THE INTRODUCTION OF S STOCK

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The S Stock is the biggest single order for rolling stock in the history of Britain's railways, with 1,395 cars making 191 trains to replace the entire SSR fleet by 2015. There will be 58 eight-car trains for the Metropolitan Line, known as S8, having a mixture of transverse and longitudinal seating, followed by 133 seven-car S7 trains with longitudinal seating only. These provide 53 trains for the Circle & Hammersmith lines and then 80 trains for the District Line.

They are the first LU trains to be fitted with saloon air-conditioning, with each car having a roof-mounted module equipped for 50% redundancy in case of failure. A wide through gangway will permit easy movement between cars. They have been built with floors 120mm lower than current trains to reduce the step at platforms and provide improved level access. Except for the four corner seats which are boxed to conceal equipment, seating is cantilevered from the car body sides, which will allow luggage to be placed beneath whilst also improving security, since unattended items are easily spotted. The trains feature all-motored axles fitted with a regenerative braking facility, and will be capable of 750v operation as power systems are upgraded.

THE S STOCK PROGRAMME

The S Stock project started in March 2005 with production of the first train, known as PP1 (Pre-Production 1), beginning in the first half of 2008. Four-car static testing started in August, with dynamic testing on the Derby test track lasting a year from late 2008. This train moved to Old Dalby in November to take the place of T2, which had spent only a short while at the Derby test track before moving to Old Dalby in February 2009.

T2 was transferred to Neasden Depot on 20 October, arriving in the early hours of the next day. The train was soon coupled with A Stock in the depot to trial failure procedures before it headed out onto the operational railway during engineering hours in early November. The Emergency Response Unit was already trained at Old Dalby in preparation for incident handling. An early test to achieve acceptance for operation of the new stock with A Stock, enabling it to travel to and from test locations during traffic hours, was undertaken between Neasden Depot and Moor Park. Initial testing will be on the Watford, Amersham and Chesham branches, and later to Uxbridge and south to Baker Street and Aldgate.

The first two trains are regarded as pre-series trains, intended for type testing. Four cars of the first production train, T3, have now been built and routine tests have been completed; the remaining four cars are in production. The first production driving-motor car (21004) completed climatic chamber testing at MIRA in Nuneaton, primarily to test the air- conditioning systems in both the saloon and cab. A start has been made on T4, with the first two cars in build on the production line, and the second two cars in an advanced state of sub-assembly, being readied for the production stage.

An outline chart of the S Stock programme showed that T1 is planned to join T2 in London around February 2010 for integration testing with systems at all platforms. Testing will include correct side door enable, selective door opening, platform-to-train microwave CCTV links, platform lengths, signal sighting, stopping marks, etc. Both trains will then be used for crew training. They will return to Derby for rework in mid-2010, being replaced by T3, which will be the first train to enter passenger service soon after. The two pre-series trains will have test equipment removed and interiors refitted to standard, before being used for 7-car integration testing on the rest of the SSR through most of 2011. They will enter service on the Metropolitan Line as the final S8 trains late in that year. In 2012 delivery of S7 stock for the Hammersmith & Circle lines will commence, continuing into early 2013, from when remaining trains will be delivered for the District main line until order completion in mid-2015.

OLD DALBY TEST FACILITY

The former BR Research track at Old Dalby, east of Loughborough near Asfordby, Melton Mowbray, has been equipped with 4km of four-rail track for vehicle type-testing. It is fitted with a variety of track forms and conductor rail types, and signalling equipment has been installed to make the infrastructure as representative as possible. This provides a dedicated facility with consistent, planned access available. It reduces track access requirements in London, with no impact on the operational railway. It also avoided delays which would have been caused by the need for a possession when testing commenced in London. However, the case for this investment was based on its use for mileage accumulation on each of the 189 production trains prior to delivery to London, avoiding the need for test paths on LU.

The pre-production 2009 Tube Stock trains were delivered before Old Dalby was available, and were tested on the 1km Derby test track, where they could reach their maximum 80km/h design speed. That order is for only 47 trains. However, the S Stock must be tested to its maximum 100km/h, which requires a longer run for both acceleration and braking. Production 2009 Tube Stock will also be tested on the Derby track before being transported to London.

STOCK LENGTHS

The S Stock will be longer than current trains. This is particularly noticeable through the open gangways of an 8-car train from one cab to the other, a view never seen before! However, the S8 train, at 133.68m over couplers, is only 2.2m longer than the current A Stock trains. On the District Line the S7 trains will, at 117.45m, be 6.55m longer than the D stock, which were themselves shorter than the trains they replaced. It is on the Hammersmith & Circle lines that the greatest difficulties will arise, with the new trains being over 23 metres longer than the current C stock, equivalent to adding another 1.5 cars to those trains! Selective door operation will therefore be necessary at some locations.

