GEC

2700hp
DIESEL ELECTRICS FOR BRITISH RAIL

CLASS 50

GEC Traction Limited

ENGLISH ELECTRIC | AEI

D400 CLASS 2,700 HP DIESEL-ELECTRICS FOR BR

Automatic control of tractive effort using solid state components makes optimum use of available adhesion

THE 50 English Electric Type 4 locomotives of 2,700 hp now entering service with the London Midland Region of British Railways as the D400 class represent a significant step forward in traction engineering because they embody a number of features combined for the first time in one design. These arise from the continuing demand by railway operators for increased power output per ton of locomotive weight, a consistently high standard of reliability, and maximum efficiency of traction power equipment. These 2,700 hp locomotives represent the introduction of a new power range of English Electric diesel-electric locomotives and designs for overseas service have been prepared.

The principal features that have been brought together in the D400 class are automatic tractive effort control, dynamic braking, inertia filtration, and slow speed control.

Continuing developments with solid state components, principally thyristors, have been used by English Electric in the design of prototype control equipment for 25 kV a.c. multiple-unit train-sets AM2 (unit No. 312) and AM10 (unit No. 046).

The D400 diesel-electrics represent an extension of the use of this equipment to improve the efficiency of diesel-electric traction.

The range of performance of a diesel-electric locomotive is extended by progressively weakening the fields of the traction motors as the train accelerates, and it is important that this weakening process is accurately controlled. On the D400 class electronic time delay units are used in the associated control circuits, giving a simple and precise control of the field weakening switches.

Closed loop control system

The main generator current is regulated by a closed loop control system (Fig. 1) which receives input signals from the driver's controller, the diesel engine governor, d.c. transformers in the motor circuits, and the speedometer. The outputs from these sources are fed to operational amplifiers which control the KV10 chopper circuit supplying the main generator field. This control system regulates the tractive effort, diesel engine load and train speed in response to signals initiated by the driver, which it compares with the signals proportional to the tractive effort required.

An output signal is then provided which drives the thyristor controller for the main generator field so that the locomotive performs as calculated. The system is able to correct wheelslip automatically so that, in specific operating conditions, if the available adhesion cannot sustain the tractive effort selected by the driver the automatic tractive effort control imposes a lower value. This gives considerable advantage in starting heavy trains by giving more precise and efficient control over the power equipment besides quickly correcting wheelslip. In addition a Westinghouse anti-slip brake is fitted.

Preset control

The driver has the means of presetting the tractive effort required and the control system will maintain this value constant through acceleration. In short, automatic tractive effort provides

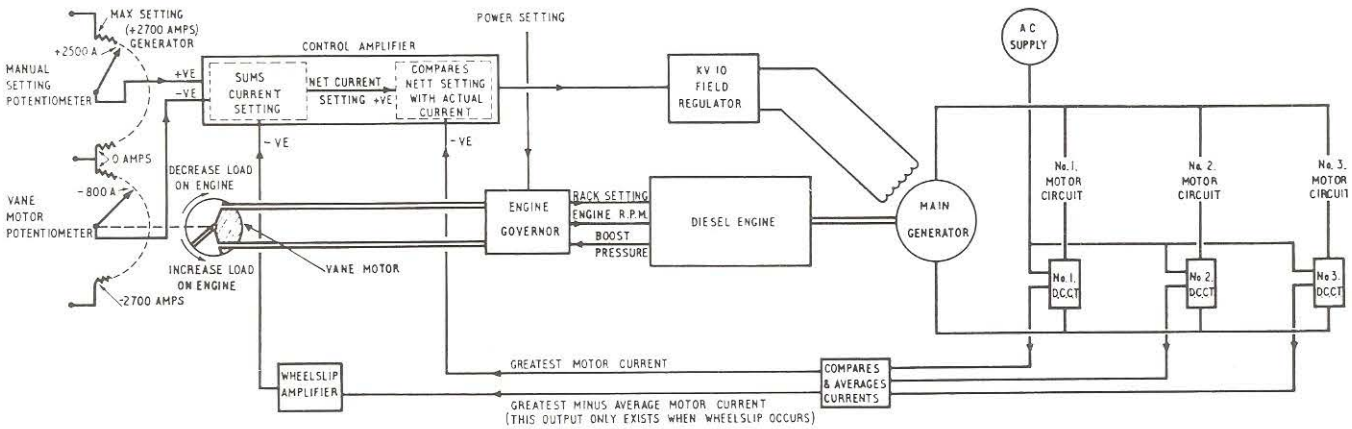

Fig. 1. Closed loop control system for regulating tractive effort, engine load and train speed to the driver's instructions

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more consistent utilisation of the locomotive's capabilities under varying operating conditions with the most efficient use of the electrical equipment. The control equipment is housed in a single cubicle.

