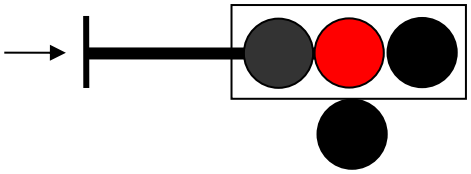
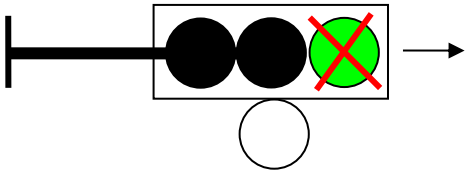
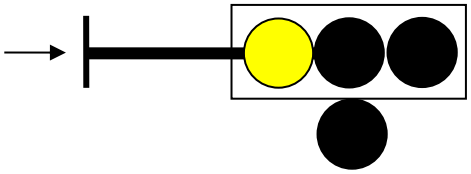
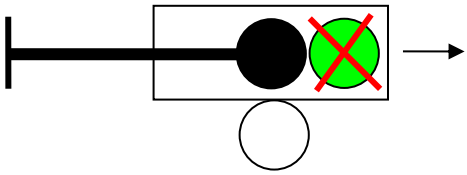
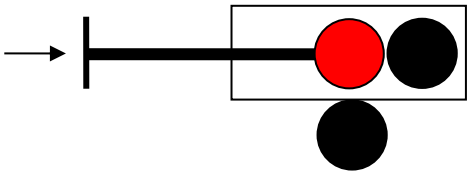
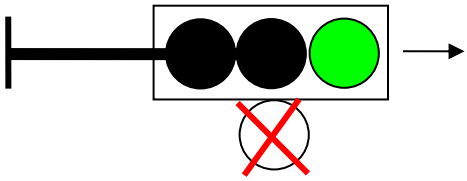
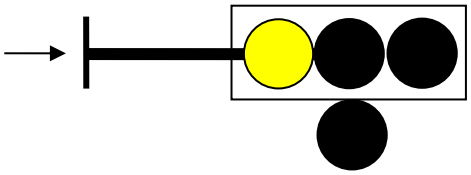
R	H	FH	FD	D	W	SU	NB	NH	R	H	FH	FD	D	W	SU	NB	NH
0	0	0	1	0	0	1	0	0	0	0	0	1	0	1	1	1	1

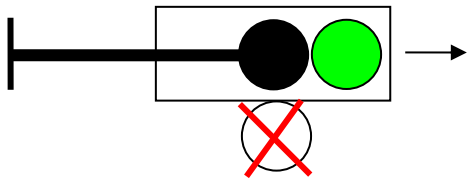
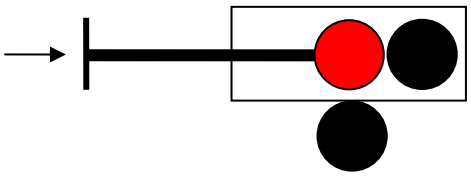
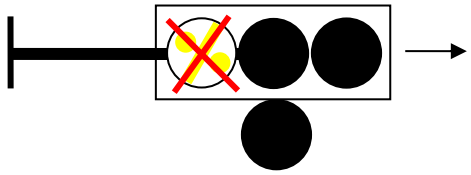
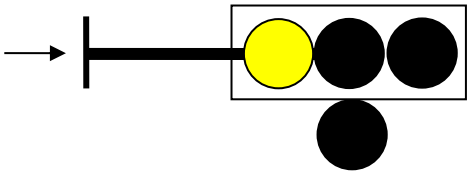
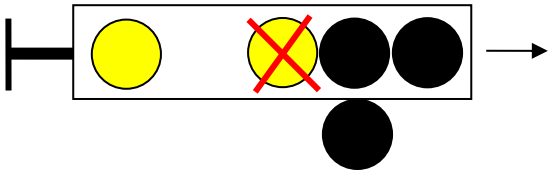
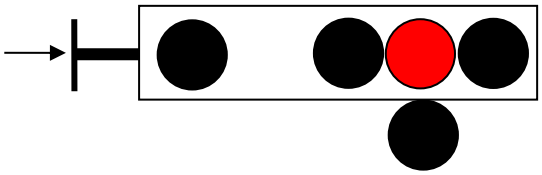
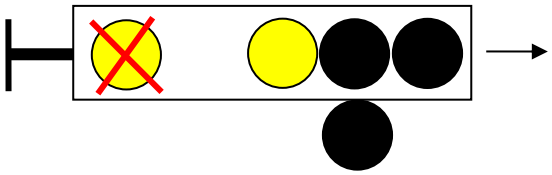
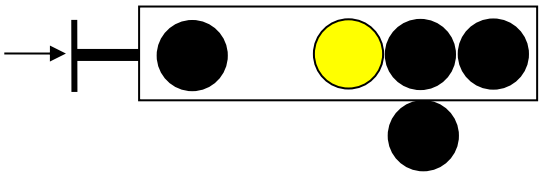
9. Annexure B

