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Class 377/6

By Piers Connor

Heritage

The Southern Railway's latest batch of the ubiquitous Class 377 - the 377/6 variant – in now in production at Derby. The first train was shown to the press on 19th December last. The 377/6 order is the latest in a series that stretches back to 1997 and has become the most numerous in Britain. The new trains will enable more 10-car trains to go into service on the Southern's suburban routes via Sutton, Hackbridge and Gipsy Hill December 2013.

The first trains in this now huge fleet of 1400 vehicles were ordered for the South Eastern franchise from Bombardier back in the days when it was still called Adtranz and the South Central franchise was run by Connex. The design was a derivative of the Class 357 series built for the London, Tilbury and Southend (now C2C) route – basically a DC-capable version with inter-unit corridor connections. The 375 was itself an electric development of the 165/168/170 DMU range built at Derby, already becoming a successful and widely used family of trains. The 357/375 design was further developed into EMU Classes 376, 377, 378 and 379. The combination of this long development and widespread popularity has now become part of the Derby coach-building heritage.

Orders

The initial Class 375 order was for 120 vehicles to replace the South Eastern's slam door Class 411 fleet, followed by another 90 vehicles to replace their Class 421s. A further order was split between Connex's SE and South Central services. When Govia took over the South Central services in August 2001, the South Central part of the order was adopted by Govia for the Southern Railway. The first 28 units of this batch of 240 vehicles were 3-car sets and were the first of the breed to be seen on the Southern. The remainder were 4-car units for South Eastern. Then, in March 2002, Govia ordered 460 more cars from Bombardier at a cost, according to figures published at the time, of £815,000 apiece. The latest order for the 377/6s works out at £1.45million a car, rather more than you would expect from inflation, which would give a £1.14million price tag.

Class 377, as the new units became, differed from the previous order in that they were given Dellner, rather than Tightlock couplers. Dellner couplers were said to be "more robust" and easier to use. The Southern's existing 375 units later had Dellners fitted and became 377/3s.

The fleet now comprises 28 three-car (84 cars) and 154 four-car sets (616 cars), 15 of which have 25 kV 50Hz capability to run north of London, as well as the usual 750V DC. Another batch of 23 x 4-car dual voltage sets were ordered in 2007 to work the Thameslink Bedford-Brighton service. These were leased by Southern and sub let to First Capital Connect. Southern units started working to Bedford in March 2009. The 377/6 order will push the 377 fleet total to 962 cars.

Design Philosophy

The design philosophy behind the Electrostars was driven by the commercial focus pushed by privatisation. Privatisation gave manufacturers an opportunity to move away from a "made-to-measure" approach to an "off-the-shelf" product. They understood that they had to propose, as far as they could, non-specific trains - "go almost anywhere" designs - in order to match the new demands of the ROSCOs. Train operators also had to adapt to the regime. They had to buy standard trains, airline style, only being able to vary the furniture and the paint job. Some concessions are made to backwards compatibility and past custom and practice; like the Southern's long-standing in-service uncoupling policy and their inter-unit corridor connections but otherwise what you get is a railway version of the Airbus. Adtranz took up the idea soon

after privatisation and developed a new train concept that became, first, the Turbostar DMU and then the Electrostar EMU.

With more than half an eye on the export market, the new “star” car body was designed to allow pre-formed and pre-welded aluminium sections to be huck bolted together in an assembly shop, so that this could be done anywhere in the world without the need for expensive, large scale body welding facilities and highly systemised computerized monitoring and validation equipment. Sections could be pre-wired, pre-piped, pre-painted and finished off with a fancy corporate vinyl livery. The whole lot are then bolted together. Cabs and trailing car ends are built and tested in a separate shop before being added to the car during its final assembly stage. Bombardier has an impressive testing facility that allows all the cab controls and systems to be tested and validated before the cab is wheeled into the erecting shop and plugged into the car body end.

There were some doubts in the early years about how customers would take to the idea of a train held together by bolts but these quickly vanished in a maelstrom of gauging and electro-magnetic compatibility arguments that left £200million worth of stock hanging around in the yard at Derby for two years while Railtrack played silly games raising the acceptance bar each time a new submission was offered. Then there was the power supply debacle….OK, I won’t go there.

Bodywork

The Electrostar vehicle bodies are made up of six side subassemblies (the panels either side of the door openings), plus the floor pan and the roof, all formed from welded aluminium extrusions. The higher stressed areas, like the drag box and bolsters, are steel fabrications and the structural parts of the cab and trailing ends are also steel.