To improve the efficiency of the braking system and to minimise undue wear on brake blocks and rigging, the design features electro-mechanical dynamic locomotive braking integrated with the mechanical train brakes. These are correctly and automatically integrated, and are controlled by the driver with a single handle.

Inertia filtration

Conventional oil-wetted air filters have been eliminated and primary inertia filtration is installed with secondary filter systems using disposable dry-pack elements. One primary system supplies air to the No. 1 end traction motor blower and, through a secondary system, to the two engine turbo-blowers at that end. At No. 2 end the second primary system supplies the traction motor blower at that end, the main generator and the dynamic brake compartment, with the remainder of the air supply going to the other pair of turbo-blowers. A small motor-driven extractor fan removes dirt from the inertia filters.

Slow-speed control

For precise working in the speed range below 3 mile/h, as is required for merry-go-round trains, the driver can pre-set the speed and the control system will maintain this value constant regardless of gradients or trailing load. An electronic speedometer is fitted which, at the given speed, will give a signal bringing in automatic control for slow-speed working.

The electronic speedometer is part of the linked electronic control system already mentioned.

Up to three locomotives are capable of being operated in multiple, and there is also provision for push-and-pull working, but only Nos. D400 and D401 are so fitted at present. With minimum modification buckeye centre couplers can be fitted subsequently, while the drag-box is designed to accommodate the UIC centre drawgear if this should be required in the future.

Principal details of the D400 Class

Wheel arrangement	Co-Co
Number series	D400 to D449
Weight in working order	117 tons
Maximum axleload	19½ tons
Length over buffers	68 ft 6 in (20,880 mm)
Overall width	8 ft 10 in (2,530 mm)
Overall height	12 ft 9 in (3,900 mm)
Bogie wheelbase	13 ft 6 in (4,110 mm)
Bogie centres	42 ft 8 in (13,010 mm)
Wheel dia.	43 in (1,092 mm)
Minimum curve radius	4 chains (80,450)
Diesel engine	English Electric 16-cylinder Type 16 CSVT turbo-charged and intercooled
Engine rating	2,700 hp at 850 rev/min
Maximum tractive effort	48,500 lb (22,000 kg)
Continuous tractive effort	33,000 lb at 23·5 mile/h
Train-heating generator (continuous)	320 kW at 800 V d.c.
Maximum service speed	100 mile/h
Fuel capacity	1,000 gal

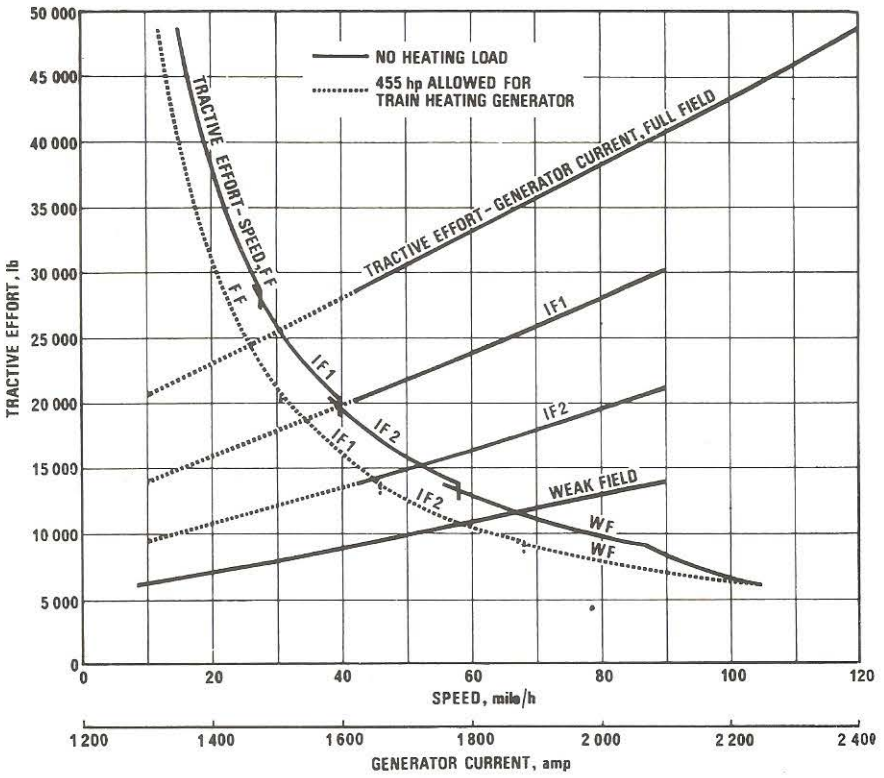


Fig. 2. Performance characteristics of the D400 class

The performance characteristics of the locomotive are in Fig. 2. These locomotives are being allocated to the London Midland Region for use on heavy mixed traffic duties over Shap on the West Coast main line between Carlisle and Crewe.

