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Analysis of the Indian Maintenance center for WAG-9 Electric Locomotives and improve for new railways service

THESIS

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ELECTRIC LOCOMOTIVE SHED WAG-9 KAZIPET

INDIAN RAILWAY ELECTRIC LOCOMOTIVE WAG-9 KAZIPET

In Indian railway electric locomotive WAG-9 was the new version of the electric locomotive and it located in view states. Kazipet junction railway station is located in Warangal Urban district of Telangana It is an important railway junction connecting north and south India. We have Electric Locomotive WAG-9 in kazipet Loco Shed.

Figure-1 Indian railway electric locomotive WAG-9 kazipet

Figure-1 Indian railway electric locomotive WAG-9 the picture was taken from inside the electric locomotive shed Kazipet.

1. Introduction

This locomotive is referred to as the "Heavy Haul" freight locomotive of the Indian Railways (IR).

This locomotive was conceived owing to the extreme growth in the rail freight transportation sector.

The growth in this sector is considered to be of great importance in the growth of the economy of India.

This need had arisen the need for more electrification and electric locomotives in India. Around 60-65% of the freight haulage of IR takes place on the electrified section of the Golden Quadrilateral (Indian Railways) & diagonals (which account for 25% of the route).

These routes are very busy routes, so clearance is a necessity. This power Give it a great sectional clearance Ability. Thus these locomotives are important for the Indian Railways.

2. Block Diagram of Electric Locomotive WAG-9

The block diagram was showing every part located in electric locomotive WAG-9. The parts names and Description are show in below the block diagram (figure 2).

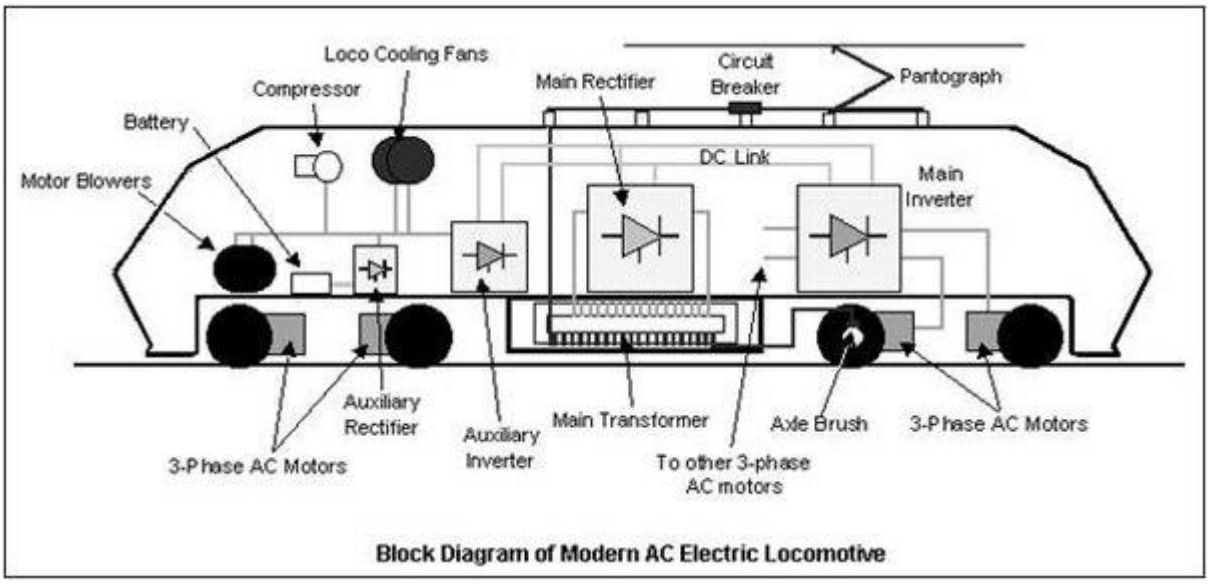


Figure-2-Block Diagram of modern AC Electric Locomotive

In this figure-2 the parts are named and clearly indicates by the arrow marks of block diagram modern AC electric locomotive. There are:

- Main Transformer.
- Auxiliary Inverter.
- Auxiliary Rectifier.
- Axle brush.
- 3-phase AC motor (total 4 motors).
- Motor blowers.
- Compressor.
- Cooling fans.
- Main rectifier.
- Circuit breaker.
- Pantograph.
- Main inverter.