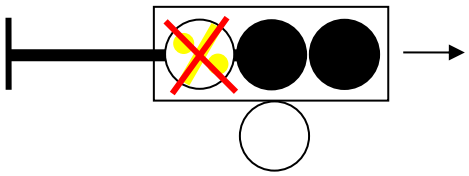
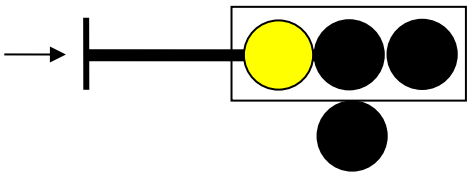
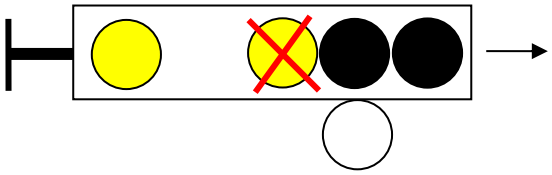
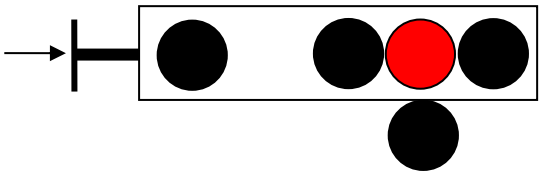
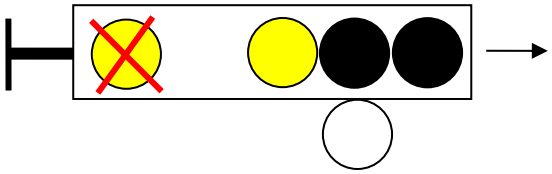
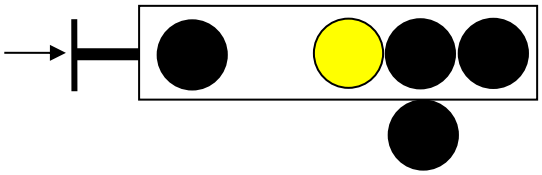
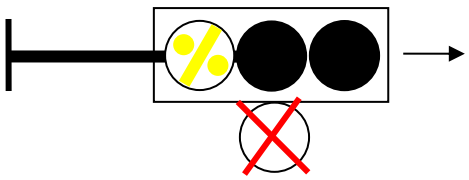
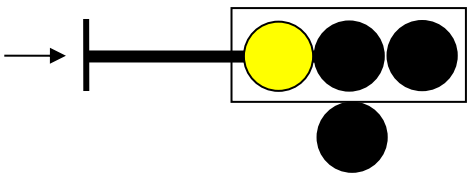
9.1. Reduced Aspects on Called Signal with failures:

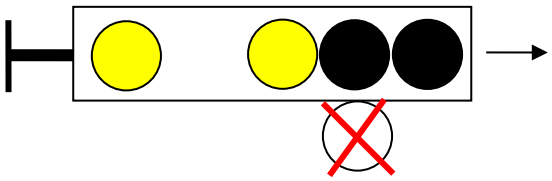
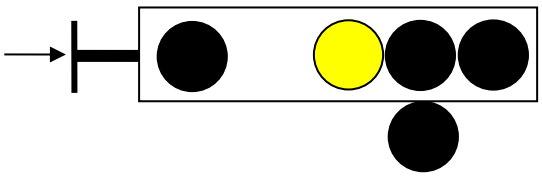
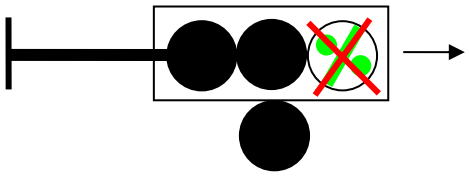
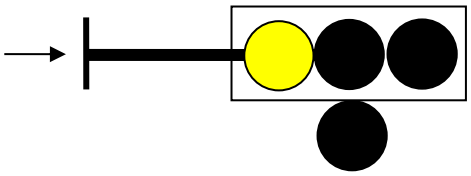
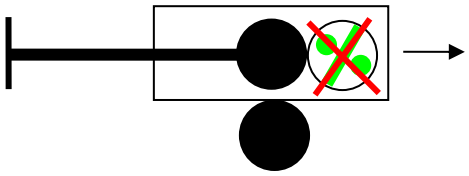
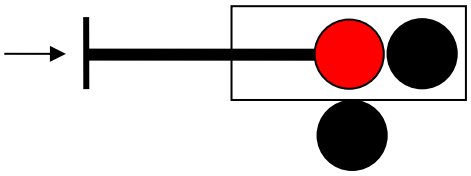
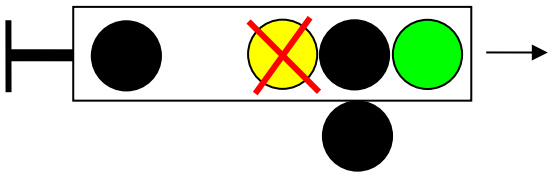
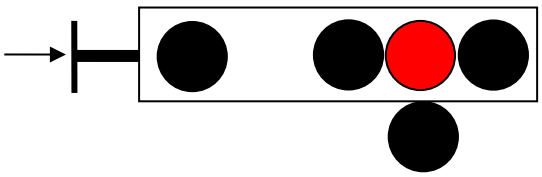
A red cross over an aspect in the table drawings indicate that the specific aspect has failed.

