

Guidance Document

G2521 Programme Machines

(Formerly M7057)

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MAYOR OF LONDON

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1 Purpose

- 1.1 This document is the Manual of good practice relating to the application of Programme Machines to Signalling Control Systems presently used on London Underground.
- 1.2 The Control of the London Underground railway is exercised through a Control system of which the signalling Control system is a part. The philosophy of Signalling Control Systems is described in standard E7002, Signalling Control Systems.

2 Scope

- 2.1 This Guidance Document applies to Programme Machines in service at the date of issue of this document.
- 2.2 This document replaces M7057 A2.

3 Requirements

3.1 Safety considerations

3.1.1 General

- 3.1.1.1 The programme machine system is a non- vital system and as such does not have to be assured to vital standards. However it is safety related, in that a failure of the system can result in delays to train services and trains being held in tunnels between stations. The vital integrity of the signalling system is provided by the interlocking.

3.3.2 Product Safety

- 3.3.2.1 The programme machine, as already stated, is prevented from causing an unsafe situation on the railway by the interlocking. The lever operation circuits mirror the interlocking design to ensure that conflicting requirements are not requested; however as these circuits are to non-vital standards the interlocking assures the safety of the railway.

3.3.3 Occupational Safety

- 3.3.3.1 The programme machine system is located in secure equipment rooms such that only authorised persons may come into contact with the equipment. All engineering staff working on the programme machine system require to be trained in its operation and potential occupational hazards.
- 3.3.3.2 The design of the system minimises hazards such as high voltages and finger traps. When working on the system care needs to be exercised due to the presence of 100V supplies and air pressure of 60 psi (47.8kg/m²).

3.2 Functional requirements

3.2.1 Operational Requirements

3.2.1.1 Modes of Operation

- 3.2.1.1.1 There are four modes of operation
 - (a) Programme Machine
 - (b) Programme Machine Only
 - (c) First Come First Served

(d) Push Button (Routes called for manually)

(a) Programme Machine

In this mode for a route to be called there must be available the correct set number, train description, route availability and timetable time coincidence with the train present at the sighting point.

- (i) The set number from the programme machine, in binary form, is transmitted to the Control room, decoded and displayed on a diagram.
- (ii) The train description code from the programme has to make a correspondence check with the Train Describer System (a totally separate system) to request a route.
- (iii) The route hole allows an independent reference (i.e. separate from the train description) for the route to be taken. At a diverging junction such as previously used at Kennington on the northbound, a train could take a route via Charing Cross or the City, but still have a destination of Barnet. If there are more than 4 routes the route holes are used in a binary form but the first four major routes must have a one hole code i.e. 8, 4, 2 or 1 of the allocation then the remaining subsidiary routes have a code using more than one code hole.
- (iv) The code on the programme coded holes make reference to the 0.5 minute pulse true time unit and until there is co-incidence between them the route will not be called.

Unless all of the above references, (ii) to (iv) are satisfied the route will not be called.

(b) Programme Machine Only

In this mode of control the coded holes are as for the PM mode except that the Train Description reference to the Train Description systems is not made. This mode is used when the incoming Train Description from a system is not received, due to failure etc. When all the other references are satisfied; the route clears and is accepted. The Train Description from the programme machine roll is transmitted into the TD system without the Operator having to take any action.

(c) First Come First Served

In this mode of control there is no reference made to time or time co- incidence. The route is requested in accordance with the Train Description system with a train on the berth track of the signal. The machine will step when the route has been accepted. The above applies to either diverging or converging junctions. This mode is used when time tabled train movements are running very late and out of order and keeps trains moving without the Operator taking action. At terminal stations an indication will be provided to the Operator after the train has been in the platform for 90 seconds, but the route for the next bound will not clear until the Operator selects it.

(d) Push Button (Routes called for manually)

In this mode the programme machine does not call for any routes. All routes are requested by manual operation of a route button. Manual routes which conflict with any programme machine routes are interlocked and cannot be requested unless the programme machine is in PB mode. The programme machine will step when a route is accepted unless the Operator has taken action and injected an extra train path into the programme.