- **Main transformer**

  A transformer is a static electrical device that transfers electrical energy between two or more circuits. A varying current in one coil of the transformer.

- **Auxiliary inverter**

  The Auxiliary Power Converter supplies the auxiliary AC-power needs of the diesel-electric locomotive.

  It charges also the batteries. The unit is installed inside the locomotive. The unit enables use of maintenance free AC-motors for the auxiliary drives.

- **Auxiliary rectifier**

  Power from the motor comes from the on-board electrical supply or, sometimes, directly from the traction supply.

  On electric locomotives, the supply can come from the transformer, via a rectifier and on a diesel locomotive, from the auxiliary alternator.

- **Axis brush**

  A brush or carbon brush is a device which conducts current between stationary wires and moving parts, most commonly in a rotating shaft. Typical applications include electric motors, alternators and electric generators.

- ***3*-phase AC motors**

  A traction motor is an electric motor used for propulsion of a vehicle, such as an electric locomotive.

  An AC induction motor only generates useful amounts of power over usually, the traction motor is three-point suspended between the bogie, Air cooling, Electric vehicle battery. Induction motor & Three-phase AC.

- **Motor blowers**

  An electric locomotive consists of various equipment.

  Traction motor cooling blower and its motor is one of the important auxiliary machine.

  There are two traction motor cooling blowers fitted in a locomotive. Each for cooling of one group of three traction motors.

- **Compressor**

  The compressor itself consists of a pump driven by an electric motor.

- **Cooling fans**

  Locomotive radiators keep engines cool. The radiator system is intended to keep the engine operating at nearly the same temperature, regardless of the ambient air outside the locomotive.

- **Main rectifier**

  Rectifier, A converter consisting of thyristors and diodes which is used to convert AC to DC. A modern locomotive will usually have at least two, a "Main Rectifier" for the power circuits and one or more for the auxiliary circuits. Relay a remotely controlled switch which uses a low voltage control circuit.

- **Circuit breaker**

  An electric train is almost always provided with some sort of circuit breaker to isolate the power supply when there is a fault, or for maintenance. On AC systems they are usually on the roof near the pantograph. There are two types - the air blast circuit breaker and the vacuum circuit breaker or VCB.

- **Pantograph**

  A pantograph is an apparatus mounted on the roof of an electric train, tram or electric bus to collect power through contact with an overhead line. It is a common type of current collector. Typically, a single or double wire **is** used, with the return current running through the track.

- **Main inverter**

  An electric locomotive is a locomotive powered by electricity from overhead lines, a third rail or on-board energy storage such as a battery or a super capacitor. Newer electric locomotives use AC motor-inverter drive systems that provide for regenerative braking.

3. Components of Electric Locomotive WAG-9

In this Table-1,we are showing electric locomotive WAG-9 components and weight as well as units, volume, electric components and mechanical components are clearly mention below.

The components are taken and the weights are calculated, units are taken, Volume are approximately And also electric and mechanical components are taken, the values are calculated accurately and the Volume are approximately.

