Presentation

Latest Developments in EMUs

(Specific to Mumbai Suburban System)

Railway Staff College: 15th Feb.2008

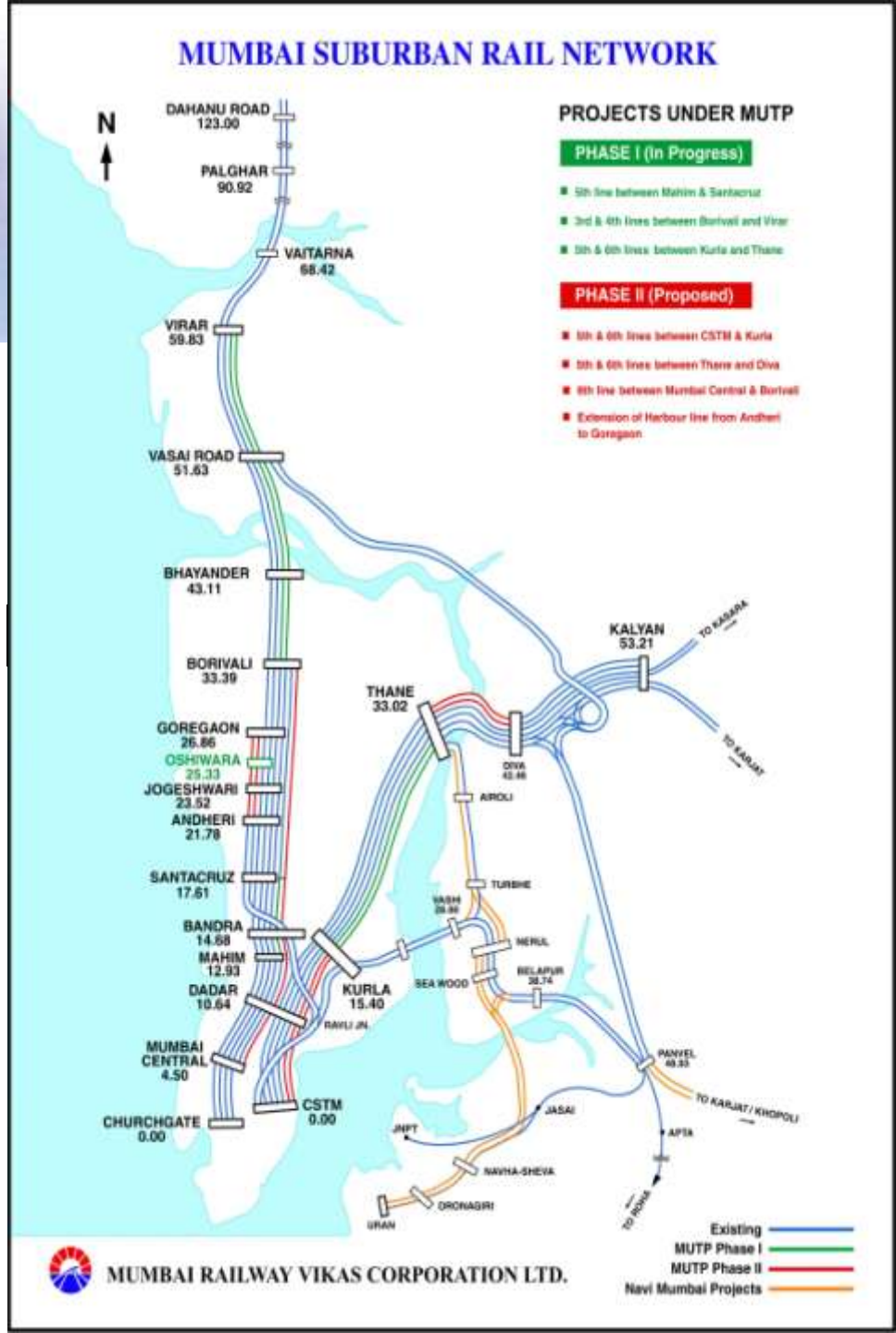
Yesterday's Memories

Today's Lifeline

Tomorrow's Technology

Mumbai Railway Vikas Corporation

Mumbai Urban Transport Project (Rail Component)



MUMBAI SUBURBAN RAILWAY SYSTEM

- Mumbai has been the commercial capital of India since pre-independence days
- Due to its peninsular geography, the city has grown linearly
- Britishers realized that only an efficient suburban railway system can become the prime mover of growth for the city
- Suburban railway system set up in 1925
- Latest technologies of 1500v DC traction and DC Electric Multiple Units available at that time used.

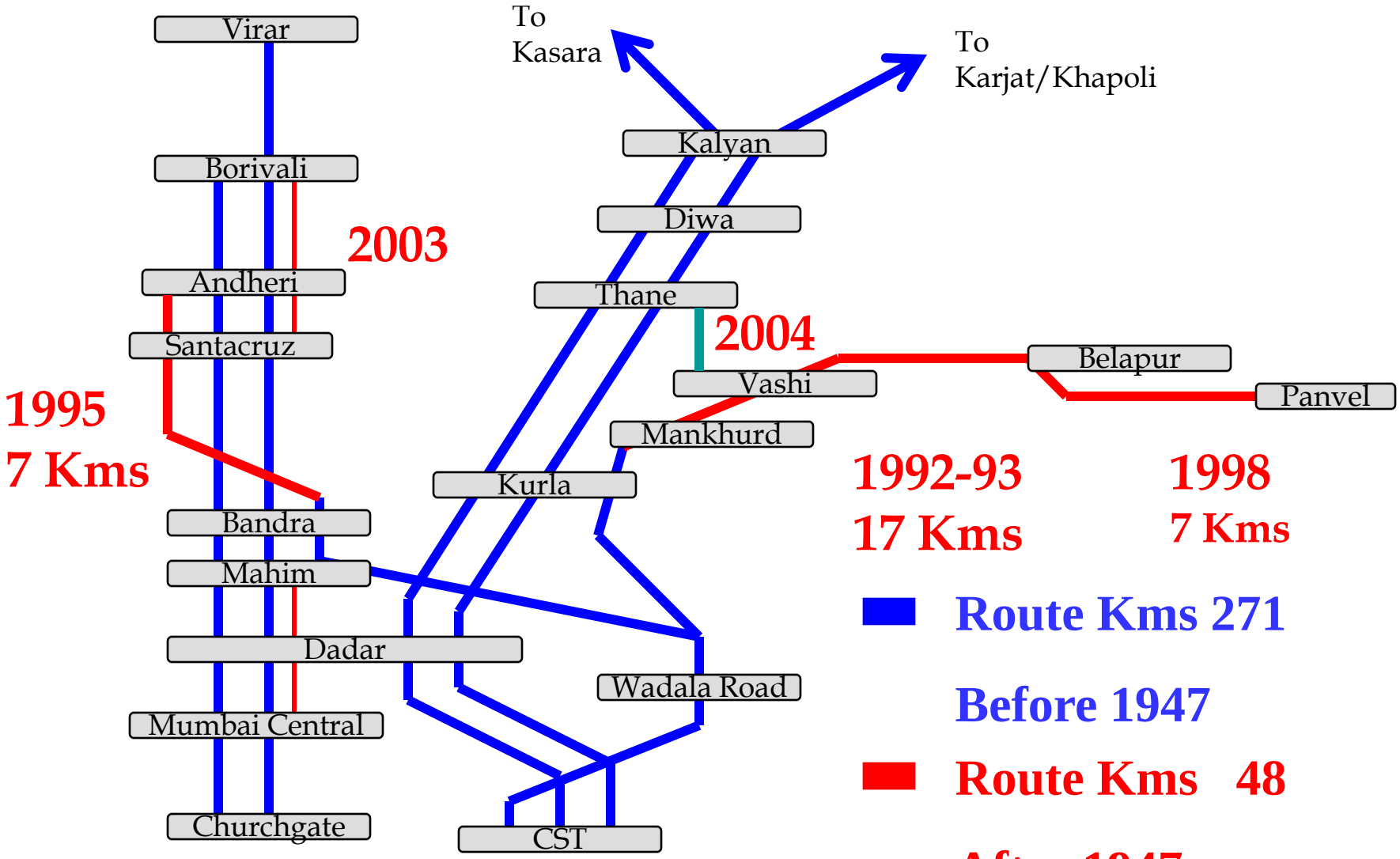
Mumbai Suburban Rail Network
An Overview