Selective door operation at short platforms will be automatic. If the train overruns the normal stopping mark by a short distance, it will allow the doors to be opened normally with the front car doors remaining shut and the normal doors for that platform remaining cut out at the rear of the train. Emergency open in other circumstances will assume worst case and retain four doors shut at both ends. For security, emergency open can only be obtained from the buttons behind the driver with the appropriate cab door open.

THE DRIVING CAB

The S Stock cab design was completed later than anticipated because of issues with getting the design right for operationally efficiency, especially placement of the Combined Traction/Brake Controller. This is now to be fitted to the left of the driving desk, freeing the right hand for operation of other equipment as required. As a result, the driving cabs of PP1 were originally fitted with temporary driving desks to allow movement around the factory and onto the test track. Photographs of these temporary desks were unfortunately published, but they have since been removed and the final design desks fitted. A fly-through video of the final cab design allowed a review of the main controls and equipment. This is the largest cab ever built by Bombardier. Even the cup holders for both sides involved much work to get them right!

Following a successful design process, which included a cab-seat road-show at all SSR train crew depots, the final design driver's seat has been chosen and the first units are currently being manufactured by Primarius Ltd. It is based on the refurbished D Stock seat with a number of key improvements (including lumber support and arm rests). The train is designed to withstand a forward impact up to 16km/h, above this speed crumple zones are designed to deform in a controlled manner around the driving position. Whilst there is some vertical adjustment provided in the seat, there is also a gas-strut supported adjustable foot rest to accommodate individual driver needs which means it will be possible for all users to maintain sight lines for signal sighting and maintain the correct position in relation to the TBC. A driver will need to know only three settings for their optimal position. All planning has been on the basis of a 30-second driver change-over, so set-up requirements have been minimised.

The screen-based Train Control Management System was demonstrated. The operator first enters their duty number, hand-held radio number and train number. This will log on to the Connect radio system automatically. A destination code is then entered – there are around 600 possible routings, non-stop patterns and destinations on the SSR, but only relevant possibilities will be displayed by the system. At platforms this display will indicate to the driver the state of all doors on each car, and provide access to relevant controls including announcements. Between stations the screen is mainly blank except for items that may still be required. When displaying the control panel, buttons are grouped in a logical manner, so that door control settings are together, as are cold weather switches for the cab demister, de-icing and sleet brushes. CCTV display can be selected for either camera in each car provided the train is stationary, and the relevant image will be automatically shown if a passenger emergency alarm is operated once the train has come to a stand.

THE DOOR SYSTEM

The door systems on S Stock are being built by Faiveley in France, and will feature both obstacle detection and anti-drag (sensitive edge) technologies. The obstacle detection system reopens a door 45mm to allow withdrawal, and then attempt to re-close. This is automatically repeated up to three times, after which the door continues to apply a closing force. The operator is then left as in the past, having to decide whether to reopen this door alone or insist on the obstruction being removed.

A sensitive door edge is intended to provide additional anti-dragging protection. Traditionally a push-back system is used, where one door of a pair is allowed to open 130mm against a spring, permitting the release of a trapped object. Dragging is detected by loss of the door interlock. On S Stock the doors remain locked once closed, and sensitive edge technology is only then enabled to detect dragging of a trapped object by the pressure on the door edge. This is in addition to a broad range of measures, including obstacle detection, platform CCTV, passenger emergency alarm operation, etc.

All passenger doors are fitted with sensitive edges which detect drag at any angle. The driver is informed of operation by an alarm, and the emergency brake is automatically applied within the platform area. A diagram showed how a bag strap could be trapped between closing doors but, when the train moves and drags a passenger, the force is detected by the sensitive edge.

There are concerns over the operational impact of this technology. Spurious activation could cause service delays, although obstacle detection may reduce trapping. The immediate release of trapped items may also cause unnecessary activation, e.g. a departing passenger pulling a trapped coat-tail free. To assess these implications, a trial in passenger service is currently underway on a C Stock train with a sensitive edge fitted to a normal door. C Stock was chosen due to its intense service duty, and the similar door configuration to S Stock – D Stock has single leaf doors, whilst A Stock doors do not see such heavy use. During this trial there is no indication provided to the train operator, but door operation is logged and a CCTV record is kept for later review. To date no spurious activation has occurred. Results of this trial could be used to refine the set-up of the sensitive edge system on production trains.

THROUGH GANGWAYS

S Stock is the first LU rolling stock to be fitted with wide, open inter-car gangways, preceded in the UK only by the new Overground trains, also from Bombardier. Ambience within the gangway is similar to the rest of the saloon for lighting, interior trim, etc to encourage passengers to use the area as they do the rest of the cars. The gangway width is 1,700 mm, with 1,160 mm at low level, and the height is 2,230 mm. Track curvature, track twist and track quality generate significant gangway movements, and so design requirements included:

- Must accommodate all relative movements between adjacent cars.
- Must control gaps in moving parts to less than 6mm (derived from standards for children's play equipment).
- Must be capable of being cleaned and meet material fire requirements.