Components	**Weight [t]**	**Numbers**	**Total weight [t]**	**Volume (Approx.) [m3]**	**Electrical**	**Mechanical**
Traction motor	2.3	6	13.8	0.9	yes	Yes
Transformer	10.4	1	10.4	3.7	yes	
Pantograph	0.8	1	0.8	1.5	yes	
Sandboxes	0.05	1	0.05	0.4		Yes
Auxiliary reservoir	0.1	1	0.1	1		Yes
Main reservoir	0.3	1	0.3	1.1		Yes
Filter cubicle	0.4	1	0.4	1.2		Yes
Oil cooling unit	1.0	1	1.0	1		

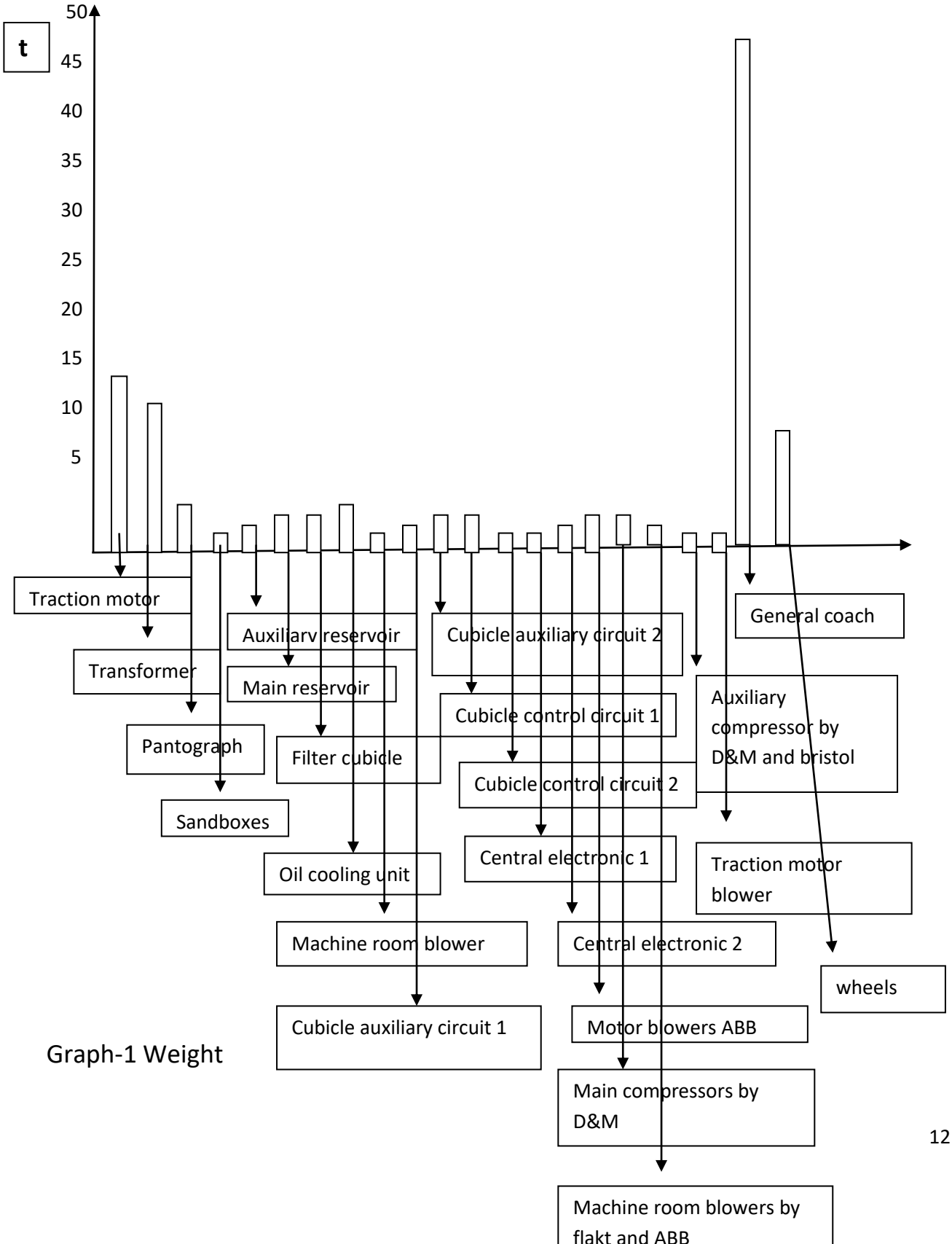
Scavenge blower to machine room blower	0.04	1	0.04	0.5	yes	yes
Cubicle auxiliary circuits 1	0.2	1	0.2	0.4	yes	
Cubicle auxiliary circuits 2	0.11	1	0.11	0.6	yes	
Cubicle control circuits 1	0.17	1	0.17	0.7	yes	
Cubicle control 2	0.18	1	0.18		yes	
Central electronics 1	0.03	1	0.03	0.3	yes	
Central Electronics 2	0.03	1	0.03		yes	
2 HCBO-605-115 type Traction Motor Blowers by Flakt and ABB	0.4	1	0.4	0.5	yes	Yes