- 319 route Kms. 842 Track Kms (Excl Loop Lines).
- 6.3 million passengers per day.
- 2105 trains per day
- Fleet of 200 rakes (9 car eq.) which are run in 9 and 12 car compositions.
- The most densely loaded trains in the world during the peak hours

Suburban Traffic Growth

	Units	1951/ 52	1960/ 61	1970/ 71	1980/ 81	1990/ 91	2000/ 01	2004/ 05
Passenger carried	Million	292	454	915	1459	1795	2275	2314
	% Annual Compounded Growth Rate		5.0	7.3	4.8	2.1	2.4	0.43
Passenger KMs	Million	4031	6365	15123	27392	40462	61195	68362
	% Annual Compounded Growth Rate		5.2	9.0	6.1	4.0	4.2	2.8
Average trip length	Km	13.8	14.0	16.5	18.8	22.5	26.9	29.54
	% Annual Compounded Growth Rate		0.2	1.7	1.3	1.9	1.8	2.37

Suburban Railway Network Development in Mumbai



Mumbai Suburban Railway System - Problems

OVERCROWDING

Overcrowded Stations

Difficult Entry & Exit

ENCROACHMENTS

ENCROACHMENTS

TRESPASSING

TRESPASSING

DRAINAGE

Lack of Investment

- The traffic demand was mainly due to phenomenal growth of population in the northern suburbs whereas the main business district continued to be in south Mumbai
- Development/Property tax used for roads & other infrastructure but not for suburban railway system
- Indian Railways also unable to provide funds for expansion as suburban system is loss making.

Mumbai Urban Transport Project (Rail Component)

- Rail projects were identified in 1998 through the project preparatory studies with the objective of:
  - Bring down the crowding in peak hour peak direction 9-car train to 3000 passengers as against existing around 5000.
  - Segregate the suburban train operation from the main line passenger and freight services.

Mumbai Urban Transport Project (Rail Component)

- Completion over a time frame of ten to twelve years.
- Total cost in excess of Rs. 10,000 crores
- MUTP (Rail Component) bifurcated in phases for the purpose of World Bank funding.

Institutional Arrangement for Rail Component of MUTP

- Ministry of Railways & Government of Maharashtra have set up **Mumbai Railway Vikas Corporation Ltd**. to undertake rail related works of MUTP for:
  - **Better coordination between GOM & MOR**
  - **Cutting down the bureaucratic delays**

OBJECTIVES OF MRVC

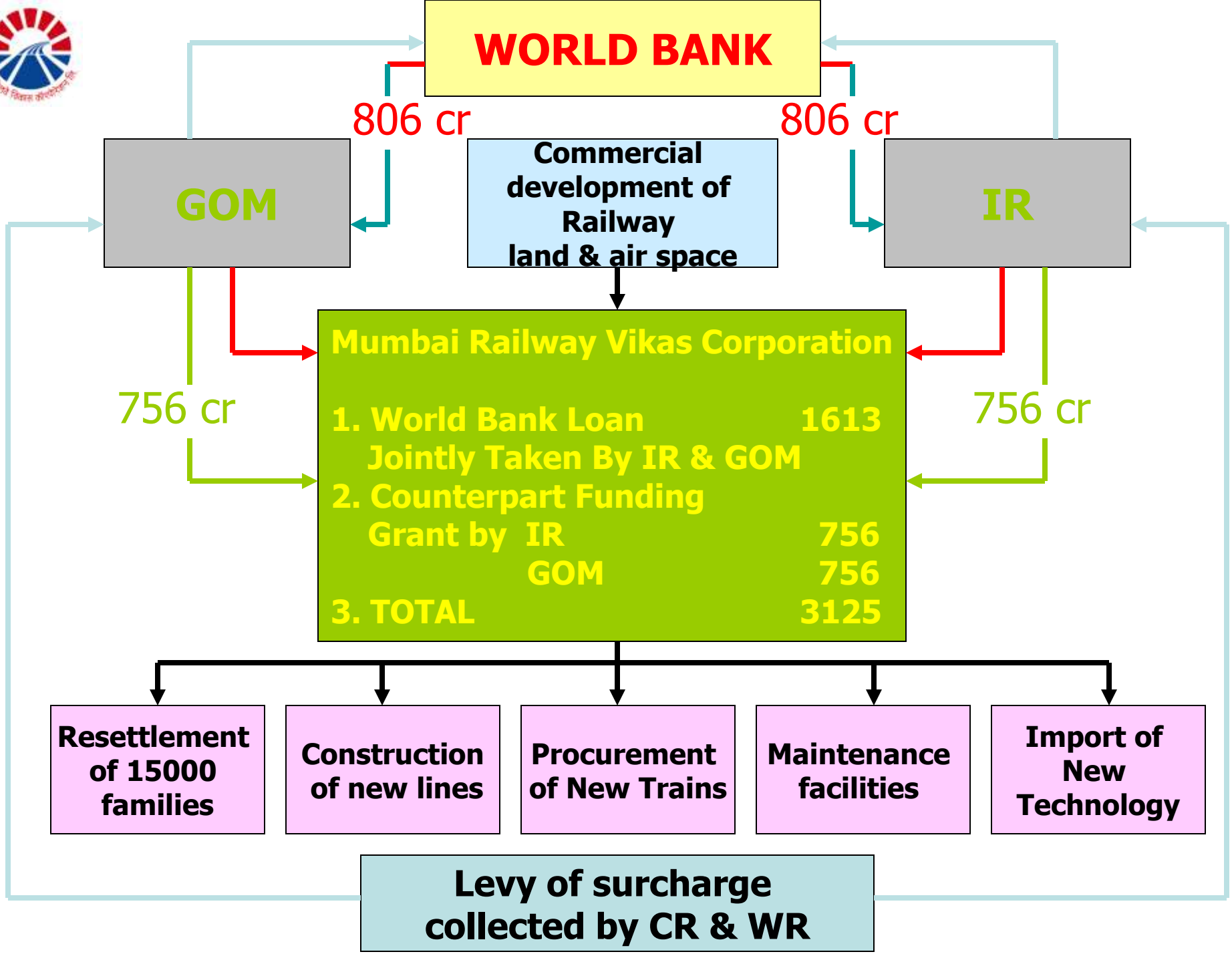
- Implement the rail infrastructure projects in Mumbai suburban sections.
- Commercial development of railway land and airspace in Mumbai area to raise funds for suburban railway development.
- Resettlement & Rehabilitation of Project Affected Households.

MUTP Phase I
(Rail Component)

- Phase I includes Works required to bring down the peak hour loading from 5000 to 3600 & to be completed by June 2009.

