Results of the 1948 Locomotive Interchange Trials

DURING 1948 the Railway Executive sponsored a series of intensive locomotive interchange trials between the various Regions of British Railways with a view to trying out representative locomotive types of the former railway companies with standard loads. As far as possible, identical conditions were selected, both over the routes on which the locomotives were designed primarily to work and on other routes in various parts of the country. These trials aroused a good deal of interest, and a report has now been compiled on them. It is not intended to make copies available to the public because of the cost of large-scale production. It consists very largely of tabular matter, descriptions of the test arrangements, loads, coal and water consumption, and so forth.

On their formation in 1948, British Railways inherited four series of modern locomotive types, one from each of the former main-line companies. Although each of these series was highly standardised within a single company, hardly any features or details were common from one company to another. In pursuance of its general policy of engineering standardisation, the Railway Executive decided that it would not continue to build four varieties of locomotives for each traffic duty. It proposed a single series of about 12 standard types, each of which would contain the best features of existing designs, and which could have added to them improvements and developments as experience and the ingenuity of the design staffs should indicate.

Of the various methods of locomotive testing, that which gives the quickest general survey of passenger and economy is the dynamometer car, which measures draw-bar pull, speed, and horsepower. The indications so given, related to the coal and water consumed, are a fair measure of the overall efficiency of the locomotive.

Fourteen types of locomotives were tried on selected routes on each of five Regions, ranging as far north as Inverness and as far west as Plymouth. The test covered the period from April to December, 1948, and the results fill 131 pages of the report. The tests were not intended to be a contest between locomotives of similar types, which it was appreciated had been designed, for the most part, to fulfil the requirements of their particular Regions. The results, therefore, do not disclose any dramatic or unexpected features, nor is it possible to declare that one type of locomotive is "the best."

From the outset it was realised that these indications would be of a very broad kind, as the trials were carried out under the normal operating conditions obtaining at the time of each test run and without any special preparation of the locomotives. It was agreed that the locomotives used should be taken direct from traffic, having run between 15,000 and 20,000 miles since last general repair and there was consequently some variation in mechanical conditions, particularly in the case of freight locomotives. It was also realised that, in the existing circumstances, inequalities which are liable to be experienced in any variable speed testing on the track would be present. Traffic delays and temporary speed restrictions may be mentioned as examples of these inequalities and, whilst the traffic delays tended to cancel out over a number of tests, the number and siting of temporary speed restrictions affected some locomotives more than others. It was appreciated, however, that further testing would subsequently have to be undertaken on the Rugby and Swindon testing plants and with the mobile testing plant when such limitations would not apply.

The Western Region locomotives had grate and smokebox arrangements specifically designed to suit Welsh coal, and these, together with the firing technique to which the Western Region enginemen had been trained, differed from what is customary with the types of coal used on the trials. In view of these conditions it was arranged that, on completion of the trials, additional tests should be made on the Western Region using Welsh coal.

The greatest care was taken to make the test runs as nearly comparable as possible. Every controllable factor was controlled; and unpredictable conditions such as weather, signal and permanent-way checks, and late running are all recorded, so that their influence can be borne in mind. As the engines concerned were not all fitted with continuous blow-down, the apparatus was put out of action on the locomotives which normally carried it. All the three dynamometer cars which were used were calibrated on uniform lines at Derby before the trials began. Coal used for lighting-up was separated from that used during actual runs; and care was taken to see that the quantity of fuel remaining in the firebox at the end of a test was about the same as at the commencement. Similarly, tenders were calibrated beforehand; and then at the end of a run the water level in the boiler was brought to the same level as at the beginning of the test.

At the beginning of the report, some extremely interesting figures are given, to convey, in the briefest way, the summarised results. They show the ratios of All coal/All work for the various engines, and are derived from the grand totals for all engines of the class throughout the whole series of tests over all applicable routes. The coal ratios are expressed in total weight (lb.) divided by work done (h.p.-hr.). Water ratios are also given to show the evaporation secured on the different locomotives; in this case the figures are: Water (total weight, lb.) divided by work done (h.p.-hr.). These results are given in the accompanying table.

The general plan of the report is to present, first, dimensions and other relevant data of the types of locomotives concerned, followed by folding tables, showing details of the test results, including coal and water consumption. Later pages give the performance figures over selected portions of the routes (speed, horse-power, cut-off, and regulator position), notes on adhesion and slipping and draw-bar pull characteristics, and diagrams showing the oscillations encountered with the various locomotive classes are included, followed by dynamometer car records illustrating the coasting tendencies of the freight engines. The methods of working the various locomotives then are given, followed by a five-page appraisal of the mechanical condition of the engines, with notes on the defects which developed during the trials. Finally, there is an Appendix devoted to the additional tests carried out on the Western Region.