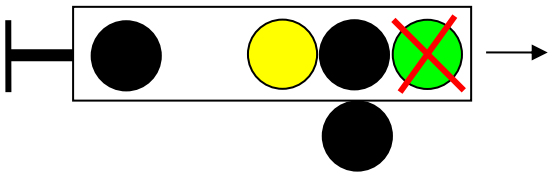
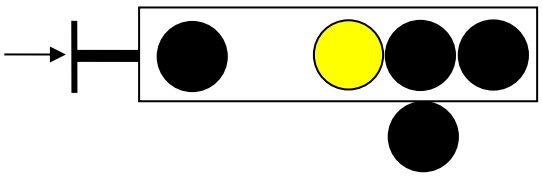
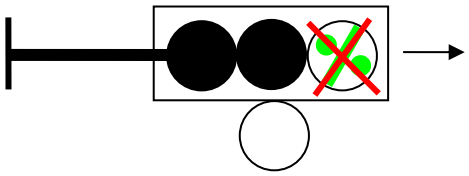
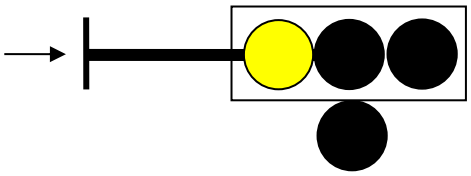
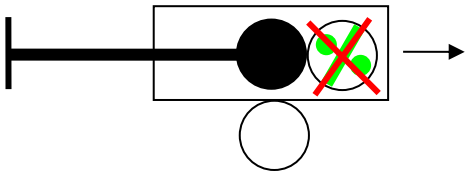
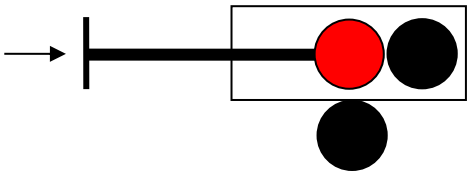
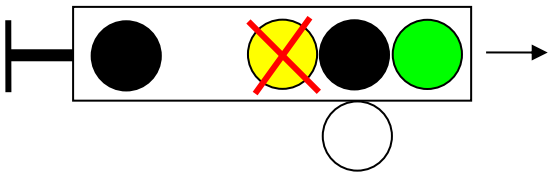
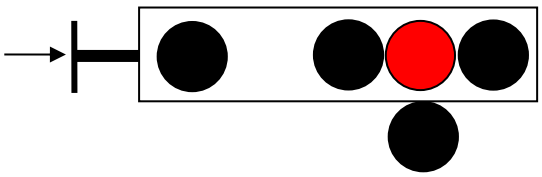
Case no.	Called Aspect	Reduced Aspect
1		
2a		
2b		
3		