2 2A3200 C13-T32 type Main Compressors by D&M	0.6	1	0.6	0.4	yes	Yes
2 HCBO-415-60 type Machine Room Blowers by Flakt and ABB	0.1	1	0.1		yes	Yes
FF 3145 type Auxiliary Compressor by D&M and Bristol	0.05	1	0.05	0.4	yes	Yes
Scavenge blower to traction motor blower	0.04	1	0.04	0.3	yes	Yes
General coach	49	1	49	5		
Wheels	1	8	8	0.5	yes	
Total			87.8			

Table-1 Components of electric locomotive WAG-9

From Table-1, this all are the components, weight, units, volume and electric & mechanical components, and the total electric locomotive WAG-9 weight was 88t.

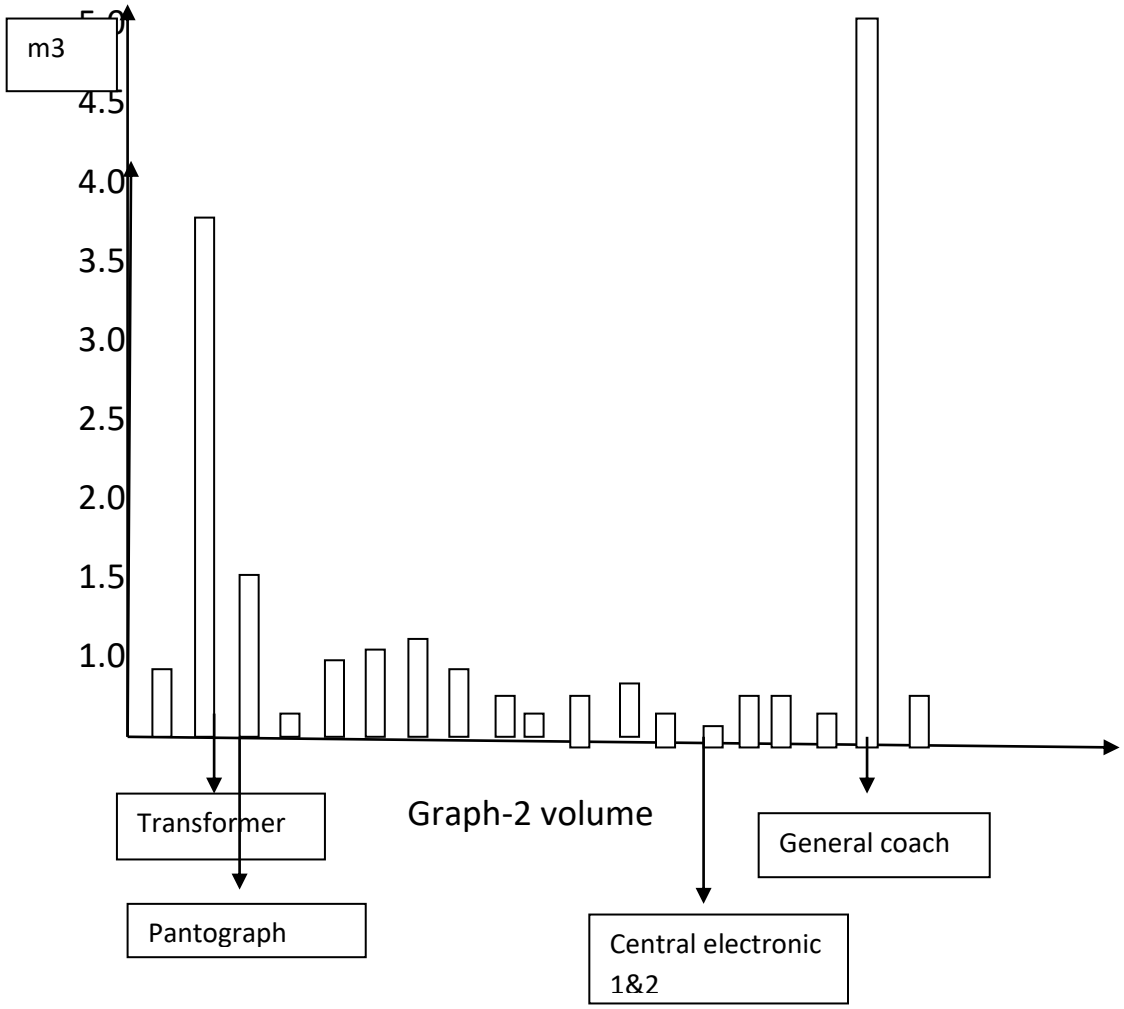
From table-1, we are taking the graph of weight are shown below