MUTP Phase I (Rail Component)

New Lines:	
Quadrupling of Borivali-Virar section	416.0 cr.
WR 5th line Santacruz-Mahim	59.0 cr.
Kurla Thane Additional pair of lines	166.0 cr.
Sub-Total (New Lines)	**641.0 cr.**
EMU procurement & manufacture:	**1359.2 cr.**
DC to AC Conversion	**380.4 cr.**
Resettlement & Rehabilitation:	**290.0 cr.**
Optimisation & Other Works:	
Optimisation of Western Railway	50.1 cr.
Optimisation of Central Railway	99.5 cr.
Optimisation of Harbour line	19.7 cr
Virar Car Shed	93.0 cr
Maintenance facilities for EMUs	64.3 cr.
Stabling lines for EMUs	48.5 cr.
Track Machines	31.3 cr.
Institutional strengthening & studies	48.2 cr.
Sub-Total	**454.6 cr.**
Grand Total	**3125.2 cr**


WORLD BANK
806 cr
806 cr
GOM
Commercial development of Railway land & air space
IR
Mumbai Railway Vikas Corporation
1. World Bank Loan 1613
Jointly Taken By IR & GOM
2. Counterpart Funding
Grant by IR 756
GOM 756
3. TOTAL 3125
756 cr
756 cr
Resettlement of 15000 families
Construction of new lines
Procurement of New Trains
Maintenance facilities
Import of New Technology
Levy of surcharge collected by CR & WR

MAJOR INPUTS IN MUTP PHASE I

- Addition of 93 track Kms – base figure 790 Kms
- 101 new 9-car rakes - 51 on additional account and 50 on conversion account. (base figure 199 rakes)
- Resettlement & Rehabilitation of about 15,000 Project affected households
- Lengthening of all platforms (excluding harbour line) to handle 12 car rakes
- Respacing of signals to achieve 3 minutes headway on all the lines
- DC to AC conversion in all suburban section except Thane CSTM which will be taken up in Phase II

Surcharge

- Surcharge has been levied on Mumbai Suburban Commuters w.e.f. 15.09.03
- Surcharge levied will be shared by GOM and MOR in the ratio 50:50
- MOR to pass on Surcharge to MOF towards Loan Repayment

Benefits of MUTP Phase I:

- 550 additional trains per day – an increase of 26.5%.
- Vehicle Kms per day will increase by 32.5%
- Vehicle Kms in the peak hours will increase by 38.0%
- Overcrowding during peak hour peak direction will come down from existing more than 5000 to 3600 per 9-car rake

EMU PROCUREMENT

EMU Procurement:

- Total No. of rakes - 174, 9 Car.
  - MRVC Contract - 101, 9 Car.
  - GP-194 - 56, 9 Car.
  - GP-194 (30%) - 17, 9 Car.

Progress

- Total 5, 12-car rakes Manufactured

1st Rake : 12th Nov. 2007 (W.R.)

2nd Rake : 17 Dec. 2007 (W.R.)

3rd Rake: 13th Jan. 2008 (C.R.)

4th Rake: Recd on CR on 4th Jan 2008.

5th rake: Under Despatch from ICF.

- Series production of Balance Rakes from February 2008 – June 2009

Hon’ble Chief Minister inspecting the New EMU Rake

New Rake in Public Service

New Rake in Public Service

Improved Features of MRVC EMU Rake

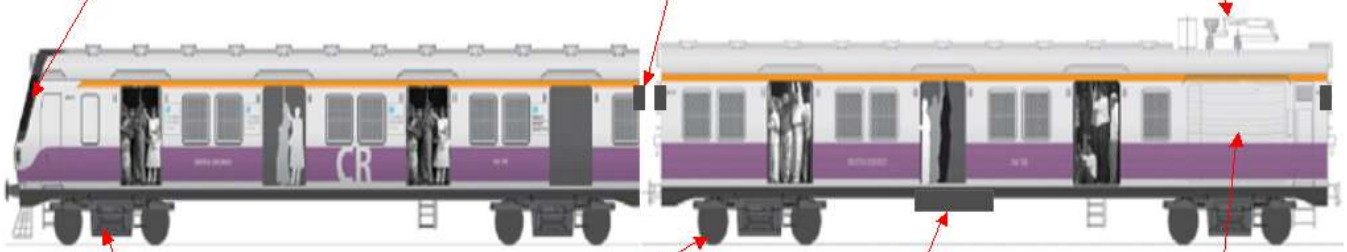
Technical Features

Details of Equipments

▪ Driver's Desk

▪ Ventilation Blower

▪ Pantograph



▪ Air Spring

▪ Traction Motor

▪ Traction Transformer

▪ Traction Converter

System Requirement

- Max. Axle load ⇒ 20.32 tones
- Typical Run ⇒ 1.5 km on level tangent track in less than 113 sec
- Acceleration (average ⇒ 0.54 m/s^2 with SDCL. Jerk: 0.75 m/s^3 from 0 to 40 Km/h)
- Deceleration ⇒ 0.76 m/s^2 (100 to 50 kmph) 0.84 m/s^2 (50 kmph to Stand still)
- Traction voltage ⇒ 1500 volt DC and 25 kv AC (Dual Voltage)
- Bogie suspension ⇒ Metallic springs in Primary, Air springs in Secondary.
- Brakes ⇒ Blending of Regenerative and Frictional brakes
- Main / Aux. Converter ⇒ IGBT based
- SEC (KWH /1000 GTKm) ⇒ 29
- Life ⇒ 25 year

Main Transformer

Traction Transformer	
Continuous KVA rating	1250 KVA
Continuous Secondary Voltage (at 25KV primary)	2 X 950 V
No. of secondary windings	2
Type of cooling	ODAF
Type of coolant	Mineral oil
Weight	App. 3100 Kg
Efficiency	App. 96%

Power converter-inverter

Traction Converter	
Nominal Input voltage	2 x 950 V AC (AC Mode) 1500 V DC (DC Mode)
Nominal DC link voltage	1800 V DC (AC Mode) 1500 V DC (DC Mode)
No. of 4 quadrant choppers (4QC)	2 (IGBT based)
No. of pulse with modulated inverters (PWMI)	2 (IGBT based)
Continuous rating per 4QC	620 KW
Continuous rating per PWMI	535 KW
Output voltage	1217 (line to line, fundamental value)
Control	Microprocessor control
Cooling	Force air cooled
Weight	App. 2200 Kg