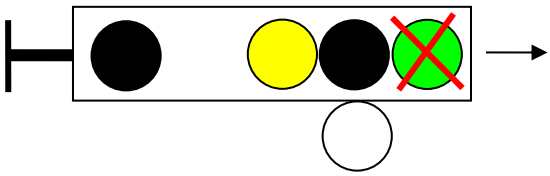
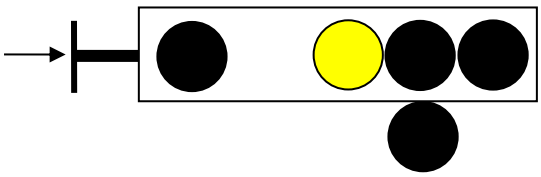
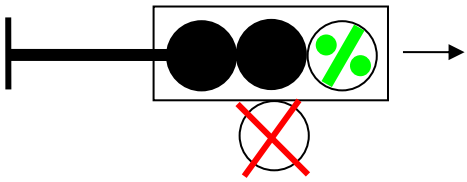
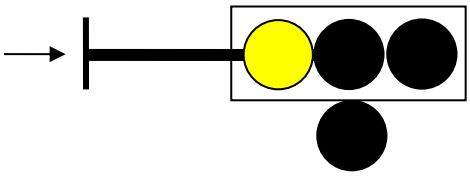
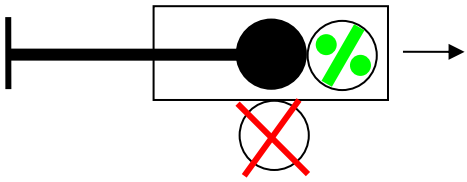
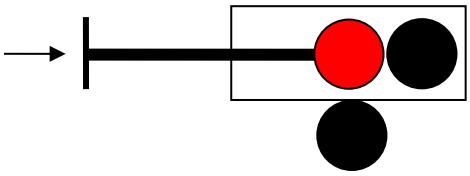
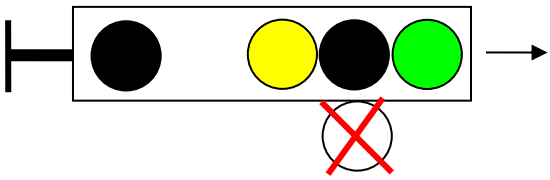
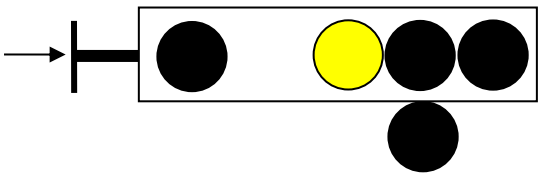
Case no.	Called Aspect	Reduced Aspect
4		
5a		
5b		
6a		

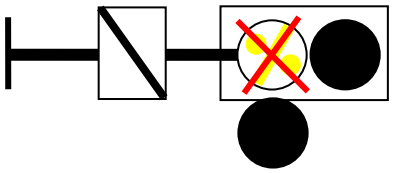
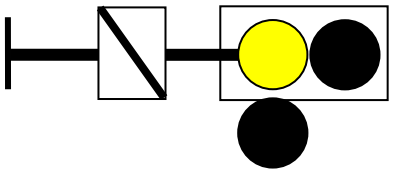
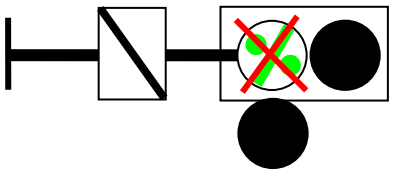
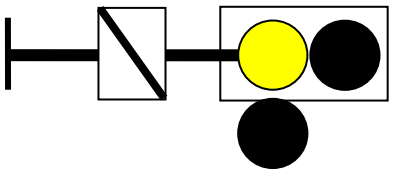
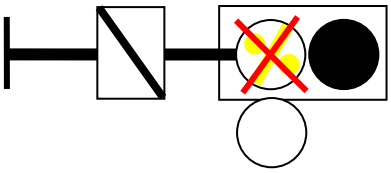
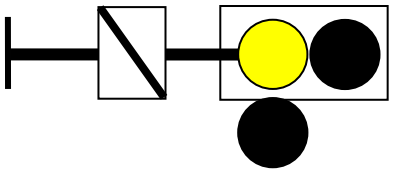
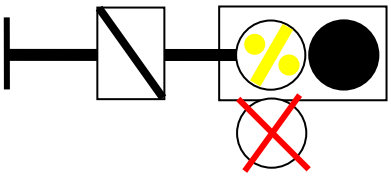
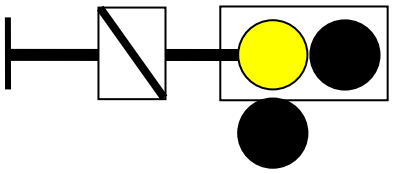
Case no.	Called Aspect	Reduced Aspect
6b		
	Flashing fails:	
7a		
	First Yellow fails:	
7b		
	Second Yellow fails:	
7c		

