Telex : 0535 - 2424 RDSO -IN
Fax : 91-0522-450374
Telephone : 454657 & 451200
Telegram : 'RAILMANAK',
Lucknow
e-mail : edse@ lw1.vsnl.net.in

सत्यमेव जयते

भारत सरकार - रेल मंत्रालय
अनुसंधान अभिकल्प और मानक संगठन
लखनऊ - 226011
Government of India – Ministry of
Railways
Research, Designs & Standards
Organization, LUCKNOW – 226011

No.EL/3.1.3

Date: 04-09-2000.

Technical Circular No. ELRS/TC/ 0065-2000 (Rev. '0')

Chief Electrical Engineer,

Central Railway, Mumbai CST- 400 001
Eastern Railway, Fairlie Place, Calcutta – 700 001
Northern Railway, Baroda House, New Delhi-110 001
Southern Railway, Park Town, Chennai –600 003
South Eastern Railway, Garden Reach, Calcutta –700 043
South Central Railway, Rail Nilayam, Secunderabad-500371
Western Railway, Churchgate, Mumbai –400 020

Sub: Optimum deployment of electric locos - Relationship of SEC with maximum service speed and trailing loads.

With progressive deployment of higher h.p. electric locos for passenger services, it is essential to consider the trailing load, maximum service speed, total journey time of trains and SEC for optimum deployment of electric locos. The SEC for passenger train rises steeply with maximum service speed of trains, it drops considerably if trailing loads are increased. If WAP4 loco replaces WAM4 or WAP1 loco for say, on 18 coach train, the total journey time can be reduced or alternatively number of coaches can be increased for the same journey time. Both ways it is to the benefit of both passengers and I.R.. Similarly choice between single WAG5, singleWAG7 and twin WAG5 may be optimised for freight operations.

Keeping this into consideration, computer simulation runs for different types of loads and sections have been conducted to see how best the electrical rolling stock should be utilised to optimise the productivity in terms of per unit energy consumed. The study is classified into three type of services:

a. Mail/ Express services
b. Freight services
c. Passenger/Commuter services

1.0 **Mail Express Services**:

The simulated run for 18 coach, & 24 coach train with WAP4 loco have been conducted for NDLS-HWH and HWH-IGP sections. During simulation only permanent speed restrictions have been considered. The results are tabulated as follows:

1.1 Effect of speed on SEC for 18 coach & 24 coach train:

(Simulation for NDLS-HWH section with WAP4 loco)

Max Service Speed in	SEC		%SEC saving with 24 coach train	%rise in SEC with speed	
	18 coach train	24 coach train		18 coach train	24 coach train
85*	15.42	14.64	5.05	00.00	00.00
95	17.10	16.24	5.02	10.94	10.90
105	19.10	18.03	5.60	23.87	23.17
110	20.09	18.92	5.82	30.33	29.21
120	22.00	20.62	6.27	42.69	40.81
130	23.90	22.06	7.70	55.00	50.64
140**	25.38	22.65	10.35	64.63	54.72

*85 km/h is the speed which meets the running time as per the time tables of important M/E trains prior to change of traction.

* * Simulated speeds for comparison only, as the above section is fit only for 130 km/h.

From the above it could be seen that SEC would be about 65% higher for service speeds of 140 km/h compared to a service speed of85 km/h for 18 coaches train. Also, SEC is less when trailing loads are higher for the same service speed.

1.2 Effect of saving in running time and %rise in SEC for 18 coach train:

(Simulation with WAM4/WAP1 loco in HWH-IGP section for Geetanjali Express type train)

Maximum service speed (km/h)	%saving in running time with 85 km/h as base	%rise in SEC
95	9.75	17.20
110	17.25	30.48
120*	19.73	38.67

*Simulated speeds for comparison only, as the above section is fit only for 110 km h

1.3 Reduction in SEC with increase in trailing load for same running time with higher h.p. loco:

Route	Running time (min)	Speed (km/h)	WAM-4		WAP-4	
			No of coaches	SEC	No of coaches	SEC
HWH-IGP section (Geetanjali type)	1170	105/110	18	19.56	24	19.41
HWH-NDLS section (Kalka Mail type)	1060	105/110	21	20.94	24	18.92

The table at 1.2 indicates if any higher h.p. loco is put replacing lower h.p. loco, for the same time table lower values of SEC are to be adopted for comparison. However, since maximum attainable speeds will be higher, a suitable reduction in journey time may be made to the benefit of passengers. This will also benefit I.R. by way of creating additional goods paths, as the ruling sections' running time will be less. Alternatively, as seen from 1.3 above, for the same running time, trailing loads could be increased, if demand exists.