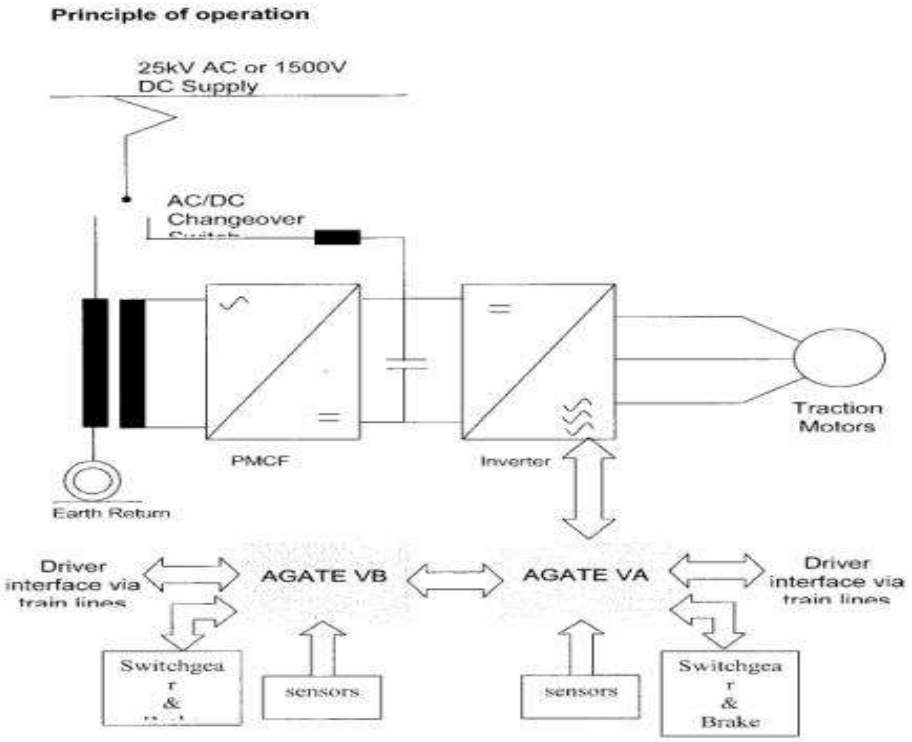
Traction Motor

Traction Motor & Gear	
Type	3 phase AC asynchronous traction motor Axle hung nose suspended
Continuous rating	240 KW (at 2000 rpm)
One hour rating	270 KW (at 2000 rpm)
Gear ratio	5.71
Design speed	3452 rpm (fully wom wheel, 100 kmph)
Insulation system	MICALASTIC T, 2.3 KV, Class 200
Cooling	Force air cooled
Weight	App. 1734 Kg
Efficiency	App. 94%
Weight	App. 2200 Kg

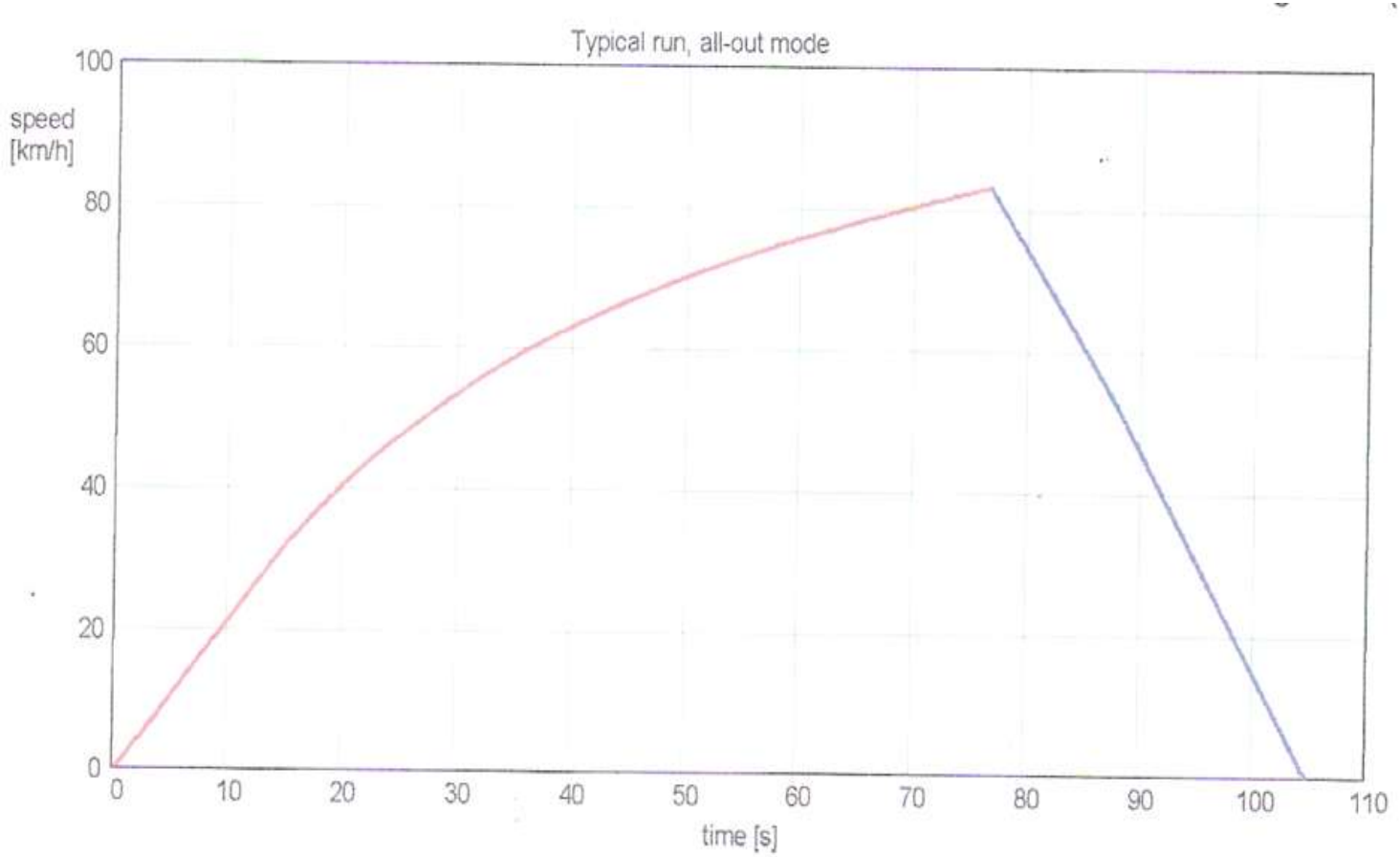
Auxiliary Systems

Auxiliary Converter & Battery Charger	
Nominal input voltage	1500 V DC
Nominal output voltages	415, 3 ph. AC, 50 Hz 110V, 1 ph AC, 50 Hz 110 V DC
Ratings	415, 3 ph. AC, 87 Hz 110V, 1 ph AC, 20 Hz 110 V DC – 9 KW
Semiconductor device	IGBT based
Control	Microprocessor control
Cooling	Force air cooled
Weight	App. 1200 Kg
Efficiency	> 90%

Power circuit



Typical run in a Mumbai suburban system



Improved Performance Features of MRVC EMUs

Features	MRVC EMUs	Existing EMUs
• Acceleration with super dense crush loading	0.54 m/s^2	0.36 m/s^2
• Decelaration	0.76 m/s^2 (100 to 50 kmph) 0.84 m/s^2 (50 to stand stilll)	0.6 m/s^2
•Max Service Speed	100 kmph	80 kmph
• Specific Energy Consumption	27 units per Thousand Gross Ton Km	40 KWH/100 GTKM

Improved Performance Features of MRVC EMUs

• Traction Motor Power Rating	240 kW	187 kW
• Traction Control	Microprocessor based control & Fault Diagnostics	Resistance Control
• Auxiliary Power Supply Capacity	70 kW	12 kW
•Passenger Information System	Menu Driven Digital Audio –Visual system in each coach	Normal PA System

Commuters will get information like which is the next halting station & on which side platform will be there, on speakers as well as on LED display panels.