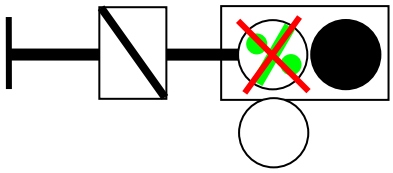
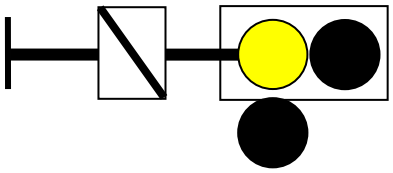
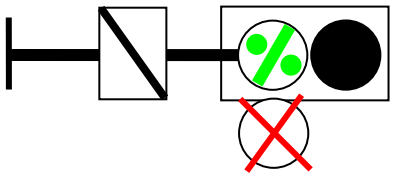
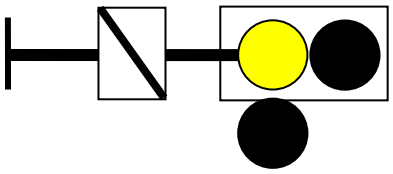
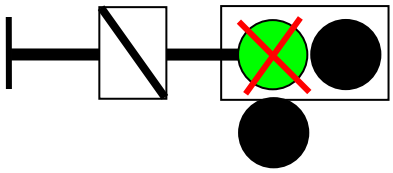
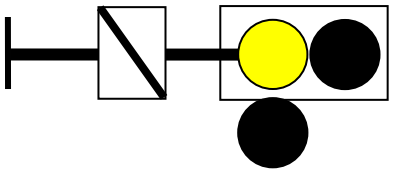
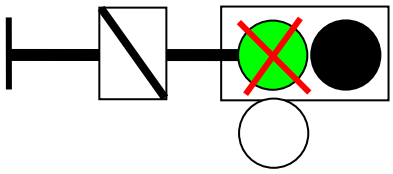
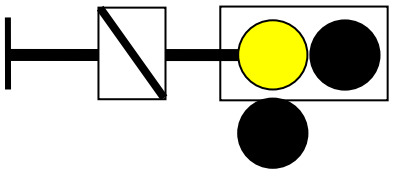
Case no.	Called Aspect	Reduced Aspect
	Flashing fails:	
8a		
	First Yellow fails:	
8b		
	Second Yellow fails:	
8c		
9a		

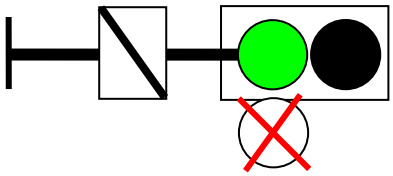
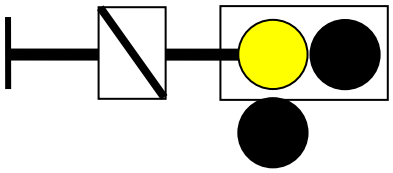
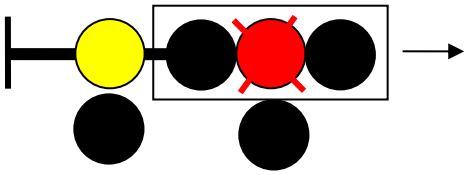
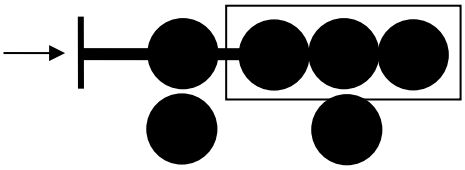
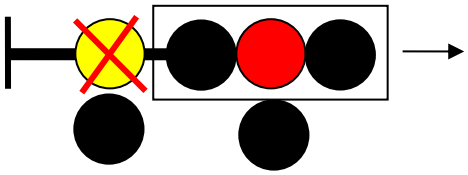
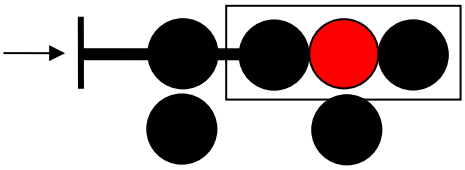
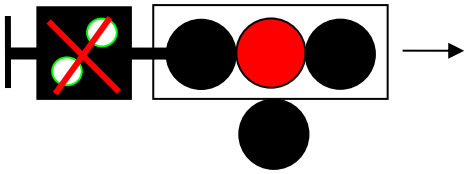
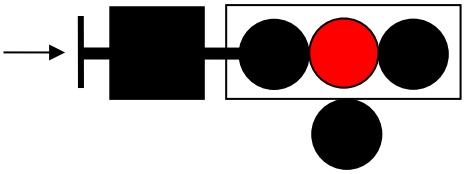
Case no.	Called Aspect	Reduced Aspect
	First Yellow fails:	
9b		
	Flashing fails:	
10a		
	Flashing fails:	
10b		
	First Yellow fails:	
10c		

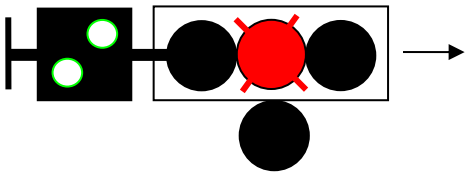
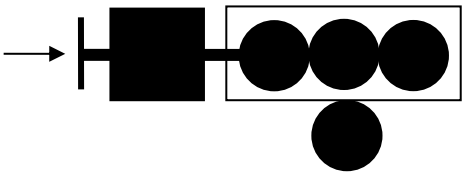
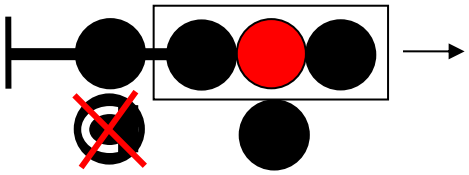
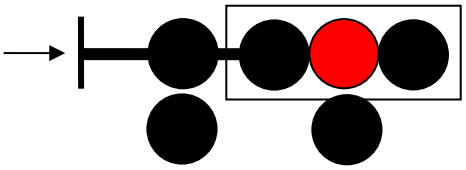
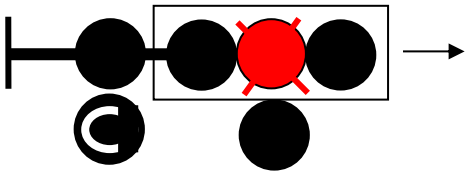
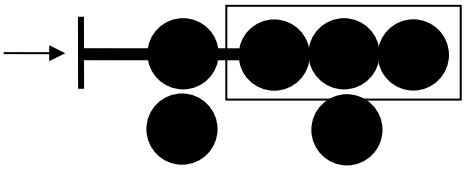
Case no.	Called Aspect	Reduced Aspect
	Green fails:	
10d		
	Flashing fails:	
11a		
	Flashing fails:	
11b		
	First Yellow fails:	
11c		