1.4 **Effect of fuel cost on equated performance for different traction**:

The computer simulation conducted for electric loco hauled and diesel loco hauled train on equitable operating performance parameter indicated that the fuel cost/energy cost for electric traction is lower by 33% than the diesel traction excluding cost of lube oil. A typical example of Geetanjali Express is analysed and placed at annexure-I.

2.0 Freight Service:

The result of computer simulation run for WAG7 loco hauled loaded 58 BOX'N' train between HWH-GZB for stoppages at every 50 km is as given below:

2.1 Effect of speed on SEC:

Max Speed (km/h)	SEC
50	6.79
60	7.62
70	8.89
80	9.32
90	9.88
100	10.20

2.2 The comparative figures for twin WAG-5 & single WAG7 for simulated run of 58 BOX 'N' train in graded section Bilaspur-Durg is as under:

SEC		%saving with WAG7	Speed in km/h after start at grade 1:200		%increase in balancing speed with twin WAG5
Single WAG7	Twin WAG5		Single WAG7	Twin WAG5	
9.42	10.91	10.5	35	62	77.2

It would be seen that in this section, deployment of twin WAG5 may be overall beneficial. An optimum choice, therefore, may be done for individual ruling sections of Zonal Rlys between twin WAG5 & single WAG7.

3.0 Passenger/commuter services:

3.1(a) The result of simulation run of 600 t/12 coach passenger train stopping at all stations(25 nos) between NDLS-TDL is as under:

Max Service Speed(km/h)	SEC
90	26.34
80	22.0

3.1(b) Effect on SEC of average speed on passenger services:

AV Speed as per time table (km/h)	SEC
18.52	38.29
28.27	30.79
37.00	29.40
39.20	26.50

The conclusion drawn from the above two tables is that the maximum service speed be changed to a lower value if the average speed of the train as per time table is lower.

3.2 Commuter service: MEMU:

Effect of SEC on coasting keeping the maximum speed same for a rake of (2MC + 6TC) 8 coach:

%coasting	SEC
0	29
5	23
10	19
15	17

As per the acceleration & de-acceleration the average %coasting is in the range of 10-15%, therefore SEC for MEMU service is about 17-19 kwh/1000-GTKM. The SEC for MEMU is less primarily due to better power to weight ratio and better acceleration, resulting in more coasting time.

3.3 Comparison of running MEMU & Loco hauled train:

The actual run of a electric loco hauled 10 coach train and MEMU train of 12 coach have been compared and tabulated. SEC is worked out with computer simulation run.

SN	Type of stock	Speed booked/max (km/h)	Running time(Min) as per time table	Time saved w.r.t. loco hauled train (Min)	AV speed in km/h	SEC as per simulated run
			TDL-CNB	TDL-CNB		
1.	MEMU	85/90	320	230	42.93	17.39
2.	Electric loco hauled	90/100	550	--	24.98	30.79

From the above, it is evident that the MEMU operation replacing loco hauled commuter trains, is much beneficial from all considerations viz capital cost, fuel cost, operating cost, higher utilization, reduced lie over period and above all higher average speed. The higher average speed benefits both commuter (reduced journey time) and Indian Railways (by reducing detention to goods train). It is felt that there will be increase in average speeds of goods train in the section with introduction of MEMUs. Thereby increasing the line capacity of congested routes, which is the need of the hour. Railways' experience on this aspect may be watched and feed back given to RDSO.

This circular is intended to give an in depth analysis of various combinations available for efficient use of electric rolling stock. Since this analysis is based on computer simulation studies, Railways may conduct the actual field trial(s) to arrive at the actual benefit and adopt most appropriate option.

Feedback from Railways is requested.

