

CHAPTER 7

ELECTRICAL MULTIPLE UNITS

7.1.0 BRIEF HISTORY

7.1.1 DC EMUs

With Railway Electrification starting in India in Mumbai region of the erstwhile GIPR (now Central Railway) and BCR (now Western Railway) at 1500V DC, both Railways decided to run commuter train suburban services based on **Electrical Multiple Units (EMUs)**. The first service ran on 3rd February 1925, from Victoria Terminus to Kurla via Harbour Line.

While choosing the EMU stock, width of the stock became an important parameter. It was decided that 12' wide coaches would be used instead of 10'8" wide coaches which was the all India standard moving dimension. The 12' wide coaches provided over 22 % more passenger carrying capacity under dense crush peak hour loading condition. A 4-car unit could carry almost 250 more passengers.

After Independence, with the increased traffic requirement, other imported stocks were introduced from 1951 onwards. While the earlier units were with vacuum brakes, all further stock was with pneumatic brakes. Initially all the stock was imported from Europe. However, subsequently imports of the entire stock or the electrics were made from Japan also. In due course manufacture of EMUs was started in India, including the electrics.

All these EMUs were of straight DC type, drawing 1500 V DC from OHE and driving DC Traction Motors with cam shaft voltage control.

7.1.2 A.C. and A.C./D.C. EMUs

By mid fifties electrification had started in Eastern region, first on 3000 V DC system and then on 25 KV AC. To meet the requirements of suburban system, in 1958-59 Railways inducted 16 nos. 3- coach units with one spare motor coach of 3000 V DC/ 25KV BG EMU stock purchased from M/s Machison Fabric Augsburg Nuraberg (MAN) with electrics supplied by Allgeneine Electricitats Gesellschaft (AEG). This stock was put in service on the Eastern Railway.

In the same year (1958-59) another 16 three coach units of 3000 V DC BG EMU stock were inducted, purchased from M/s SIG Switzerland. One of these units was later converted to 1500 V DC operation and put into service on Western railway in 1960-61. Twelve of these units were also converted to dual voltage (3000 V DC / 25 KV)

By this time (1959), M/S Jessop & Co based at Calcutta were ready to build coaches for EMU stock and sixteen three- Coach units with one spare motor coach of these first time indigenously built units were purchased from them in 1959-60. Electrics for this stock were imported from AEG.

By the end sixties Indian public sector giant, Bharat Heavy Electricals Ltd. (BHEL) started manufacturing electrical equipment for EMUs and with coach manufacture by M/S Jessops, **history was made as totally indigenous EMUs started entering Indian Railways.**

In the mean time, by late sixties, Integral Coach Factory (ICF) of Indian Railways, situated at Madras (now Chennai) also established capabilities to manufacture EMU coaches, both 1500 V DC for Central & Western Railways and 25KV AC for Eastern Railway. Since then all EMU stock requirements have been met by ICF for all Indian Railways where EMUs have been progressively introduced for commuter traffic.

With the conversion of Southern Railway's Meter Gauge suburban section at Madras to 25 KV AC system, ICF also supplied the required MG AC EMUs.

7.1.3 Three Phase EMUs

By mid nineties, Indian Railways had taken two important decisions:

- To upgrade the technology of EMUs to the energy efficient and maintenance friendly Three Phase Drive, and
- To convert the 1500V DC system of electric traction in Mumbai area, to 25 KV AC system, in uniformity with the entire Indian Railway system.

The process of conversion to 25 KV system necessitated induction of dual voltage (1500V / 25 KV) EMUs for the period of conversion. Technologically the three phase drive was ideally suited for dual voltage EMUs.

Thus, it was decided to procure three phase drive kits to be used for retrofitment in the existing DC stock and also for manufacturing new EMUs at ICF. To start with, three phase drive kits were procured from M/s ALSTOM and M/s BHEL.