Inside, air conditioning is standard but there is a bewildering array of seating arrangements, where 1st class seats are the same as standard class but in a different part of the coach, the standard can be 2 + 2 seats or 2 + 3 within the same unit and even within the same coach and all firsts are 2 + 2. There were some complaints about the more cramped firsts when the stock went into service but with the need to be able shift stock between TOCs with differing seating needs means this is likely to be the norm for future designs. The new units won’t have first class but the partition door will be provided, locked out of use, in case it is required in the future. The 377/6 order has a new seat design and a wider seat pitch and there will be power sockets for all passengers.

All trains are provided with DOO capability but only those working on the inner suburban “metro” routes actually use it. Southern attempts to introduce it elsewhere have met with stiff resistance from both unions and passengers. The original Southern units were the first to be equipped with external CCTV cameras for DOO. The fleet also has selective door opening (SDO) using GPS. Those working on the Thameslink service have the Tracklink II system to augment the GPS. Tracklink II uses a balise fitted on the approach to stations with short platforms to tell the train which station it is approaching and the length of its particular platform. The balise is required because the GPS isn’t accurate enough to pinpoint the correct platform at multi-platform stations.

Doors are sliding plug. Despite their slow operation and complex mechanical systems compared with simple sliding doors, these are considered essential for trains with 100mph capability and possible passing speeds of twice that. They provide good thermal and sound insulation and prevent that annoying bang from the air pressure of a passing train. Door release for stations is normally from the driver’s cab, while the conductor actuates closure from a position inside one of the cars. Each car has two door control panels – one on each side.

An interesting feature of the 377/6s is the provision of forward facing cameras in the cabs. I wondered how drivers had reacted to this idea and Southern told me that their drivers liked it. It offered proof of signal aspects, trespass, track faults and, of course, vital evidence when something or someone got hit by a train. Reflecting on my own ten years “on the front”, albeit a

very long time ago, there were a number of occasions when I would have been glad of it. The new trains will also have track debris cameras.

Bogies

The Derby theme of standardisation has continued with the bogie design. This has remained basically the same throughout the Electrostar's production. The Series 3 bogie is one of the family of bogies which was first manufactured in 1974 and which subsequently proved successful as the standard British Railways multiple unit bogie. The design uses rubber chevron primary and air bag secondary suspension on a welded steel frame. The Class 377 versions of the bogies are classified by Bombardier as P3-25 for the motored bogie and T3-25 for the trailer bogie.

Electrical

All 377s are designed for 750V DC and 25kV AC operation but only a limited number are provided with the pantographs and transformers for 25kV operation. Where the transformer is not fitted, the space has to be weighted to compensate for its absence. Each driving car has four collector shoes and there is an internal busline through the unit. With the 3-, 4- or 5-car formation variants, there are differences in the motored axles and power ratings (See Table).

The traction equipment is from Bombardier's Vesteras, Sweden, factory, the former ASEA works. The basic 4-car units have six motored axles; two on the inner bogie of each driving car (the DMCO) and on the inner bogie of the intermediate motor car (the MSO). Each motor bogie has two 250kW 3 phase AC motors controlled by a "motor converter module" (MCM) fed through a DC link from the traction supply. The trains are designed for 0.67m/s^2 acceleration. Auxiliary converter modules (ACMs) are located on the two driving cars providing 3 phase 400V AC 50Hz and 110V DC outputs for air conditioning, lighting, communications and control systems. The two ACMs on a unit are linked so that if one fails the other will cover essential supplies. On the 5-car 377/6s, there will be an extra motor car (MSOL) giving another 500kW for traction.

Regenerative braking capability was provided on the trains from the beginning but it was not used until May 2008 when, after a long and involved testing process, the DC power supply system was proven to be capable of accepting the additional intermittent high voltage inputs. Part of the process involved proving the trains' own ability to regulate the input according to the acceptance capability of the line. If the train detects that the line is unable to take the extra voltage, the regenerated power is dumped into an on-board resistor grid.

The trains are all fitted with the well-known Bombardier MITRAC train control management system (TCMS). The latest version on the 377/6 brings together control for train and car, traction, auxiliaries, passenger information, environment and diagnostics into one fully integrated package while retaining operating compatibility with the earlier versions.

Shoes

Current collection has always been an issue for electric traction, especially for third rail systems. Every winter, trains in the south of England arc and spark their way across the countryside, struggling with even the slightest manifestations of ice and snow despite valiant attempts to keep things moving. To help combat this, the 377s are provided with an "Ice Mode" control that can be switched in to eliminate the risk of the train being shut down by its line interference monitor because of excessive arcing from the shoes.