Passenger Friendly Features

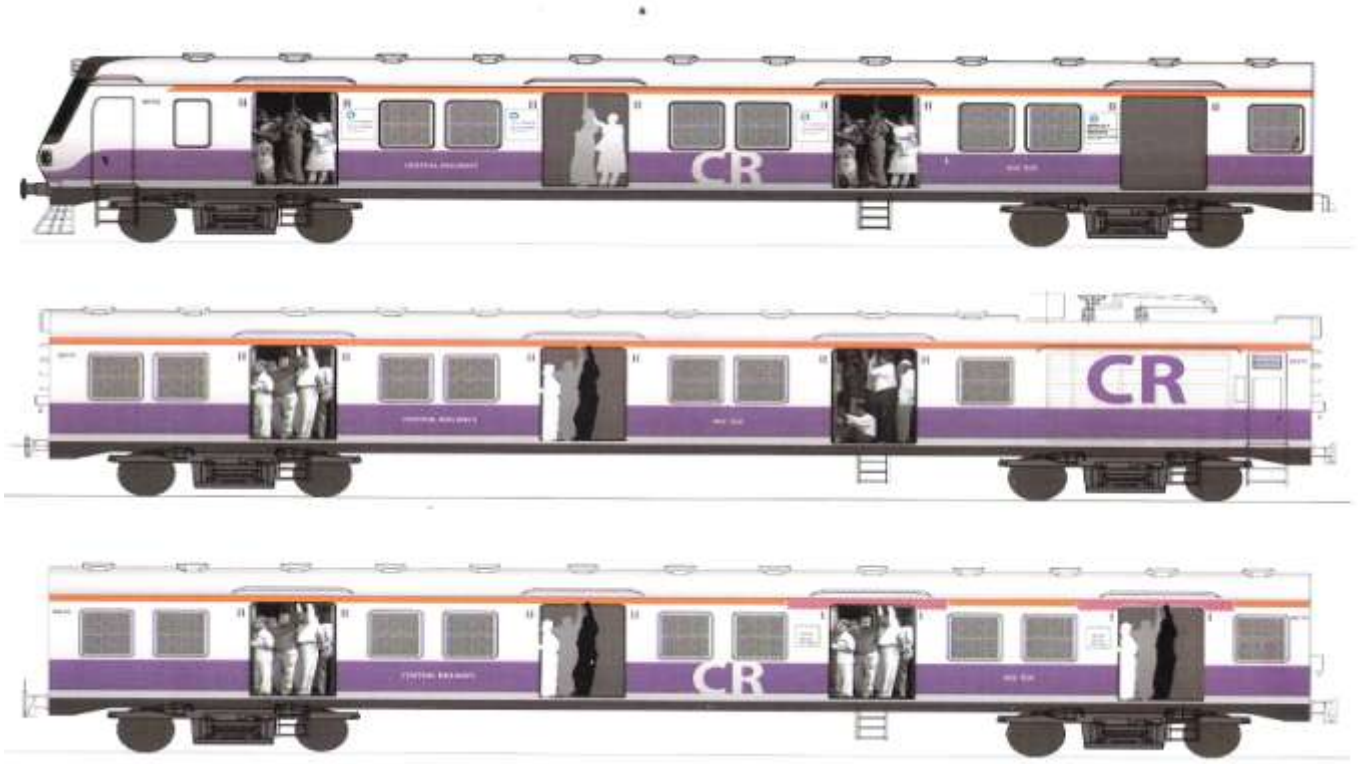
Improved Features

1. **Exterior colour scheme**: *Designed by National Institute of Design (NID), Ahmedabad.*
2. **Window:** *Lift-up window with fixed polycarbonate lower AT TOP with Tinted Glass.*
3. *Polycarbonate seat with stainless steel frame for second class.*
4. *PU cushion seat with stainless steel frame for first class.*
5. **Grab rails:** *Addition of one extra rail.*
6. **Handholds:** *Improved design to reduce dangling and material changed to stainless steel.*
7. **Grab poles:** *3 grab poles provided at door as against 1 in existing design.*
8. **Inside roof paneling:** *Stainless steel canvass finish roof paneling provided.*
9. **Trough floor and flooring:** *To reduce corrosion, stainless steel trough floor and flooring provided.*
10. **Doorway and compartment partitioning:** *Improved design stainless steel partition provided.*

Improved Features

11. **Coach door:** *Powder coated aluminum door with polycarbonate window provided.*
12. **Luggage rack:** *Stainless steel rack provided.*
13. **Ventilation:** *Forced air ventilation system provided.*
14. **Sidewall and end wall panel:** *FRP panels used for better aesthetics and long life.*
15. **Head code:** *LED type head code provided.*
16. **Secondary suspension:** *Pneumatic spring used to improve comfort and safety.*
17. **Signage:** *NID design signage with stickers.*
18. **Improvement in coach insulation:** *Recron thermal wadding used.*
19. **Rainwater gutter:** *Stainless steel water gutter provided.*
20. *Passenger information system*

1. Exterior colour scheme: *Designed by National Institute of Design (NID), Ahmedabad.*



Exterior Colour Scheme

2. **Ventilation:** *Forced air ventilation system*

3. Window: *Lift-up window with fixed polycarbonate lower AT TOP with Tinted Glass.*

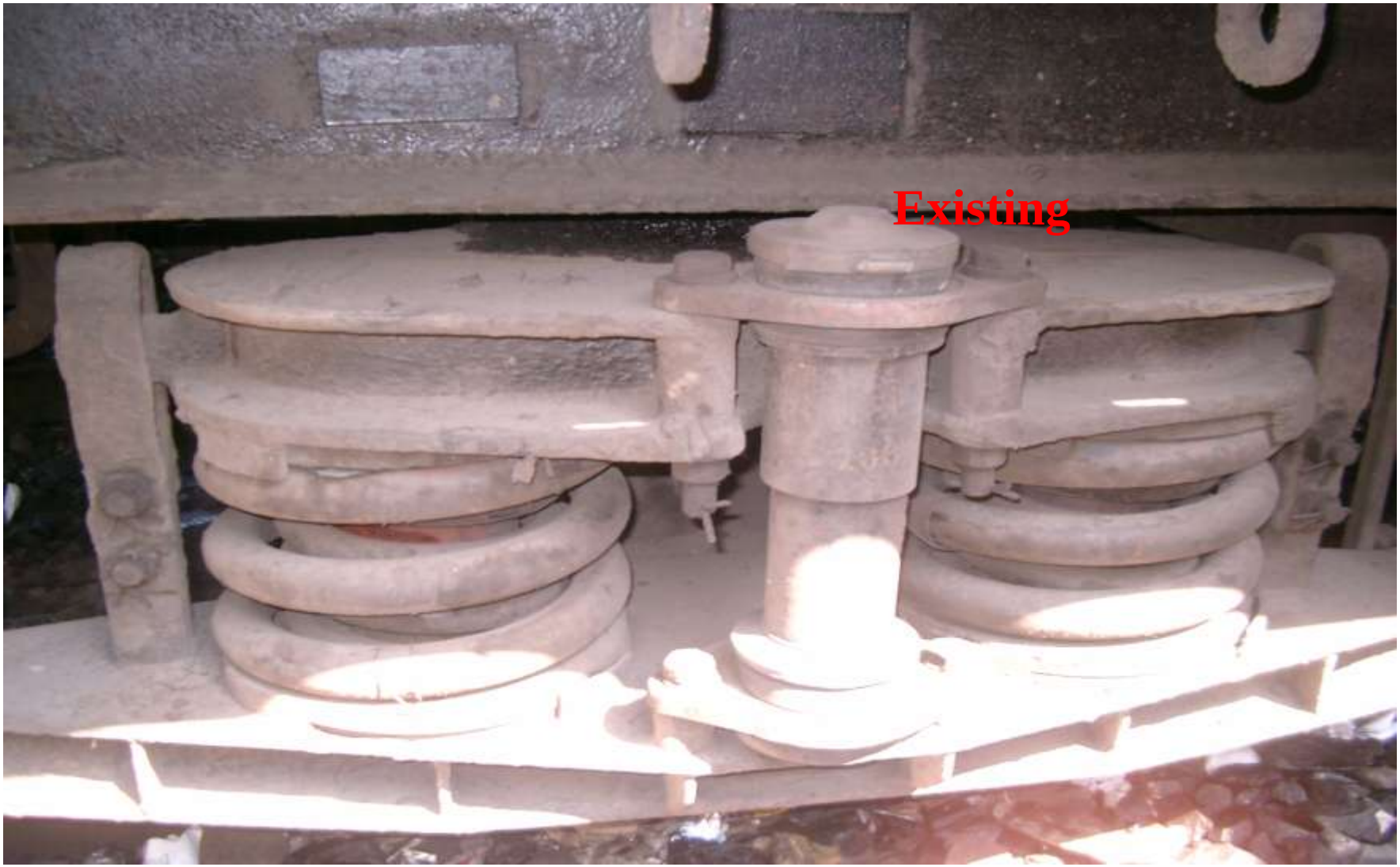
Windows and Protective Window screen

Existing EMU

4. Passenger information system

5. **Secondary suspension:** *Pneumatic spring used to improve comfort and safety.*