Graph-1 Weight

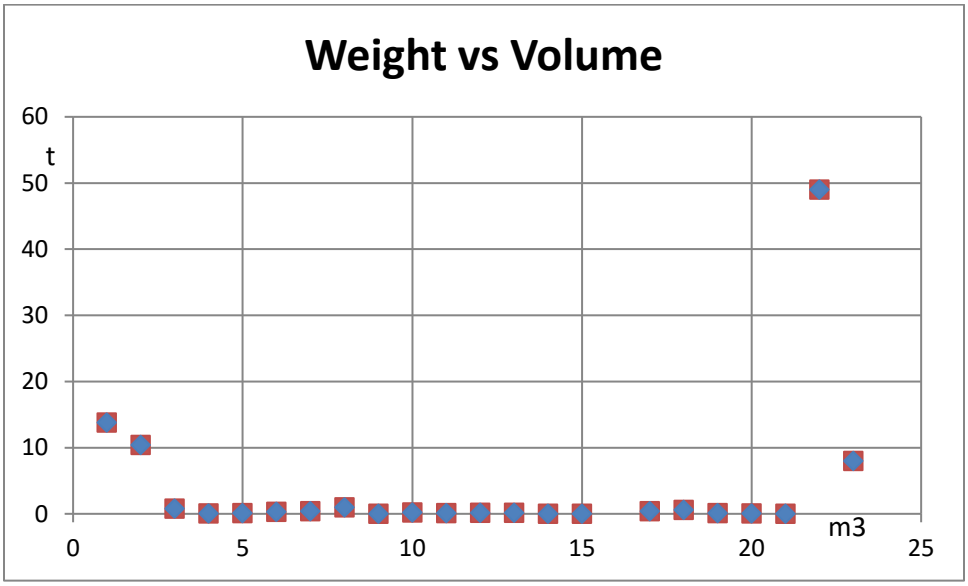
In this graph-1, we shown all components weight from this components the higher weight general coach, and the lower weight are central electronic 1, central electronic 2.

From table-1, we are taking the graph of volume shown below.



From graph-2, we are notes that the volume was higher in general coach, and the least are in central electronic 1&2, as well as this volume are taken from the table-1.

Then, from table-1 we are taken the graph of weight and volume, now we are taking the graph of the weight vs volume are shown in the below.



Graph-3 weight vs volume

From graph -3, we are showing the weight vs volume accurately located in the graph-3.