7.1.4 Main Line EMUs (MEMUs)

Apart from metropolitan areas of Mumbai, Kolkata, Delhi and Chennai, Indian Railways run a large number of short distance commuter trains around other important towns. These trains had the disadvantages of slow speed, low acceleration and braking, less passenger capacity due to having normal main line coaches, and lower efficiency as one loco was hauling only 8 to 10 coaches. The average speed of these trains was very low. Being slow and having frequent stoppages, these trains drastically reduced the sectional capacity.

It was felt that EMU type trains, with their characteristic fast acceleration and braking, could be used for such services. However traditional EMU stock posed severe limitations as high level platforms are required at every station and major structural modifications are required to run the 12 feet wide EMU stock as against the clearances being available only for the traditional 10 ft. 8 inches stock.

Thus came up the idea to develop a new type of stock, incorporating the required features of both the main line coaches and EMU type drive. This stock has been named as Main Line EMUs, MEMUs in short.

The 10'-8" or 3250 mm wide 25 Kv AC BG stock designed by RDSO was manufactured by ICF during the last quarter of 1993-94. It was initially commissioned by the Eastern Railway on Bardhaman- Asansol section in September 1994. The bogies of these coaches are similar to existing AC EMU stock, while the shell is 3250 mm wide, similar to main line coaches with the provision of stairs and vestibule. The four-coach unit formation is DMC-TC-TC-TC. All electrics on MEMUs are supplied by M/s BHEL similar to 12ft AC BG EMUs. The units are provided with Electro- Pneumatic brakes similar to existing EMUs.

The MEMU services are fast becoming very popular on all electrified sections and have already been introduced on East Central, Western, Northern, Eastern, South Eastern, South Central, and Southern Railways.

Main advantages of MEMUs over conventional loco hauled trains can be listed as under:

- Higher acceleration and braking resulting in reduced travelling time between stations – on an average there is a saving of 11 minutes per 100 kms. in travelling time as compared to loco hauled passenger trains.
- Higher average speed.

- Better reliability, as failure of one motor coach does not affect the train running.
- Quick reversal, as driving cabs is at both ends.
- Higher passenger capacity per coach - 230 passengers per MEMU coach, as compared to 185 passengers in normal passenger train coaches.
- With abundant power available from OHE, coaches are provided with better illumination
- Lower overall capital costs

Optimisation studies by computer simulation of MEMU vs. loco hauled passenger train services in Tundla - Kanpur section of Northern Railway (taking it as a representative main line section) were carried out in October 1999 by RDSO and it was found that there is a saving of 24 mins. in total running time in MEMU trains as compared to loco hauled trains. These findings were further verified with actual trials in the same year in Tundla - Kanpur section with a 12-car MEMU train and 12 coach loco-hauled passenger trains. A saving of 60 min. in total running time with MEMU was observed.

7.2.0 CAPACITY AUGMENTATION

7.2.1 With a given infrastructure, the line capacity is totally dependent on inter-sectional running time. Lower the inter-sectional running time, higher the line capacity. EMUs and MEMUs make the most significant contribution in increasing the line capacity due to their intrinsic characteristic of higher acceleration and deceleration. Essentially, there is severe limitation to maximum acceleration and deceleration in a loco hauled train, which is limited by adhesive capacity or "ADEHSION". In case of EMUs and MEMUs, since tractive power is distributed all along the train, much higher values of adhesion are achieved resulting in higher acceleration and deceleration. This, in turn, provides greatly reduced inter-sectional running time contributing to augmented line capacity.

7.2.2 There are some other factors that also contribute to capacity augmentation with EMUs and MEMUs. These include:

- With driving cabs at both ends there is no time lost in reversal of motive power at terminals, thus making it possible to run increased services with a given number of coaches.

- As the tractive power is mounted under-slung, loco space is replaced by revenue earning coach.