Charge-cooled engine

The English Electric 16-cylinder 16-CSVT turbo-charged and charge air-cooled diesel engine with an output of 2,700 hp at 850 rev/min was extensively tested in the prototype DP2 and has proved most successful. The Woodward governor with fuel limiting device later fitted to the prototype DP2 has been adopted for the production series of 2,700 hp locomotives.

The speed of the radiator fan is automatically varied by an electronic sensing device to match the requirements of the cooling system. This ensures that no power is wasted in driving the fan at a higher speed than is necessary, and that the engine is maintained at the optimum operating temperature. The radiators are of the spiral tube pattern and pairs of panels are mounted—one behind the other—on each side of the locomotive. The outer panels are interconnected and cool the water circulating in the charge-air coolers and engine lubricating oil cooler. The two inner panels are also interconnected and cool the engine-jacket water and turbo-blower cooling water.

Also incorporated in the new locomotives, after service experience with DP2, is the EE840/4B main generator continuously rated at 1,800 A 970 V at 850 rev/min. The EE911/5C auxiliary generator is overhung from the free end of the train heating generator. Its output voltage is maintained constant at 110 V by an EE Type AE7319 static voltage regulator.

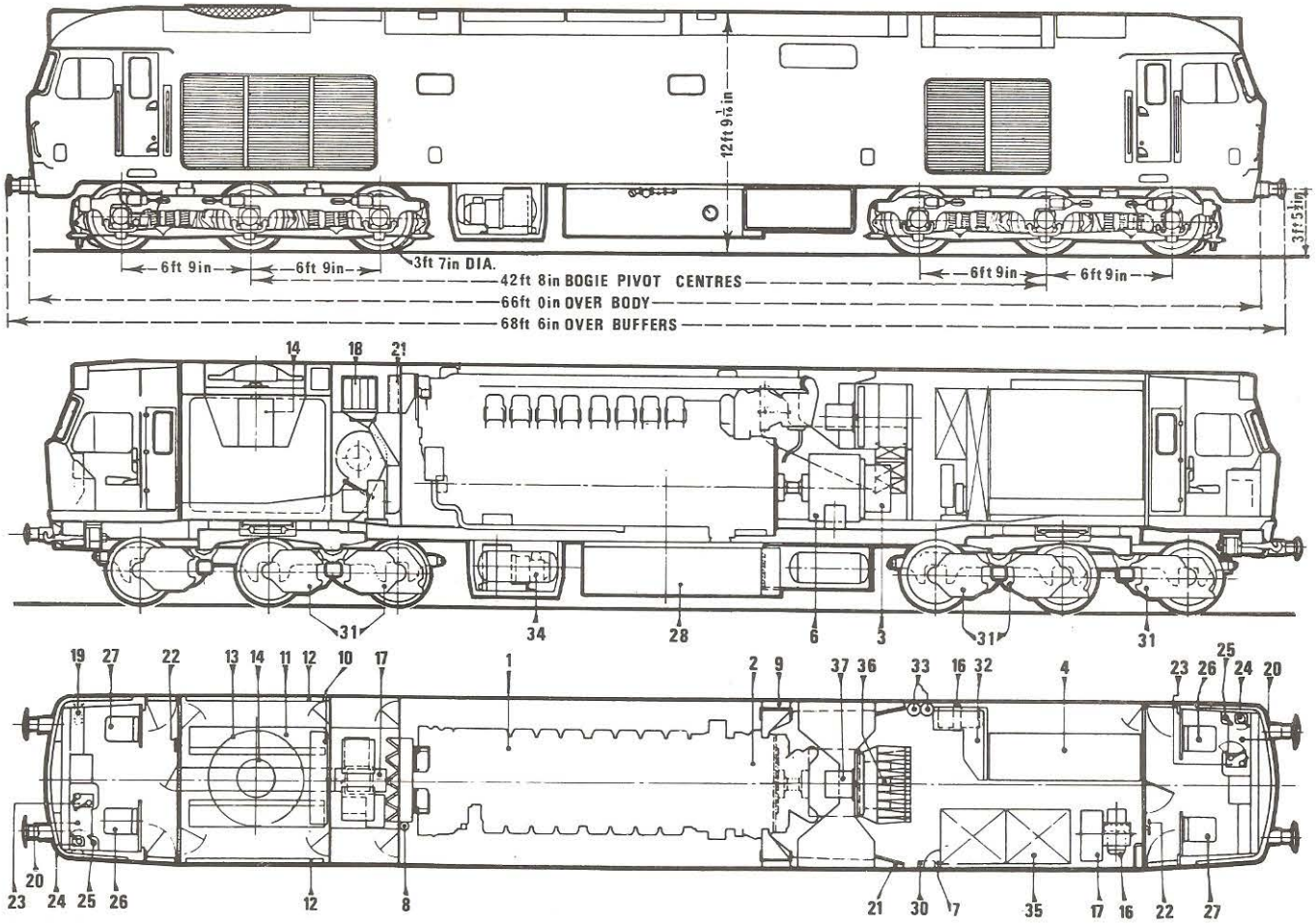
Train heating

Electric train-heating is provided by an EE915/1B train-heating generator driven off the main generator by a cardan shaft. It has a continuous rating of 320 kW at 850 rev/min and will produce 800 V d.c. at full output down to 550 rev/min. At the idling speed of 450 rev/min it will give 650 V. Output voltage is maintained constant at 800 V by an EE Type KV10 field supply unit in conjunction with an NPE7 control unit.

Traction motors

The traction motors are Type EE538/5A axle-hung similar to those used in the English Electric Types 3 and 5 locomotives. Two types of axle roller suspension units are provided, manufactured by Timken and SKF, and particular attention has been paid to the oil sealing arrangements to prevent gear lubricant from getting through to the suspension bearings. The suspension tubes are electrically insulated from the axles, and the motors on each bogie, are interconnected with earthing cables and connected to the bogie frame which, in turn, is connected by an earthing cable to the superstructure.

Among the auxiliary electrical equipment, as part of the inertia filtration



1. Engine 16 CSVT
2. Main generator EE 840
3. Auxiliary generator E 911
4. Main equipment frame
5. Batteries
6. Train heating generator
7. Urinal
8. Engine fuel supply unit
9. Engine air ducting
10. Radiator header tank
11. Radiators
12. Radiator shutters
13. Radiator fan
14. Radiator fan motor
15. Compressor WTG 3VC75
16. Exhausters
17. Traction motor blowers
18. Air filters
19. Sand fillers
20. Driver's desk
21. Air filters
22. Handbrake
23. Master controller
24. Automatic air brake valve