The following are two examples of PB operations:

- (i) with a train approaching a diverging junction signal which is programmed for both branches; route 1 to platform 1 and route 2 to a siding for a reversing train. The programme machine is registering a train movement for route 1 but the Operator has been informed that the train is to be taken out of service so the Operator places the machine into PB mode. When the train is on the berth track, the Operator operates the route button to allow the train into the siding. With the train accepting the route the machine will step, without transmitting any train description forward, to the next train register so keeping to the programme of time tabled train movements.
- (ii) With a train in a siding and when a non-programmed route is required, which conflicts with any route set up by a programme machine or machines, the Operator has to place the machine or machines into PB mode and inject an extra train condition into the machine or machines so that when the route is accepted the machine or machines do not step and so keep to programme.

3.2.1.2 Commands

The following commands are one train movement over-rides of programme machine functions.

Programme Machine Acknowledge With a Programme Machine in PM mode and the machine registering a train; should there be an out of agreement of the Train Description on the programme to that from the Train Description system with the arrival of the train, a warning is given to the Operator. If the Operator takes no action within one minute then the Train Description from the Train Description system will be transmitted forward and the route called. If the Operator takes action by operating a button named Programme Acknowledge "PM.ACK" the Train Description from the machine will be transmitted forward.

The PM.ACK button does the same operation as the PMO mode but only for one train movement.

No Out Of Turn ("NOOT")

This over-ride of the programme machine is only for converging junction machines. With the machine in PM mode and trains arriving at the signal protecting the junction, after one minute out of turn train movements can occur. However if the Operator takes action following a warning that an out of turn train movement is to take place, by operating the NOOT button, this will prevent the out of turn train movement from taking place for the one train movement.

Train Ready to Start (Terminal Stations) When a Terminal Station has had a disruption of service and trains are being dispatched in FCFS mode, as the trains arrive into the platforms and following expiry of a predetermined layover time, a Train Ready to Start button will flash on the desk. When the Operator operates the button, the route for the first train out will be requested.

Train Cancellation

In the event of a timetabled train, i.e. a train registered on a programme machine, being taken out of service or not being brought into service there are facilities to store one cancelled train on each programme machine at a time. Should the train appear again on the programme roll some hours later the process of cancelling the train on the machine must be repeated. A further requirement is that only one machine at a time be activated to ensure the instruction to cancel is stored. Once in store, another programme machine can be dealt with. Although any number of machines can be primed to await the instruction to cancel, the voltage drop when the control circuits are activated for more than one machine can result in the cancel function not switching into the store.

To cancel a train, the Operator selects the Programme Machine at any time prior to the cancelled train's scheduled time. He then selects the train number buttons (3 digit) and the number is displayed on a unit on the desk. Facilities to alter or erase the number are provided in case of mal-operation so that the operation can be repeated. Having primed the control circuits for the programme machine, the train cancel button is operated. The number is now placed in store and an indication is given to say the machine has a train cancellation requested stored on it. The Operator has the facility to recall the machine to check the set number on his desk at any time. When the programme machine steps on to the train to be cancelled, the number on the programme and the number in the store will be in co- incidence. The co-incidence will step the machine to the next register, cancelling the number in the store unit. At the same time the desk unit will indicate three zeros and the train cancel indication for the machine will be extinguished. The machine can now be reprimed if necessary as only one train cancel or extra train store is possible on any machine.

To cancel a train through a site with more than one programme machine in the route, the train entry on each programme machine needs to be cancelled from each machine in the route.

Extra Train Running

Should there be a requirement to have a train path for a non-programmed train between the programmed trains, the same storage unit is used as for the Train Cancel. The action of priming the storage is similar to that for the train cancel except that the programmed train registered number preceding the extra train path is placed in the store. For example if the programme register set numbers are 065, 033 and the sequence is to be 065, extra train path, 033, the number to be put in store is 065.