From this graph-3 the higher tons are the general coach.

4. Electric Power Supply to WAG-9

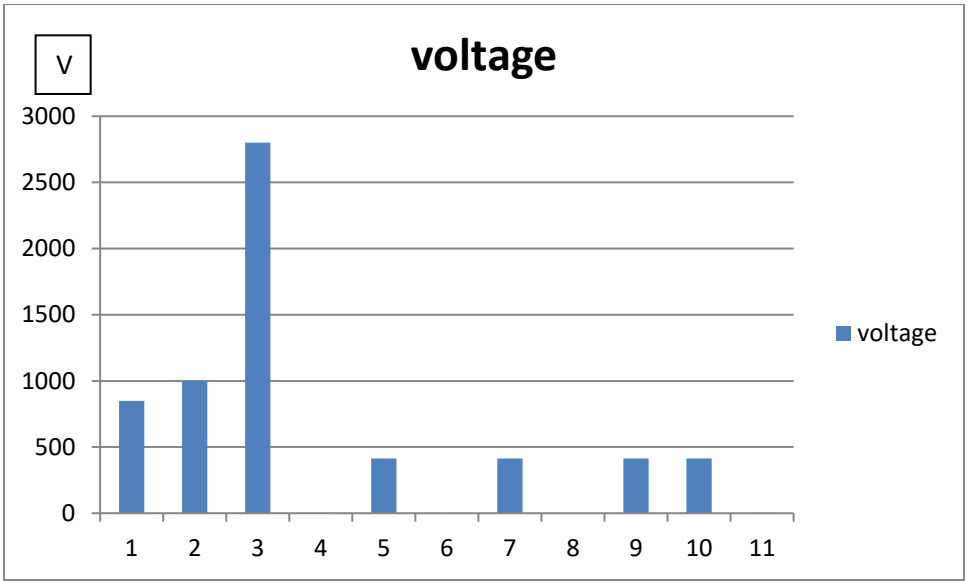
In this Table-2, we are showing the electric power supply to WAG-9, the electric power produce to the components and as well as the units are mention below the table-2.

Electric locomotive WAG 9 power Supply		
Components	Power produce	Units
Traction motor	850	kW
Transformer	1000	Voltage
2 power drives	2800	Voltage
Transformer oil Pump motor	415	Voltage
Main compressor motor	415	Voltage
Auxiliary converter by ABB	415	Voltage
Blower motor	415	Voltage
Heater capacity	2.2	kW

Table-2 Electric Power Supply to WAG-9

From Table-2, the electric power supply are shown. In that, traction motor was consume higher kW and the lower power consume by the main compressor, Auxiliary converter, blower motor, transformer oil pump motor.

From table-2, we are taking the graph-4, electric locomotive WAG-9 voltage.



Gragh-4 voltage

From graph-4, we are observed the power was consume very higher in transformer motor and heater capacity in kW and the lower power consume in transformer oil pump motor, main compressor motor, blower motor, auxiliary converter by ABB.

5. Kazipet Electric Loco Shed.

From Kazipet electric loco shed, we have taken some pictures by the cam. The Side view of the electric loco shed of Kazipet and as well as front view of shed and the inside view of electric loco shed Kazipet picture are shown below(Figure-3, Figure-4, Figure-5).

Figure-3, The side view of the Kazipet electric loco shed.

Figure-4, The entry gate of the Kazipet electric loco shed.

Figure-5, Inside view of electric loco shed Kazipet, and we can see how there are repair the locos.