Secondary suspension



6. Improved Lighting : *illumination levels increased to 300 lux.*

7. Sidewall and end wall panel: *FRP panels used for better aesthetics and long life.*

8. **Head code:** *LED type head code provided.*

9. *Polycarbonate seat with stainless steel frame for second class.*

10. PU cushion seat with stainless steel frame for first class.

Seats of Existing Rakes

1. **Handholds & Grab rails :** *Improved design to reduce dangling and material changed to stainless steel.*

12. Inside roof paneling: *Stainless steel canvass finish roof paneling provided.*

13. Doorway and compartment partitioning: *Improved design stainless steel partition provided.*

14. Coach door: *Powder coated aluminum door with polycarbonate window provided.*

15. **Signage:** *NID design signage with stickers*.

16. **Improvement in coach insulation:** *Recron thermal wadding used.*

17. Grab poles: *3 grab poles provided at door as against 1 in existing design.*

18. Trough floor and flooring: *To reduce corrosion, stainless steel trough floor and flooring provided.*

Trough Floor and flooring

19. **Luggage rack:** *Stainless steel rack provided.*

20 Rainwater gutter: *Stainless steel water gutter provided.*

Details of Cost

Cost 20 Crores

Cost of Imported Rake 60 crores

Ventilation System

VENTILATION Problem:

Ventilation system

- MRVC procured a portable carbon dioxide meter and measured the CO_2 levels inside the running trains.
- The CO_2 levels in the existing SDCL condition was 2500 ppm.

Ventilation system

- Detailed study was carried out referring ANSI/ASHRAE standard to modify the RDSO specification.
- ANSI/ASHRAE standard 62-2001 recommends that the maximum indoor CO2 concentration should be less than 700 ppm above the outdoor air concentration

Ventilation system
Fresh Air Requirement

- Passenger Loading per coach:
  - Seating Capacity 90 passengers
  - Normal standing for peak 90 passengers
  - Total passengers traveling in SDCL 570 passengers

Ventilation system
Fresh Air Requirement

- CO_2 Generated per Coach:
  - CO_2 generated per passenger .018 m^3/hr
  - CO_2 generated by 570 passengers in SDCL 10 m^3/hr
- Calculation of Fresh Air Requirement:
  - Fresh Air Required = $\frac{\text{Total } CO_2 \text{ generated}}{\text{Permissible PPM}}$

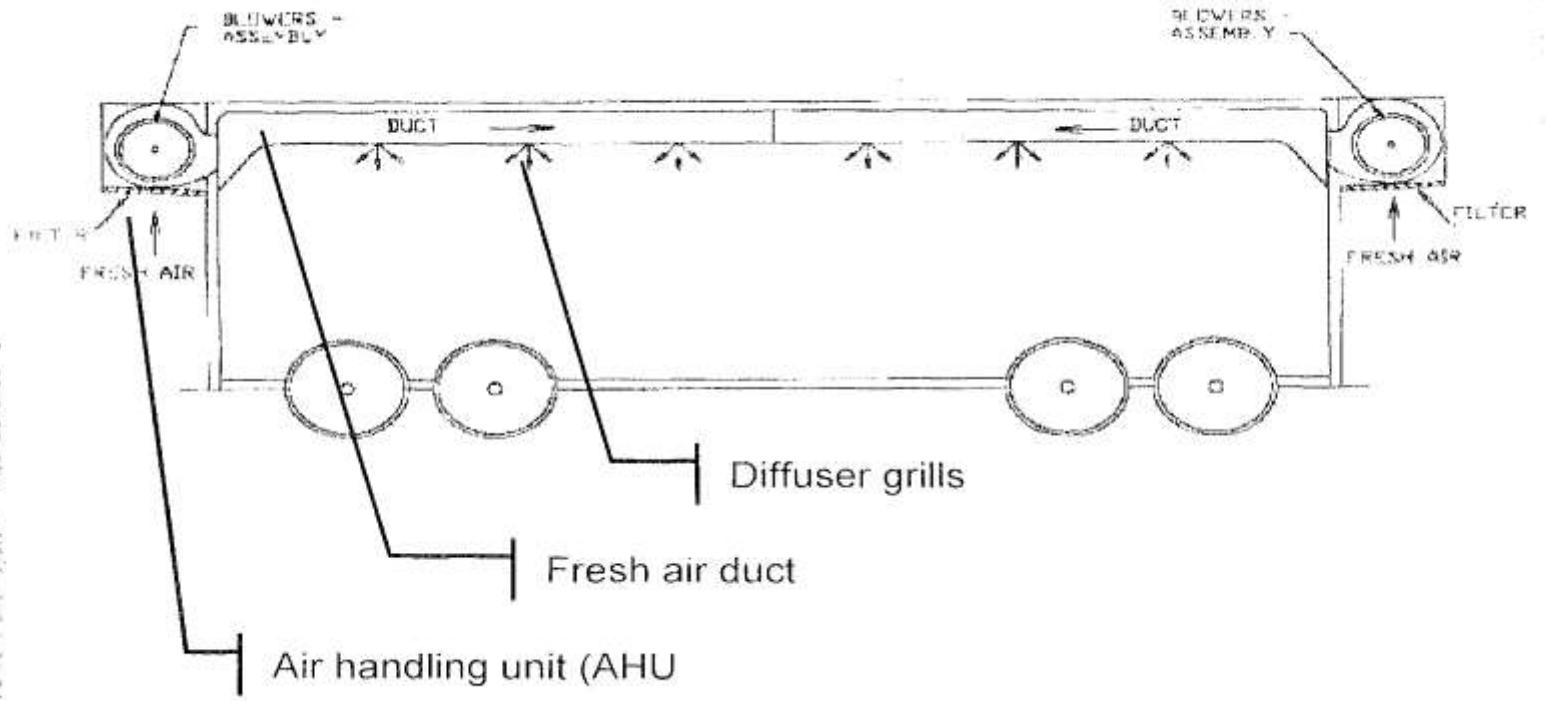
    = $\frac{10 \text{ m3/hr}}{700 \text{ X } 10^{-6}}$

    = **15000 m^3/hr**

ADDITIONAL FRESH AIR REQUIRED = 15000 m^3/h

VENTILATION SYSTEM

The Design Concept :