In recent issues of *The Railway Magazine*, Mr. Cecil J. Allen has published his own observations of these trials, made from the point of view of a passenger. It is interesting to examine some of the performances recorded during the trials and to see how the test data compare with Mr. Allen's impressions.

On May 14, the "Merchant Navy" engine *Belgian Marine* put up an excellent performance between Penrith and Preston with a train of 503 tons tare (525 tons full), gaining 6 minutes (8 minutes net) over the schedule time of 86 minutes for this 72.2 mile run, which includes the ascent, from the north, of the notorious Shap incline—9¼ miles in all, at gradients

Region	Class	Coal consumption ratio = Coal (total wt., lb.) / Work done (h.p.-hr.)	Water consumption ratio = Water (total wt., lb.) / Work done (h.p.-hr.)
Western	4-6-0 "King"	3.57	28.58
Eastern	4-6-2 "A4"	3.06	24.32
London Midland	4-6-2 "Duchess"	3.12	27.08
London Midland	4-6-2 "6P"	3.38	25.81
Southern	4-6-2 "Merchant Navy"	3.60	30.43
Western	4-6-0 "Hall"	3.94	29.97
Eastern	4-6-0 "B1"	3.59	27.64
London Midland	4-6-0 "5"	3.54	27.99
Southern	4-6-2 "West Country"	4.11	32.64
Western	2-8-0 "2800"	3.42	26.80
Eastern	2-8-0 "O1"	3.37	25.73
London Midland	2-8-0 "8F"	3.52	27.26
	2-8-0 "Austerity"	3.77	28.75
	2-10-0 "Austerity"	3.52	28.05

varying from 1 in 106 to 1 in 142. A recorded drawbar horse-power figure of 1,629 was obtained, at 49.7 m.p.h. (equivalent to 1,920 h.p. on level) which is even higher than Mr. Allen's estimate of 1,700 (assuming that he was also working on the "equivalent" figure). The cut-off was 33 per cent.; the boiler pressure 255 lb. per sq. in. and the steam-chest pressure 225 lb. per sq. in. The notes on the engine working, record that a better performance seemed to be obtained when it was being worked fairly hard. The regulator was usually ¼ to ⅓ open on rising gradients, when the cut-off was normally 23-25 per cent., the increase to 33 per cent. being required evidently to get the heavy train up Shap. The coal burnt per mile, over the whole trip (Carlisle to Euston) averaged 50.22 lb., i.e., 0.079 lb. per ton-mile (including engine) or 3.86 lb. per drawbar horse-power-hour. The corresponding water consumption was 31.80 lb. per drawbar horse-power-hour.

Another Bulleid engine, the "West Country" class Pacific *Bude*, did brilliantly on runs between Marylebone and Manchester. Mr. Allen noted a climb up the 1 in 105 to Amersham after the earlier part of the run had been spoilt by a series of checks. The train was 360 tons (380 tons full), and speed rose from 27 to 45 m.p.h. up this gradient; while later, climbing from Great Missenden to mile-post 31½ speed only fell from 71½ to 60 m.p.h. The report shows recorded drawbar horse-powers, at various points en route, as varying between 1,266 and 1,574 (equivalent to 1,600 to 1,962 h.p.) with a cut-off varying between 25 and 30 per cent. Coal consumption was 4.07 lb. per d.b.h.p.-hr. over the whole run, and water consumption 31.43 lb. per d.b.h.p.-hr.

The Western Region "King" class worked under difficulties in regard to fuel when engaged on the Kings Cross and Leeds trains. There was much smoke, and it was difficult to keep the fire in good condition. The engine, nevertheless, got away well, and cleared Finsbury Park very swiftly. The load was 525 tons full (495 tons tare) yet the coal consumption, in spite of the nature of the fuel, was only 3.43 lb. per d.b.h.p.-hr. (53.93 lb. per mile over the whole trip). Water consumption was 28.35 lb. per d.b.h.p.-hr. Recorded horse-power amounted to 1,480 (equivalent) at Wrenthorpe with regulator half-open and cut-off 35 per cent. The boiler pressure then was 240 lb. per sq. in. The report states that "the black smoke indicated that the firing rate was too high, and this condition led, on occasions, to steam being wasted at the safety valves."

However, special additional trials were held on Western Region metals, using the Welsh coal normally supplied to Western Region engines. The *average* coal consumption using the Welsh coal was about 6½ per cent. less, in lb. per d.b.h.p.-hr. or 9.2 per cent. in lb. per train-mile. These figures make due allowance for the difference in calorific value between the two kinds of coal. With the "Hall" class the difference was far more marked, the figures being 17.7 and 19.0 per cent. respectively.