Ramesh Chandra.
04.9.2000

DA: As above

(Ramesh Chandra)
for Director General/Elect

Copy to: As per standard mailing list no. EL/M/0028/Ver '0'

ANNEXURE

Economics of Haulage of Geetanjali(2860) on HWH-IGP, AC Electrified Section by Diesel vis-a-vis Electric Loco

1. The energy consumption rises steeply with the service speed, the SEC for 130 km/h is much higher than SEC at 105 km/h or 90 km/h. Computer simulation done for HWH-IGP section for Geetanjali Express are enclosed. For comparison purposes speeds of 140 km/h also have been simulated, though the section is fit for 105 km/h. It would be seen that operation at 140 km/h
2. requires 65% more energy than at 83km/h. Also, with increase in trailing loads, SEC reduces. For realistic comparison, the energy consumption for Diesel & Electric should be made on same running time and performance basis.
3. WDM2 loco will not be able to attain 105 km/h speed during actual running due to the fact that it requires a continuous stretch of above 50 km, which is unlikely in view of passenger halts, permanent & temporary speed restrictions and non-availability of run through condition at times.
4. For a load of 18 coaches, one WDM2 loco will need a bare running time including scheduled halts as 1414+90=1504 minutes plus 348 minutes as ER/TR i.e. a total of 1842mts. Against this the timetable provides for 1770 minutes. Thus, one WDM2 can reach the destination in time only if ER/TR is restricted to 276 minutes.
5. WAM4 loco with balancing speed of 95 km/h will take 1277+90+348=1715 minutes only against permitted 1770 minutes. For balancing speeds of 105 km/h, this will be 1172+90+348=1610 minutes. To maintain the level of timings of diesel loco, the balancing speed required will be 83 km/h.

The energy consumed for the entire journey between HWH & IGP(A.C.Section) is as under:

6. For 83 km/h : 32300 kWh
   For 95 km/h : 37868 kWh
   For 105 km/h: 40910 kWh

Fuel cost analysis:-

For the same level of performance of WDM2 & WAM4 the fuel cost will be as under:

Elect traction cost of energy =32300 units x Rs 4.19/- p.u.*
= Rs 1,35,337/-

Diesel traction cost of fuel (excluding cost of lube oil) = Rs 2,02,398/-**

*All India average.

**Considered SFC of 6.69 for S.E. Rly and 5.23 for C. Rly as per statement 27B of Indian
7. Railway Annual Statistical Statements.

Thus haulage by WAM4 is cheaper for obtaining equal performance as WDM2 by Rs 67,061/- **(i.e. 33.0%).**

However, it is felt that the benefits of higher h.p. should be passed on to the consumer by curtailing the total running time of the train which will be beneficial to Rly also, by way of generation of additional goods path made available due to less time of occupation of ruling sections. The savings in the total journey time will be as follows, as compared to WDM2:-

8. **WAM4(upto 105 kmph) 3 hrs over WDM2.**
   WAP4(upto 105 kmph) 3 hrs 30 mts over WDM2.

It is recommended that the time table is reviewed to curtail running time by about 3 hrs.

Also, with single WAM4, the no of coaches can be increased beyond 18 coaches. With WAP4, the additional coaches could be upto 24 which is a regular feature in peak season while with WDM2 any additional coach will require double headed operation. Also, with more number of coaches the SEC for electric locos will be even lower.

TRENDS OF SPECIFIC ENERGY CONSUMPTION FOR 18/24 COACH TRAIN WITH WAM4 & WAP4 ELECTRIC LOCOMOTIVE AT VARIOUS SPEEDS

Section: HWH-IGP

Distance: 1831.39 km

No of coaches: 18(1073 t) **Combination : 15GS+3AC**

WAM4					WAP4			
Speed (km/h)	Running time (mts)	Energy (kwh)	Specific Energy Consumption (SEC)	%rise in energy for higher speeds	Running time (mts)	Energy (kwh)	Specific Energy Consumption (SEC)	%rise in energy for higher speeds
83	1414	32300	14.87	--				
95	1276	37868	17.43	17.2	1263	38858	17.89	20.3
105	1198	40910	18.8	26.6	1172	42969	19.78	33.0
110	1170	42148	19.56	30.48	1135	44792	20.62	38.6
120	--	--	--	--	1077	48246	22.2	49.3
130	--	--	--	--	1035	51150	23.54	58.3
140	--	--	--	--	1013	53407	24.58	65.3

No of coaches: 24(1430 t) **Combination: 20GS+4AC**

WAP4				
Speed (km/h)	Running time (mts)	Energy (kwh)	Specific Energy Consumption (SEC)	%rise in energy for higher speeds
110	1167	54850	19.41	--
120	1117	58438	20.67	6.5
130	1087	61044	21.60	11.2
140	1076	62308	22.04	13.6