7.3.0 WAY AHEAD

- 7.3.1 IGBT based three phase technology has already proved to be a more efficient and maintenance friendly technology. Its energy efficiency is further improved by almost 35 to 40 % due to use of regenerative breaking. Indian Railways are now gradually switching to the three phase propulsion in EMUs and MEMUs.
- 7.3.2 With adequate power available from OHE, public demand of running air conditioned suburban trains can be easily met. There is already a proposal to manufacture two air conditioned EMU rakes for Mumbai area on experimental basis.
- 7.3.3 The intrinsic advantage of higher acceleration and deceleration in EMU type trains is now proposed to be utilized in some of main line trains. Such trains are called 'Train Sets'. It has been estimated that more than three hours' running time can be knocked off Rajdhani train between Delhi and Mumbai. Besides, such train sets will not need power cars as all the electric load can be drawn from OHE, thus releasing revenue earning capacity.

CHAPTER 8

DIESEL MULTIPLE UNITS

- 8.1.0 DMU's were developed for meeting the needs of the fast growing population centers to reap the following benefits:
- Fast and frequent services
 - No need for reversal facilities
 - Low capital & maintenance cost
 - Minimum damage to environment
 - Efficient use of rolling stock.
- 8.2.0 BG DMU : Two types of stock were conceptualized: Diesel electric (DEMU) and Diesel hydraulic (DHMU).
- DEMU : This is a three coach unit consisting of one power car, one trailer car and one trailer cum drive unit. The manufacture was undertaken by ICF. After oscillation trials, the prototype was commissioned in October '94. Up to 2002, 56 sets of DEMUs (each consisting of 3 coaches) had been manufactured. Combination of diesel engine model VTA 17102/INTAC 3412 TA and electrics supplied by NGEF/BHEL/KEC were used. The DEMUs were earlier cleared for operation upto 80 km/h. Later they were suitably modified for operation upto 100 km/h .
 - DHMUs: DHMU incorporates under-slung power pack and transmission for 3 coach set unit. After oscillation trials, the prototype was put to commercial use in July '97. Uptil 1202, 3 sets of DHMUs each having 3 coaches had been made. The DHMU is powered by twin underslung power pack, each consisting of engine NTA 855R and Voith transmission T 2111rz. The DHMUs were cleared for operation upto 95 km/h.
 - 1400 HP high power DEMU : It was decided to develop a high horse power diesel multiple unit for suburban sections on Indian Railways. A feasibility study brought out immense potential of such stock for non- electrified sections of IR. The prototype 1400 HP DMU was manufactured at ICF /Chennai & cleared for operation upto 100 km/h. Later, more than 20 nos of these DEMUs were manufactured.

8.2.1 The DEMU incorporates the following equipments:

- (a) One Cummins KT A 3067 L fuel efficient diesel engine capable of producing 1400 hp under standard conditions along with accessories and excitation control & speed governing LCC system.
- (b) One BHEL make traction alternator model TA 7003 AZ.
- (c) One BHEL Make three phase bridge type rectifier.
- (d) Four BHEL Make 4303 AZ model traction motors.
- (e) One Kerala Electrics Make Auxiliary alternator with voltage regulator.
- (f) One complete set of BHEL Make propulsion control equipment.

8.2.2 The operating requirements were:

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|------------------------------------------|---------------|
| (a) Maximum operating speed | 100 km/h |
| (b) Gear ratio | 20.91 |
| (c) Motor Grouping | 4 P Permanent |
| (d) Maximum tractive effort at start | 15,000 kg. |
| (e) Continuous rating tractive effort. | 7100 kg. |
| (f) Installed power (standard condition) | 1400 hp. |
| (g) Installed power (site) | 1370 hp. |
| (h) Power input to traction (site) | 1250 hp. |


8.3.0 MG DMU : The following types were conceptualized:



- On board electric transmission version.
- Underslung hydraulic transmission version.
- It was also decided to convert MG coaches to DMU in Izatnagar Workshop of N.E.Railway. Railway Board directed that initially only one MG DMU set of 3 coaches should be manufactured and based on field performance two more sets of DMU will be ordered. The prototype DMU was manufactured and cleared for operation at a speed of 55 km/h.
- MG DEMU : Development of 350 HP MG diesel Electric Multiple Unit was also done.