VENTILATION SYSTEM

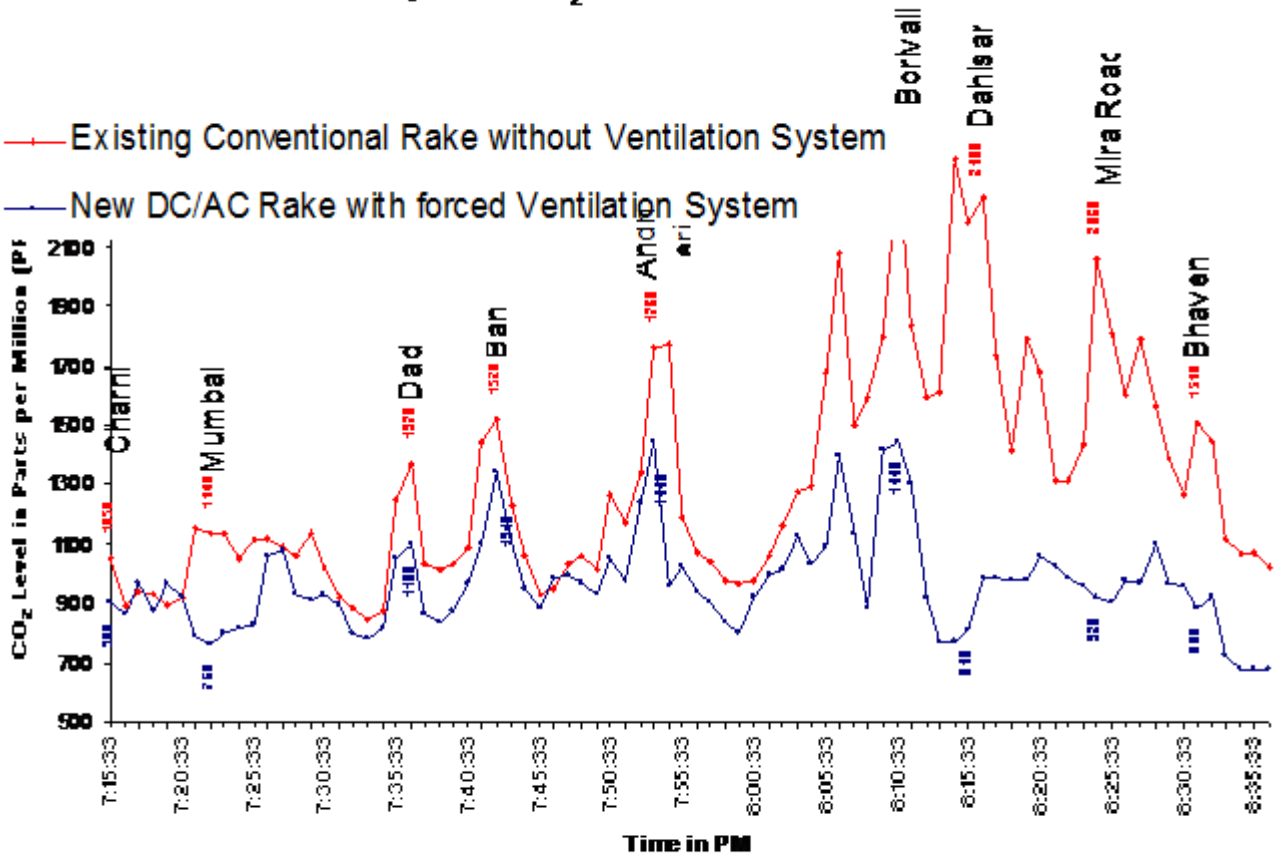
- **Ventilation:** *Forced air ventilation system*

External Air Blowers for forced ventilation

VENTILATION SYSTEM

Photograph of Mock-Up

Comparative CO_2 Levels In SDCL EMU Train



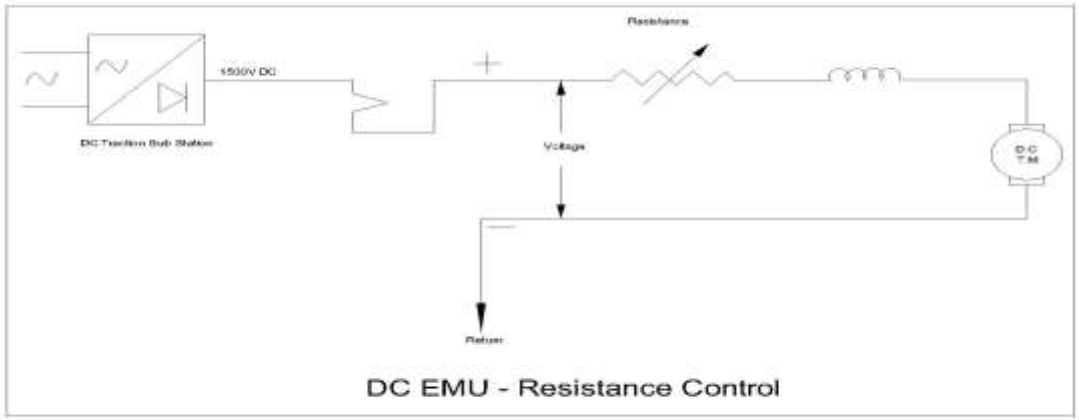
* Above Comparative Graph Shows an appreciable reduction in CO_2 level in the EMU Train fitted with Forced Ventilation System

Contribution to prevention of global warming due to saving of Electric energy

Existing DC EMUs design details of power circuit and brake system

- **Power circuit**

  The present design of EMU rakes draws electrical power from OHE at 1500V DC, which is fed to four DC traction motors of 210 kW capacity. The control of speed of traction motors is through resistance control, i.e. current is reduced or increased by resistances