The Operator, having input the set number (which can be altered or erased), now activates an Extra Train Button for the machine. The restriction of one extra train or train cancel on a machine at a time applies as for the Train Cancel. Upon the set number entering the store, the desk unit will show the number with a red frame around it and an indication to show that the machine has an extra train. The Operator can recall the machine to view the set number with its red frame.

For the above example, with the machine registering 065, there is number co-incidence with the storage and a further storage will be primed to indicate that the extra train path follows this train. When 065 accepts the route the machine will step to register 033. The storage will cancel the extra train but the indication will remain illuminated until the store is empty i.e. all out of turn storage is removed.

The Operator, on a diverging junction, will place the programme machine in PB mode, operate the route button and initiate the Train Description. If necessary for a converging junction the Operator can place the machine in PB or FCFS. In FCFS the route will be requested when the train is on the berth track of the junction home signal.

When the Extra Train accepts the route, the machine will not step but the extra train store will be cancelled and the Extra Train indication extinguished. The machine is now in the normal state and can be reprimed if necessary as only one Extra Train or Train Cancel store is possible on a machine at a time.

Immediate Extra Train

The predetermined Extra Train path held within store is suited to a simple converging or diverging junction when each junction has only its own junction to consider. When the site is complex with machines at diverging junctions and converging junctions with parallel train movements, the machines on each parallel track could be out of time sequence making it difficult to select a predetermined path for the extra train to be placed in store. Under these conditions, though the machines have the predetermined extra train facility, the immediate Extra Train condition is used. This has a similar

method of setting up except that the set number is registered as three zeros with a red frame.

The Operator selects the machines as for Extra Train, but from visual observation of the signalling diagram knows the location of the extra train. The Operator will put the Extra Train path into the "next train is an extra train" store when he chooses and place the machine in PB mode and operate the appropriate route button. With the extra train accepting the route the machine will not step but the store will be cancelled. The machine can then be returned to any one of the modes.

3.2.1.3 Control Room Interface

3.2.1.3 The Control Room Interface to the Operator comprises:

- (a) Desk comprising controls and telephones
- (b) Signalling Diagram
- (c) Warning Panels
- (d) Programme Machine Diagram

Details of these are contained in section 3.4.1.8.

3.2.1.4 Site Specific Requirements

Depots

All of the Depots and Stabling sidings for programme machine working have similar circuits as most of the train movements are uniform, except for Parsons Green. At all the conventional sites a train programmed from the Main line will have its signal reading into the Depot reception road from where the shunter then takes over the control of the train. When it is in the reception road, or as at High Street Kensington where there is no reception road and the train movement is from the mainline to the siding direct, the train driver will operate a plunger to confirm the train is for the sidings and not the mainline. For train movements from the sidings or reception road to the mainline, i.e. coming into service, the train driver has to activate a plunger which will inform the Operator that the train is ready to start, so that the Operator knows that the route will be requested by the programme machine at the time tabled time. If the train is not ready then the Operator can take another course of action.

Turnaround Sidings on this Site Where the timetable has a regular programme of reversing trains other than at terminal stations and the programme coded holes have been fully used on one register, it became necessary to have two registers. The first register is for the normal train movement and when the train has accepted the route the machine steps to the second register which contains the Train Description for the next journey. This is transmitted into the Train Describer System when the train departs the siding.

3.2.2 Degraded Modes of Operation

- 3.2.2.1 Loss of Train Description (TD) In the event of the Train Description (TD) system having failed and therefore not receiving information for the Programme Machine to refer to, a facility is provided to keep trains operating in which the Programme Machine makes reference to all other information except the TD. The programme machine to be placed in Programme Machine Only (PMO) mode; in this mode the routes will be requested. When a route is accepted the TD from the programme roll will be transmitted into the TD system.

3.2.2.2 Loss of Sequence

- 3.2.2.2.1 In the event of the 0.5 minute synchronous clock system failing, the Time machine or the electronic timing units will not be functioning as time co-incidence will not be available. Under these conditions the Programme Machine, by being placed in the FCFS mode of control, will maintain train movements as time is not referenced for train movements in this mode.