Achievements

SN	Year	Area	Title	Description	Likely Benefits
1.	2007-08	Passenger amenities	Development of 3-phase 1600 HP AC-AC DEMU	Design and development of 3 phase AC/AC DEMU has been undertaken by RDSO.	Less requirement of maintenance of DEMU.
2.	2008-09	Passenger amenities	BG DEMU for J&K	Diesel Electric Multiple unit for J&K section with speed potential of 100km/h has been designed with provision to meet the cold climate of J&K.	DEMU (J&K) has provided an economic, efficient and reliable supplement to the existing means of transportation in J&K.

Achievements: Design Development of Traction Stock for IR

	<p>Diesel Hydraulic Multiple unit Passenger Service Broad Gauge</p> <ul style="list-style-type: none"> • 700 hp gross power • Speed potential upto 95 km/h • Axle load 17 t Under-slung Cummins engine and Voith transmission Passenger capacity 854.
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	<p>Diesel Hydraulic Multiple unit Passenger Service Meter Gauge</p> <ul style="list-style-type: none"> • 350 hp gross power Speed potential upto 75 km/h Axle load 11.96 t • Electric transmission Passenger capacity 1184.
	<p>Diesel Electric Multiple unit Passenger Service Broad Gauge</p> <ul style="list-style-type: none"> • 1400 hp gross power Speed potential upto 100 km/h • Air springs on the bogies for comfort riding • Transmission-electrical • Passenger capacity 1092.

Current / Future Projects

- Development of 1600 HP AC-AC Diesel Electric Multiple Unit (DEMU).

8.4.0 RAILBUS

Rail Bus was developed for sparsely populated areas with requirement of frequent service and to have the following benefits:

- Low capital investment.
- Minimum facilities for maintenance.
- Low operation & maintenance cost.
- Low axle load & track friendly.

- Frequent and efficient service.
- Use of indigenous equipment with easy inter-changeability.
- For BG, these were conceptualized as 2-axle light weight vehicles. With assistance from RDSO development work was taken up by M/s BEML, Bangalore for 5 BG railbuses. After oscillation trials, the prototype was put to commercial service in Oct. '94. The remaining 4 railbuses were commissioned subsequently. The railbuses were cleared for operation up to 60 km/h.



**Railbus
Passenger Service Broad Gauge**

- 152 hp gross power
Speed potential upto 70 km/h
- Axle load 14 t
Frame mounted Cummins engine & hydraulic transmission
- Passenger capacity 152.



**Railbus
Passenger Service Meter Gauge**

- 120 hp gross power
- Speed potential upto 55 km/h
- Axle load 11 t
- Frame mounted Ashok Leyland engine & hydraulic transmission
- Passenger capacity 120.

8.4.1 Later, another order was placed for 5 nos. more to the same specification. The manufacturer was completed & the same were commissioned.

- With the experience gained in the working of rail-buses, development for an upgraded version calling for an operating speed of 70 km/h was taken up for 10 nos. of rail-buses .
- For MG, two designs were developed one consisting of two-axled vehicle with new design body and another by conversion of 4-axled MG steel bodied coach. For the 2-axle design, a development order was placed on M/s Phooltas Tampers, Patna for 5 nos. of rail-buses. After oscillation trials the prototype was commissioned in Oct.'97. The railbuses were cleared for operation upto 55 km/h. For the 4-axle design, a decision was taken in 1995 to convert some surplus MG coaches to rail-buses. The first rail-bus was commissioned in mid '96. Later, 10 such rail-buses have been manufactured by NE Railway. After oscillation trials, these rail-buses were cleared for operation upto 55 km/h.