Even when the weather is being kind, shoegear is vulnerable to rail position variations, excessive train dynamics and high speeds. In the early Electrostar days, there were a number of incidents of shoes becoming detached and current rails dislodged by errant shoegear.

The issues causing these were eventually resolved but, in a recent research programme called TRIME (Third Rail In-service Monitoring Equipment), a joint University of Birmingham, Southern, Network Rail and RSSB programme has been in use, detecting third rail condition and its

effects on shoegear. Unit 377401 has been provided with additional shoegear and is fitted with monitoring equipment to show where excessive shoe movement is taking place. The initial trials have proved very successful in finding bad conductor rail locations and Southern are now using the unit as an unofficial generic test train. In addition to the extra sets of shoegear (one each side), there is now a sensorised bearing and a pair of intertial measurement units (one in the body and one on the bogie) that are aiming to do similar things with track quality that TRIME does with the conductor rail.

Reliability

Bombardier reports that average technical reliability is now 60,000 miles between failures with a fleet mileage of 172 million. A quick (validation) look at the Golden Spanners Awards for past years shows an initially unspectacular but improving reliability profile over the years. In 2003, annual average miles between failures was around 7,700. This had improved to 17,000 on the earliest-built units by 2006 and jumped to 25,000 miles a year later. As Roger Ford reported in Modern Railways in January this year, the latest figures show it at 35,000 miles. Doubtless there are variations in what you would classify as “technical reliability”. In Bombardier’s case, it would be what they would take the blame for.

Developments on 377/6s:

The 377/6 order sees a number of improvements over previous Electrostar batches. It uses the Class 379 body design that is TSI compliant for crashworthiness and tunnel operation. It has traditional windows instead of ribbon glazing and there is a slight difference in the body profile at floor step level. The exterior visual impact is little changed but much has been improved “behind the scenes” with new software for the “Orbiter” maintenance management system and a new CCTV image distribution architecture.

The trains have built-in hot box detection and saloon temperature detection added for real time data collection. The OTMR has ship to shore capability and a real time passenger information system. GPS is used to verify the train’s position so that relevant messages can be transmitted for the location. This is being applied system-wide.

One of the important features of the 377/6 order is that the trains must, at least as far as the crew and maintenance interfaces are concerned, be compatible with the earlier versions. It is a requirement that there shouldn’t be a need for a long training campaign across the franchise so that trains can enter service as quickly as possible and meet the target of getting them all into the December 2013 timetable. The first 5-car unit is in testing now and entry into service of the first train is due on 20th September 2013. With 130 cars to deliver, they will need to get 3 units a month off the production line to meet the December timetable. Looking at recent past orders, this seems a bit tight but Southern are confident they will get their new trains on time.

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Table showing the range of Class 377 orders.

Class	Year Built	Units Built	Cars per Unit	Total Cars	Unit nos.	Power/motored axles	Notes
377/1	2002-3	64	4	256	377101-164	1500kW/6	

377/2	2003–4	15	4	60	377201-215	1500kW/6	Dual-voltage units
377/3	2001–2	28	3	84	377301-328	1500kW/4	3-car ex Class 375
377/4	2003–5	75	4	300	377401-475	1500kW/6	
377/5	2008–9	23	4	92	377501-523	1500kW/6	Dual voltage on sub-lease to FCC
377/6	2012-14	34	5	170	377601-634	2000kW/8	

377 Suppliers:

Baker Bellfield, grab handles and Tables, Telford, UK.
BTROS, main cabling, cab back wall controls, Derby, UK
Qualterhall, underframe bolster assemblies & cab structures, Barnsley, UK.
Stauff UK , underframe pipework, Sheffield, UK.
Percy Lane, bodyside windows, Tamworth, UK.
BTROS electronics, passenger information systems, Mansfield UK.
Solo fabrications, ceiling module assemblies, Birmingham, UK.
Engements, various bracketry and sub assemblies, Derby, UK.
Datum, GRP products, Derby, UK.
Aleris, bodyshell extrusions, Koblenz, Germany
Metra , bodyshell extrusions, Ragusa, Italy
Bombardier bogies, Siegen, Germany.
FAINSA, passenger seating, Barcelona Spain.
Bombardier traction equipment from Vasteras, Sweden
Knorr Bremse brakes, Melksham, UK.