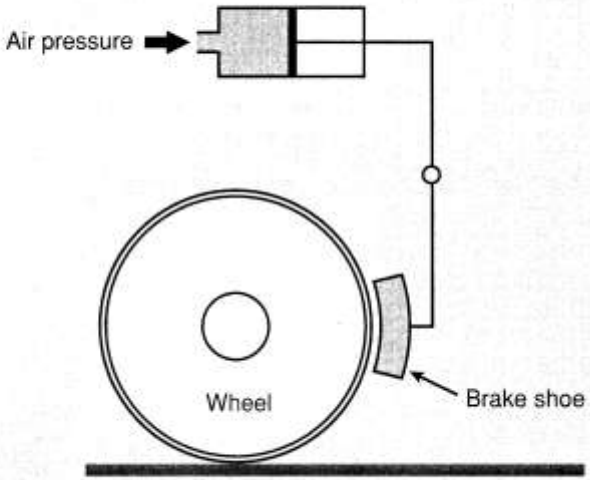


DC EMU - Resistance Control

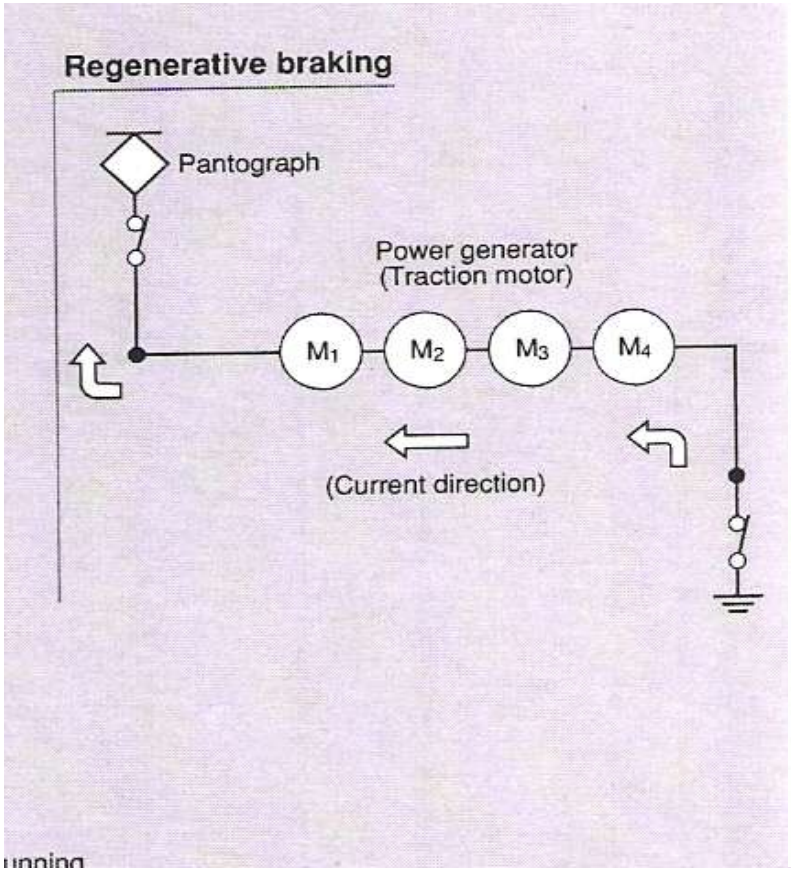
- **Present Brake System**

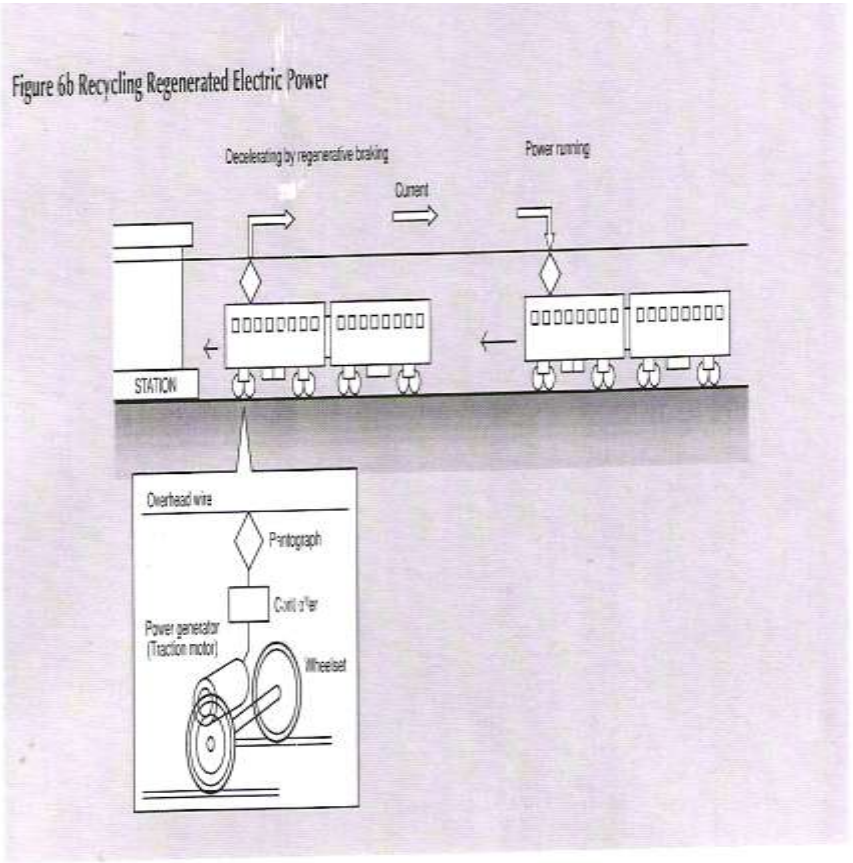
  The braking of rakes is through friction braking using tread brake system in the existing EMU's.

Figure 8 Wheel-Tread Brake System



New EMU: Regenerative Braking





Total Energy Consumption

(a)	Present (204 rakes)	:	55 Cr. Units (KWH)
(b)	After MUTP – 1 (255 rakes) if present D.C. EMU Technology were continued	:	75 Cr. Units (KWH)
(c)	After MUTP – 1 (255 Rakes) with New technology EMU rakes having regenerative braking	:	55 Cr. Units (KWH)

- Saving in units / Year: 20 Cr. Units (KWH) - This means by introducing 51 additional rakes energy requirement will not increase.

- Saving in Rs. / Year: Rs. 72 Cr.

Energy Density and Emission

	:	**Energy density**	**Emission in Kg CO2/KWH**
Coal	:	2.3 KWH / Kg.	1.046 Kg/KWH
LPG	:	7.13 KWH / Ltr	0.216 KG / KWH
Crude Oil	:	10.73 KWH / Ltr.	0.274 Kg/KWH
Natural Gas	:	10.8 KWH / m3	0.209 Kg / KWH

Benefits

(a) Reduction in fuel consumption / year (Depending upon Power Plant are anticipated as follows):-

Coal	⇨	4.6×10^8 Kg.
LPG	⇨	14.26×10^8 Ltr.
Crude Oil	⇨	21.46×10^8 Ltr.
Natural Gas	⇨	21.6×10^8 m^3.

(b) Reductions in Pollution:- By saving 20 Cr. units of power following will be reduction in pollution per year (for Coal based Power Plants).

CO2	⇨	2.092×10^8 Kg.
SO2	⇨	18×10^8 gm.
SPM	⇨	5×10^8 gm
Soot Carbon	⇨	0.2×10^8 gm
NO	⇨	20×10^8 gm

Reduction of CO_2 according to KYOTO Protocol is our commitment.

- Mumbai will receive 3 phase new technology EMU rakes with regenerative braking.
- Introduction of this technology would save about 20 crore units of energy every year
- For each unit of energy produced in a thermal power plant, 1 kg of carbon dioxide is produced.
- Thus, on account of this project there would be a reduction of approximately 2 lakh tones of carbon dioxide emission every year.
- This will qualify for Carbon Credits

Carbon Credits

- A project has been undertaken with World Bank to obtain Carbon Credits on account of this huge reduction in emission.
- The Project Idea Note for this project has already been approved by the World Bank and detailed work will start shortly.
- World Bank has approved and registered this project.
- This is a first project registered for transport sector.

Other environment friendly features of New technology rakes

- DC traction motor is replaced by 3 phase AC traction motor.
  - Carbon brushes used in DC traction motors and DC fans. Total 4 lakh carbon brushes per year will not be required.
- 110V DC carbon type fans have been replaced by 110V AC fans.
  - Mica used in commutator of DC traction motor and DC fans.
- Oil lubricated suspension bearings have been replaced by axle mounted roller bearings.
  - Mineral oil based lubricants for suspension bearing of DC traction motors. Total 85,000 litre of oil per year will not be required.
- By introducing electrical regenerative braking use of asbestos brake block for mechanical brakes reduced to 90%.
  - Ferro asbestos brake blocks. Total 1.25 lakh brake blocks per year will not be required.

Resettlement & Rehabilitation

All Project affected Household under MUTP Phase I (Rail Component) have been Resettled & Rehabilitated

Mankhurd

Majas

Oshiwara

Borivali-Virar Quadrupling:

The Borivali-Virar section has been inaugurated by the hon'ble Railway Minister on 7th July 2007.

DC TO AC CONVERSION

All the World Bank funded DC to AC Conversion contracts entrusted to MRVC have been awarded and will be completed as per schedule.

ECO SENSITIVE PROJECT IMPLEMENTATION

Noise Reduction:

- MRVC has already initiated mitigating measures to contain the noise levels.
- The noise level has been restricted to 68 decibels in the compressors of the new EMUs.
- Air springs have been provided in the EMU bogies and 108 new design bogies for EMU coaches are planned for procurement under MUTP

ECO SENSITIVE PROJECT IMPLEMENTATION

Rain Water Harvesting:

- About 15000 Project Affected Households are resettled in tenements having rain water harvesting facility.
- MRVC is also planning for rain water harvesting at other construction sites.

ECO SENSITIVE PROJECT IMPLEMENTATION

Mangrove Plantation:

- MRVC has planted 13500 saplings, 8500 at Dahisar (East) and 5000 between Mankhurd and Vashi in lieu of only 3500 mangroves affected.
- The plantation was done in 2004 and the survival is above 80%.

THANK YOU

Website:www.mrvc.indianrail.gov.in