25. Independent air brake valve
26. Driver's seat
27. Assistant's seat
28. Main 1,000-gal fuel tank
29. Main fuel tank gauge
30. Urinal flush tank
31. Traction motors EE 538
32. Brake equipment
33. CO_2 bottles
34. Air reservoirs
35. Dynamic brake
36. Air filter (equipment compartment)
37. Fan motor

Fig. 3. General arrangement and plan of the D400 class locomotive

system, is a pressurising fan motor type EE774/A supplied from the train heating generator and a dust extractor fan motor type MD7430. The a.c. supply for the static control equipment is provided by an alternator.

Control gear

The main characteristics of the automatic control have already been mentioned. The traction motors are connected in series-parallel without equaliser connections, and three stages of field weakening are provided. With electronic control of the main generator field, the excitation of the main generator is through a KV10 field supply unit.

Mechanical parts

Following BRB design specifications, the D400 has a flat-ended superstructure in place of the characteristic English Electric nose ends (Fig. 3). Two rolled steel joists extending the full length of the locomotive and tied by fabricated cross-members form the main longitudinal members of the underframe. Any accumulation of oil on the top of the underframe is localised by plated and sealed surfaces so that it can be removed through drains to a collecting tank.

Drawgear and bogies

Cast steel 13-ft 6-in wheelbase bogies of the design used for the Type 5 and some Type 3 English Electric locomotives are fitted. To enable weight transfer compensation equipment to be installed, if required at a later date, the headstocks have been modified from the previous design.

Standard Timken roller bearing axleboxes are fitted and the tyres have a modified Heumann profile.

The cab interior layout is based on the standard BRB Design Panel cab prototype and standard heat/sound insulation with forced-air ventilation is installed. An electronic device is fitted which automatically switches off all lights, except tail-lights, 15 minutes after shutting down the engine.

The locomotives are finished in polyurethane enamel in the standard British Railways livery with Rail Blue roof and body-sides, yellow body-ends and cab window surrounds, with black buffer beams, undergear and bogies.

Principal sub-contractors

Hawker Siddeley Dynamics Limited	Temperature sensors for cooling fan control
Spiral Tube & Components Co. Ltd.	Radiators
Skefko Ball Bearing Co. Ltd.	Roller-bearing axleboxes
British Timken, Division of the Timken Roller Bearing Company	Roller-bearing axleboxes
Alfred Wiseman & Co. Ltd.	Gearwheels
Westinghouse Brake & Signal Co. Ltd.	Brake equipment
Consolidated Brake & Engineering Co. Ltd.	Vacuum exhausters
Desilux Limited	Warning horns
Triplex Safety Glass Co. Ltd.	Cab windows
Walter Kidde Limited	Fire protection equipment
Oleo Pneumatics Limited	Buffers
English Steel Corporation Limited	Cast-steel bogies

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