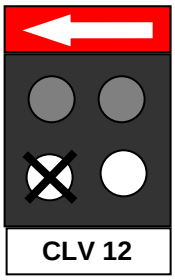
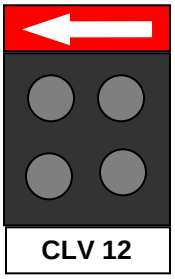
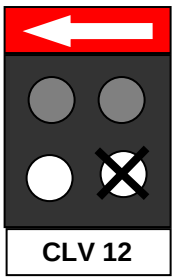
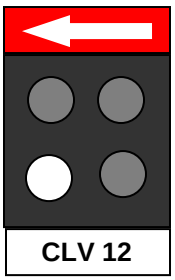
Case no.	Called Aspect	Reduced Aspect
	Green fails:	
11d		
12a		
12b		
12c		

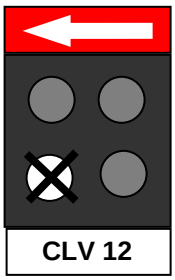
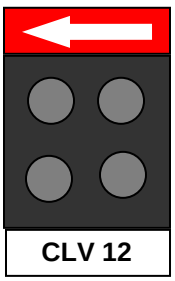
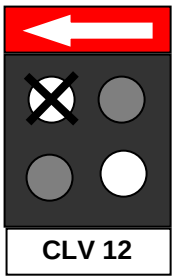
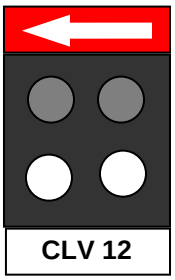
Case no.	Called Aspect	Reduced Aspect
	Flashing fails:	
13		
	Flashing fails:	
14		
	Flashing fails:	
15		
16		

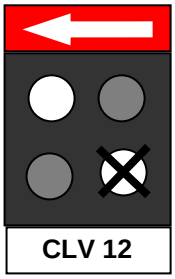
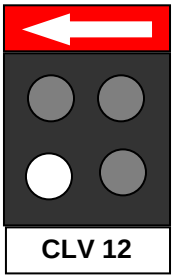
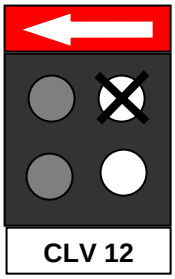
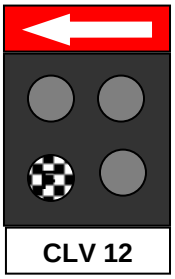
Case no.	Called Aspect	Reduced Aspect
	Flashing fails:	
17		
18		
19		
20		

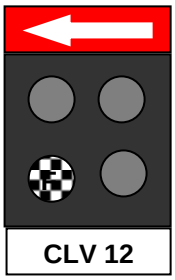
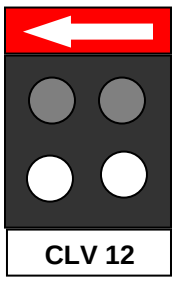
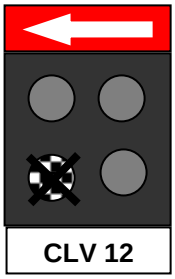
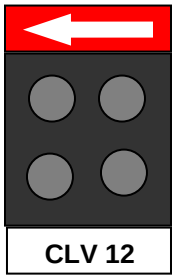
Case no.	Called Aspect	Reduced Aspect
21		
22		
23		
24		

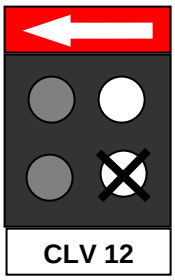
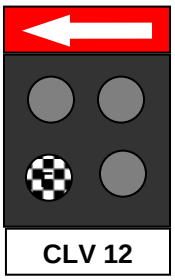
Case no.	Called Aspect	Reduced Aspect
25		
26		
27		
28	When any proceed aspect with turnout indicator has been called. → Turnout indicator fails.	The proceed-aspect remains.