The entire geometry of the SSR track was analysed, and certain defined movement conditions were established for test purposes:

00 Rest position.
01 Ealing Common depot points 13A/B (eastern pair between back of depot and platforms).
02 Ealing Common depot 1 road (rear shed road).
03 Ealing Common depot 1 road – maximum yaw.
04 Whitechapel platform 1 – worst case lateral movements in service.
05 Worst case vertical movements in service.
06 Vertical movement (opposite pitch to position 05).
07 Combined curves plus 3.1º body roll.
08 Combined curves – lateral plus yaw.
09 Twisted track.

The gangway test rig generates movement in all six degrees of freedom, and has been used to provide full validation of the gangway in all movement cases. It has also been used for full endurance testing over the equivalent of 10 years service.

DETRAINMENT DEVICE

Work on the detrainment device, which includes a bridging step and stairway, is well under way. The manufacturer (Percy Lane Products in Tamworth) has built systems recently for the Central Line and the new Victoria Line trains. Their appointed design consultancy (DCA in Warwick) have an initial prototype device and are currently building the first full scale rig. The steps are designed to be launched from within the cab with minimal lifting, and stow on the 'J' door between the cab and the passenger saloon. Illumination is provided by lights fitted to the front of the train, either side of the coupler.

ADHESION MANAGEMENT

The Metropolitan Line has well-known adhesion problems, especially each leaf-fall season. The S Stock system is based on that adopted on the Central Line with automatic train operation, using a real-time adhesion control room for the line.

Wheel Slip Protection is provided under both acceleration and braking, including emergency braking, similar to all recent stock deliveries to maximise use of available adhesion and minimise stopping distances. Automatic reporting of Wheel Slip Protection activity back to the report centre will allow developing situations to be monitored and necessary action to be taken. After the line is resignalled, this would include the ability to modify Automatic Train Operation brake rates, or revert to manual driving.

Sanding is to be fitted to all S stock trains to improve available adhesion, intended to cope with enhanced running demands after resignalling. Sand hoppers are to be fitted before the seventh wheel sets (15 litres per side) from each end on all trains, only those at the leading end being automatically activated when required. On the Metropolitan Line, additional hoppers (40 litre per side) will be fitted before the eleventh wheel set from each end, again only being activated at the leading end, to cope with the poorer conditions at the country end of the line. S8 trains will therefore have two active sand hoppers on each rail. This is one of the few differences between the S8 and S7 types, other than the saloon seating layouts.

QUESTIONS

With inter-car gangways, where are the porter's close buttons to be found?

The train operator can use the Train Control Management System (TCMS) to select 'door platform close', which sets all passenger 'door open' buttons to operate like porter's buttons, so that staff can close all doors on each car from inside or outside the train. Butterfly cocks have been replaced with emergency access devices, which require two-handed operation to reduce malicious use. These open the middle door on a car, whilst a staff egress device is provided on the two end doors, operated from within the train with a J-door key. By these means all available doors on a train partly-berthed at a platform can be opened.

Is seating as uncomfortable as recent Network Rail trains?

The seating is quite firm, but is not built to the Network Rail standard. It has been based on the best LU seating of previous trains, including 1938 and 1967 Tube Stocks, not the soft ride of the A stock. The seats line up with window pillars for the view, unlike Network Rail trains.

Why are the cab windows so big?

They are designed so that a person up to 6ft 4in tall can drive seated or standing whilst still sighting gantry signals. The lower floor height adds 120mm to all windows.

Concern was expressed about the lack of seating for Amersham line passengers. The new signalling system will allow a closer interval service to provide an increased seating capacity. Unfortunately, because of the Metronet collapse the new signalling system has been delayed and has not yet been selected. Early modelling of 2+2 seating showed this provided few extra seats at the cost of a much narrower aisle, consequently restricting the ability to move to and from the seats. The slightly narrower body than A Stock permits SSR wide operation with minimal impact on capacity, and more level platform access will speed station stops. System-wide passenger growth has reached over 3 million daily now, with over 4 million on some Christmas shopping days, and is expected to continue to increase after the current recession. The LU system was not designed for the passenger volumes that it is now required to carry. Longitudinal seating allows greater standing capacity, although some transverse seating is to be provided for the generally longer journeys on the Metropolitan Line. There are no middle cabs on these trains, freeing up space, the trains are longer, and gangways can also be used for standing.

It is envisaged that a change to 750v traction current may occur over a period of time. The main aim is to avoid the need for new substations as part of the power upgrade for enhanced performance, so if a new substation is not required there is no need to change. The system that provides Correct Side Door Enable and also Selective Door Enable can also set the voltage for the train's regenerative braking to permit this gradual change from 630v. It was mentioned that a change on the Uxbridge branch might well await the replacement of 1973 Tube Stock as part of the Piccadilly Line upgrade.

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