When the pulse system is restored, the Line Controller or Operator will communicate with the Technician to reset the Time Machine or Timing Units at the remote sites to the registered time. With this operation completed, the Operator can place the programme machine back into PM mode.

- 3.2.2.3 Loss of Centralised Control In the event of the loss of Centralised Control for a remote site, the programme machines for that site transfer to the PM mode and will therefore continue routing trains.

When Centralised Control is restored, the Line Controller or Operator will communicate with the Technician to reset the Programme Machines at the remote sites. With this operation completed, the Operator regains full control over the Programme Machines.

3.3 Performance requirements

3.3.1 Timetable Size Constraints

- 3.3.1.1 The carrier for the programme machine consists of two take up rollers, similar to an old scroll, with a magnet spring load ring on each; the rings are outside the body of the carrier. Between the rollers there is a flat nickel plate, attached to the rollers, on which the programme roll material is placed. The programme roll is held flat against the plate by a Perspex strap. The nickel plate has 30 holes evenly pitched across its face for the code pins to pass through plus two holes for light to pass through to activate photo cells. These latter holes are the register position for the programme. The distance between each register is a minimum of 10.16mm (0.4inch). This measurement can be varied as it is not critical for the stepping of one register to the next, the limit of the stepping is the photo cell hole in the programme roll included in every register.
- 3.3.1.2 Approximately 1200 registers can be accommodated on a full roll (at 10.16mm separation between registers). An example of a roll allocation, for a machine with 1 register for every train movement, is given below.

Registers

Monday to Friday at 25 trains an hour for 18 hours gives 450

Saturday at 20 trains an hour for 18 hours gives 360

Sunday at 18 trains an hour for 16 hours gives 288

Total 1098.

With the addition of the start and end of service register the carrier is nearing its maximum meaning that at a busy site where there is a double step the timetable programme is put on two carriers, one for Monday-Friday and the other for Saturday-Sunday.

3.3.2 Programme Machine Roll Information

The information is contained in "register form" and is detailed in Appendices below.

3.3.3 Storage Constraints

3.3.3.1 The programme machine, being a mechanical device, is only able to read one register at a time and unable to read what has gone or what is to come whilst reading a register. Circuit design outside of the programme machine to store register information was considered to be uneconomic at the time that the system was designed. A few machines have storage of a register as the amount of information is small. The storage is of future train movements and not those already run. The facility to provide more than one storage condition was considered to be uneconomic. The storage is provided for Train Cancel or Extra Train functions and for running out of turn. For this latter case up to five trains on one package store unit can be accommodated, with another package unit connected if more storage is required. The store only records a train is out of turn and does not make reference to the set numbers.

3.3.3.2 With the programme machine in PB mode and routes being called for by operation of a route button, one conflicting route can be selected and stored. The indication in the route button is

Route not called Extinguished

Route called or requested Yellow

When a route is set, the Signal diagram will show a green signal and the route button will continue to indicate yellow.

3.3.4 Means of Operation

3.3.4.1 The energy required for the programme machine operation is pneumatic and electrical. The air supply provides the energy via a cylinder to simultaneously move the 30 code pin contacts and ensure a good contact pressure on the code pin contacts.

3.3.4.2 The response time of the electro pneumatic valve to allow air onto the cylinder is approximately 0.5 seconds from the open contact to the closed contact of the coded pins. The stepping of the programme machine is by electric motor in conjunction with the release and application of the electric solenoid brake pads.

3.3.4.3 To rewind a programme roll of maximum length at 0300hrs takes approximately 3 minutes, with less time required for a programme roll of shorter length.

3.4 Design considerations

3.4.1 System Design

3.4.1.1 General

This chapter describes the technical design of the programme machine system comprising programme machine, control circuits, power supply and remote control subsystems.

3.4.1.2 Programme Machine

The machine has a removable carrier for holding the timetable information on the programme roll enabling timetable exchange with another timetable on another carrier when required. The timetable is in the form of punched holes on a roll of plastic material (Melinex polyester film) which is approximately 300mm wide and up to a maximum of 12 metres in length. It is rolled on to two axles on the carrier.