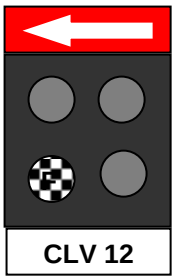
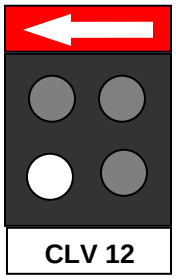
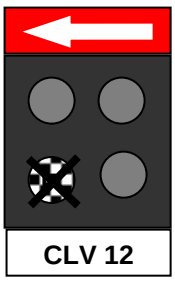
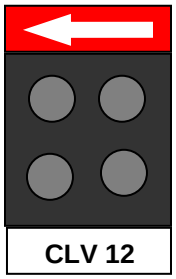
Case no.	Called Aspect	Reduced Aspect
29	When any proceed-aspect with turnout indicator has been called. → No proceed-aspect displayed.	Turnout indicator switches off.
30	 DANGER STOP	 DARK DANGER STOP
31	 DANGER STOP	 DEFAULT DANGER STOP

32	 **DEFAULT DANGER STOP**	 **DARK DANGER STOP**
33	 **SHUNT ASPECT PROCEED WITH CAUTION AS FAR AS LINE IS CLEAR OR TO THE NEXT STOP SIGNAL OR SHUNTING LIMIT**	 **DANGER STOP**

34	 **SHUNT ASPECT PROCEED WITH CAUTION AS FAR AS LINE IS CLEAR OR TO THE NEXT STOP SIGNAL OR SHUNTING LIMIT**	 **DEFAULT DANGER STOP**
35	 **RUNNING ASPECT THIS IS AN INTERMEDIATE SIGNAL THAT CAN BE PASSED**	 **FAULTY CAN BE PASSED**

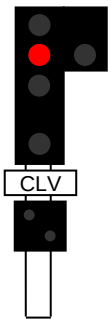
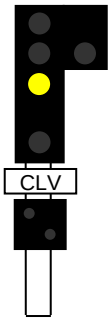
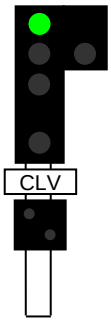
		Signal replaced by train passing:
36	 **FAULTY CAN BE PASSED**	 **DANGER STOP**
37	 **FAULTY CAN BE PASSED**	 **DARK DANGER STOP**

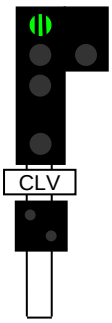
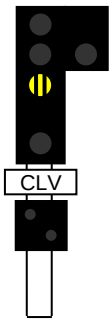
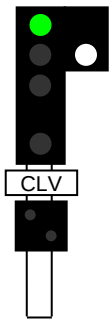
38	 **RUNNING ASPECT THIS IS AN INTERMEDIATE SIGNAL THAT CAN BE PASSED**	 **FAULTY CAN BE PASSED**

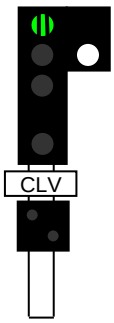
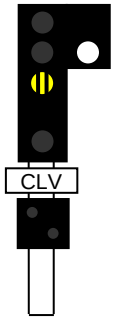
		Signal replaced by train passing:
39	 **FAULTY CAN BE PASSED**	 **DANGER STOP**
40	 **FAULTY CAN BE PASSED**	 **DARK DANGER STOP**

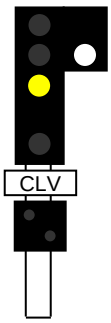
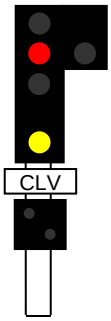
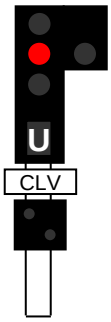
10. Annexure C:

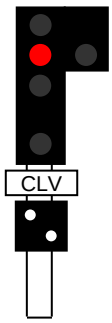
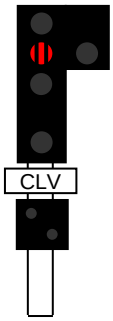
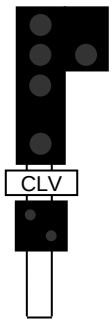
10.1. Aspects and their Meaning in the Operating Rules:

ASPECT	SIGNAL	MEANING
Red light		Danger - stop
Yellow light		Proceed, but stop at next signal unless it is seen to be at "proceed".
Green light		Proceed – next signal displays a "proceed" aspect

ASPECT	SIGNAL	MEANING
Flashing green light (the same as a green light and a yellow light (green above yellow))		Proceed at the correct speed for the train concerned to turn out or in over one or more sets of higher-speed points after this signal or the next signal. Next signal displays a "proceed" aspect. NOTE: Should the flashing green light fail the signal will display a yellow light.
Flashing yellow light (the same as two yellow lights (yellow above yellow))		Proceed at the correct speed for the train concerned to turn out or in over one or more sets of lower-speed points after this signal or the next signal. NOTE: Should the yellow light fail the signal will display a red light. Should the flashing fail the signal will display a yellow light.
White light in conjunction with a green light		Proceed, but be ready to stop at the second signal in advance, situated at less than breaking distance beyond the next signal. NOTE: Should the white or green light fail the signal will display yellow light.