The Eastern Region "A4" class 4-6-2s gave perhaps the best figures of any of the engines concerned in regard to low coal consumption per drawbar horse-power-hour; on May 7, No. 60033 *Seagull* took a 330-ton train (345 tons full) over the mountainous route from Plymouth to Newton Abbot and thence to Paddington. In spite of a heartbreaking permanent-way restriction to 15 m.p.h. at Plympton, which made it impossible to attack the 1 in 41 Hemerdon Bank in good style, *Seagull* lifted the train over the top at 18½ m.p.h. On this run coal consumption averaged 44.87 lb. per mile, or 3.19 lb. per d.b.h.p.-hr. Water consumption was 23.82 lb. per d.b.h.p.-hr. The recorded horse-power up Hemerdon Bank was 1,111 (equivalent to 1,598, with an equivalent drawbar pull of no less than 12.75 tons). Cut-off was 53 per cent. with full regulator; boiler and steam-chest pressures were 245 and 235 lb. per sq. in. respectively.

Among the most memorable revelations of the locomotive interchange trials was the capability and general excellence of the "Royal Scot" class, as rebuilt with taper boiler. These 3-cylinder 4-6-0s weigh only 83 tons without their tenders, and yet showed that they could more than hold their own against the much larger Pacifics. This was particularly noticeable on the runs to and from Waterloo. On June 18, No. 46154, *The Hussar*, running from Exeter Central to Waterloo, showed a drawbar horse-power of 1,548 (1,782 equivalent) at Crewkerne

with cut-off 30 per cent. and regulator ¼ open. The boiler pressure was then 242 lb. per sq. in. Other very high powers were also recorded during this run. The coal consumption was 3.46 lb. per d.b.h.p.-hr., the corresponding figure for water being 25.46 lb. Over this run the coal used averaged 50.65 lb. per mile, with a load of 482 tons (515 tons full). On the same route the "Duchess" class with the same load on June 25, showed figures of 3.00 and 25.87 lb. per d.b.h.p.-hr. for coal and water respectively; the *equivalent* power recorded for Chard-Crewkerne was 1,600, the cut-off being 25 per cent. and regulator first valve being full open. The boiler pressure then was 230 lb. per sq. in. The "Merchant Navy" coal and water figures were 3.49 and 30.6 lb. per d.b.h.p.-hr. At Chard the recorded horse-power was 1,550 (equivalent), cut-off being 25 per cent., and boiler and steam-chest pressures being 260 and 200 lb. per sq. in. respectively.

These are but a few examples taken from this voluminous report. The use which the Railway Executive will make of the mass of data which has been accumulated can be summarised under two main headings :—

(1) As all the locomotives demonstrated their ability to operate the selected trains to the booked timings when operating on "foreign" routes differing widely in character from the "home" routes, the Railway Executive is satisfied that no limit need be placed on its proposals for standardisation by reason of suitability of particular locomotives for the routes over which they will have to work.

(2) The tests have indicated many features of design worthy of consideration for the new standard types, and the drawing offices are now examining closely their possible application. Examples are :

(*a*) Use of the largest boilers which weight limits will allow to give ample reserve of power for all circumstances.

(*b*) Use of wide fireboxes in the larger engines for highest combustion efficiency.

(*c*) Firebox and ashpan arrangement to give best results with varying qualities of coal.

(*d*) Adoption of design features to promote good riding and minimum wear and tear on the track.

The conclusions which have been reached as a result of the trials show that for comparable conditions and duties locomotives with wide fireboxes had a higher overall efficiency than those with narrow fireboxes, but the effect of differences in other design features reversed this in some cases. The importance of correct firing technique in relation to the type of coal used, and the necessity for adjusting details of design, such as spacing of fire bars, to suit the type of coal used, were especially evident in connection with the higher power outputs. There was a clear indication, too, of the advantages of high boiler output and large thermal capacity to give a reserve of power and margin for rapid recovery without an appreciable decrease in overall efficiency.

Steam temperatures were not recorded, but there were indications that an increase in the degree of superheat effected an improvement in efficiency in the case of express passenger and mixed-traffic locomotives. In the case of freight locomotives the improvement was much less marked. The performances of the different locomotives with regard to slipping were variable, and it is recognised that further investigation is desirable. In view of the irregular draw-bar pulls recorded in certain cases it is considered that further investigation should be made into the effect of balancing, valve setting, and other relevant factors on the smoothness of draw-bar pull. The express passenger and mixed-traffic locomotives with the smaller diameter coupled wheels experienced no difficulty in attaining the speeds necessary to maintain schedules, and on all routes it was noted that the average power required from the locomotives was low in relation to maximum power required.

Whereas individual tests of this kind have been carried out from time to time by all the former companies, this is the first occasion on which so comprehensive a series has been run. It has given the Railway Executive the opportunity of basing its locomotive design policy on known and recorded facts. It must be appreciated, however, that the tests outlined cover only operating and performance features. These have to be supplemented for each locomotive by data on building and repair costs and on availability in daily service.