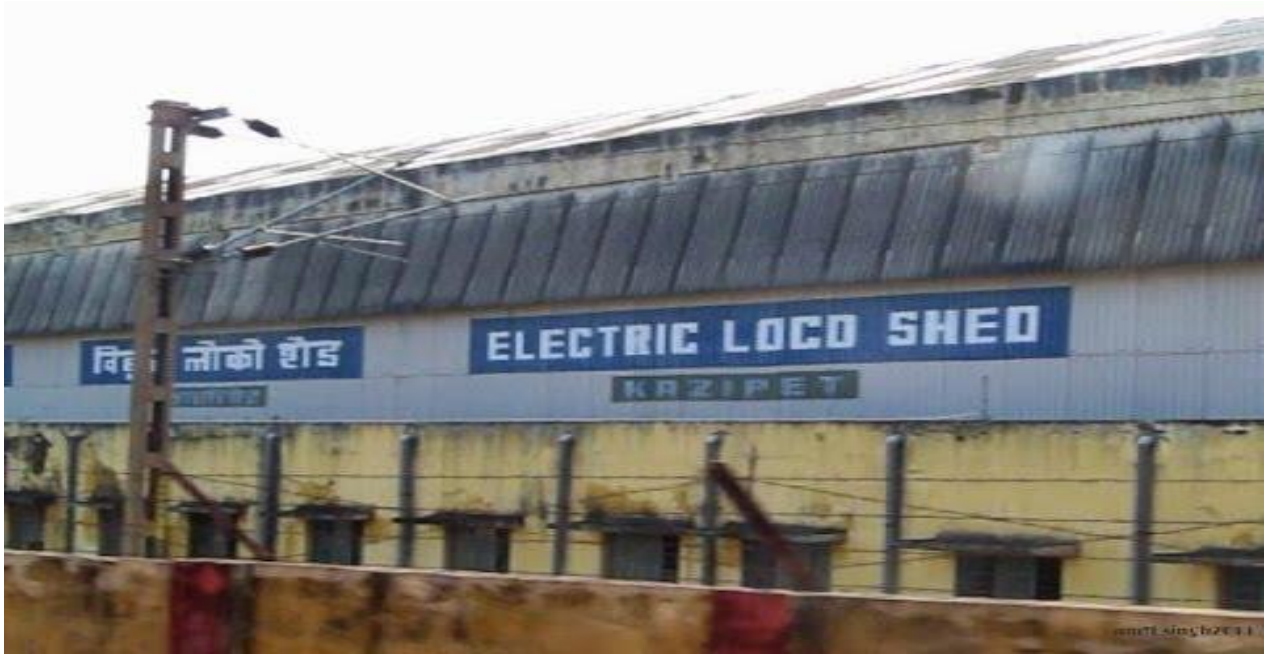


Figure-3 The side view of the Kazipet electric loco shed

Figure-4&5

Figure-4, The entry gate of the Kazipet electric loco shed.

Figure-5, Inside view of electric loco shed Kazipet, and we can see how there are repair the locos.

5.1. General Layout

Therefore, The planning layout of electric loco shed Kazipet and in this layout the total view of the electric loco shed in a manner wise shown in the below figure-6.