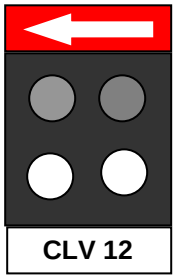
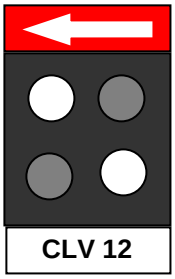
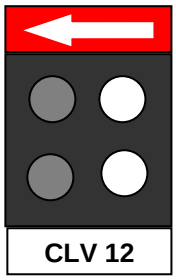
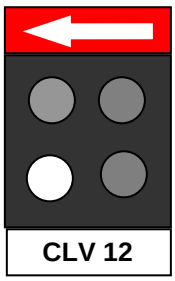
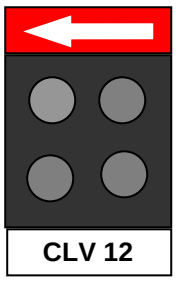
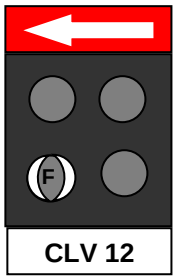
ASPECT	SIGNAL	MEANING
White light in conjunction with a flashing green light (the same as a white light in conjunction with a green and yellow lights (green above yellow))		Proceed at the correct speed for the train concerned to turn out or in over one or more sets of higher-speed points after this signal or the next signal. Be ready to stop at the second signal in advance, situated at less than breaking distance beyond the next signal. NOTE: Should the flashing, white or green light fail the signal will display a yellow light.
White light in conjunction with a flashing yellow light (the same as a white light in conjunction with two yellow lights (yellow above yellow))		Proceed at the correct speed for the train concerned to turn out or in over one or more sets of lower-speed points after this signal or the next signal. Be ready to stop at the second signal in advance, situated at less than breaking distance beyond the next signal. NOTE: Should the flashing or white light fail the signal will display yellow light. Should the yellow light fail the signal will display a red light.

ASPECT	SIGNAL	MEANING
White light in conjunction with a yellow light		Proceed slowly be prepared to stop at next signal that is situated at less than breaking distance from this signal. NOTE: Should the white or yellow light fail the signal will display a red light.
Red light and a yellow light (red above yellow) (goods or siding aspect)		Proceed – the train is being admitted onto a goods siding. [See rule No. 41(3).] NOTE: Should the red light fail the signal will display no light.
Red light and a white stencil light in the shape of a capital "U"(red above "U" light) (Route – signal aspect)		Proceed only if in possession of a valid order, token, warrant, etc authorizing the train onto the destination line. No destination signal. Route set, locked and proven up to the end of colour light signalling. NOTE: Should the red light fail the signal will display no light.

ASPECT	SIGNAL	MEANING
Red light and two white lights at a angle of 45 degrees (red above two white lights) (shunt aspect)		Proceed with caution as far as line is clear or to the next stop signal or shunting limit. NOTE: Should the red light fail the signal will display no light.
Flashing red light (the same as red light and a blue light (red above blue) (emergency aspect)		Stop – then proceed in such a manner that train may be stopped within sight distance – points, where provided, correctly set but track circuits out of order and/or line possible occupied. [See sub clause7005.4, Section 7 of the General Appendix (Part I0.] NOTE: Should the flashing fail the signal will display a red light
No light (in stop signal)		Danger - stop

A three position intermediate shunt signal may be fixed near ground level or on a post by itself and displays the “danger” signal by means of two white lights in the horizontal position, the “caution” signal by means of two white lights at an angle of 45 degrees or “running” signal by means of two white vertical white lights.

A two position ground shunt signal may be fixed near ground level or on a post by itself and displays the “danger” signal by means of two white lights in the horizontal position or the “caution” signal by means of two white lights at an angle of 45 degrees.

 **DANGER STOP**	 **SHUNT ASPECT PROCEED WITH CAUTION AS FAR AS LINE IS CLEAR OR TO THE NEXT STOP SIGNAL OR SHUNTING LIMIT**	 **RUNNING ASPECT THIS IS A INTERMEDIATE SIGNAL THAT CAN BE PASSED**
 **DEFAULT DANGER STOP**	 **DARK DANGER STOP** **WHEN SIGNAL WAS CLEARED OVER IT CAN BE PASSED**	 **FAULTY CAN BE PASSED**