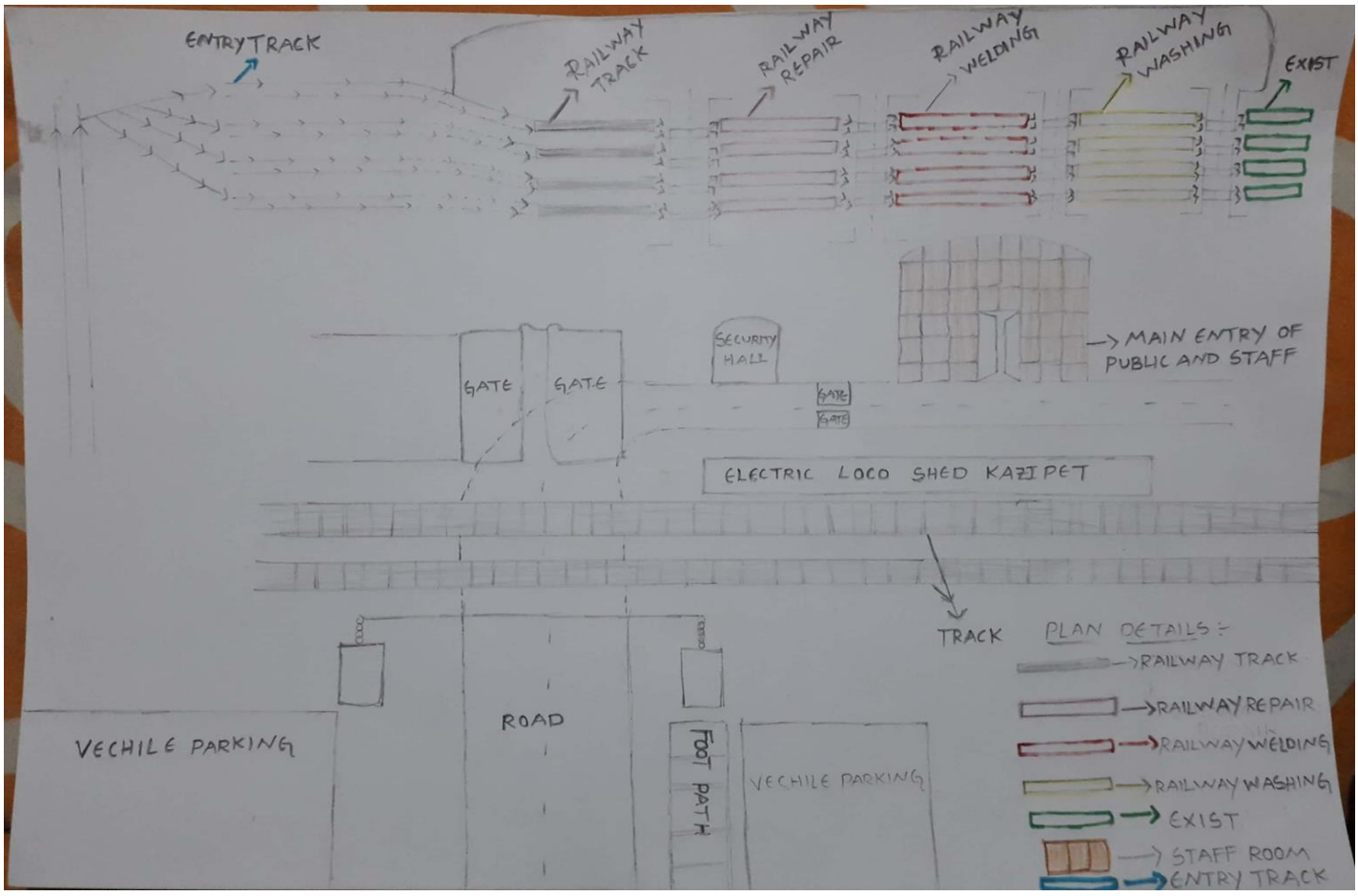


Figure-6 General Layout

From figure-6,we are showing total view of the electric loco shed and the process was when the train was repair its goes from entry track then to railway track then

to railway repair then to railway welding, railway washing, then after the loco was exist from the electric loco shed kazipet.

Therefore, in this view we are showing the entry gate and security hall, and then after main entry of public and staff department. In this we clearly shown the plan details in figure-6.

5.2 Movements to reach Kazipet Junction.

We are showing the layout of movement to reach Kazipet junction plan from figure-7.

From figure-6,we shows only the plan view of the electric loco shed, and in figure-7, It was connected to the electric loco shed Kazipet to movement to reach Kazipet junction, we shown very clearly by indicates arrow marks, while entry to the electric loco shed Kazipet and exit to the Kazipet junction. we already talk about the figure-6.

The process was in the figure-7, but we are showing the movement to entry the electric loco shed and to the exit to the Kazipet junction in plan are shown below.

From figure-7, any problem to the electric locomotive it was entry to the electric loco shed by the entring to the Kazipet junction then after we have the entry track of the electric loco shed then the same process we already talk in figure-6.

Therefore, this all are about the process of the figure-7.

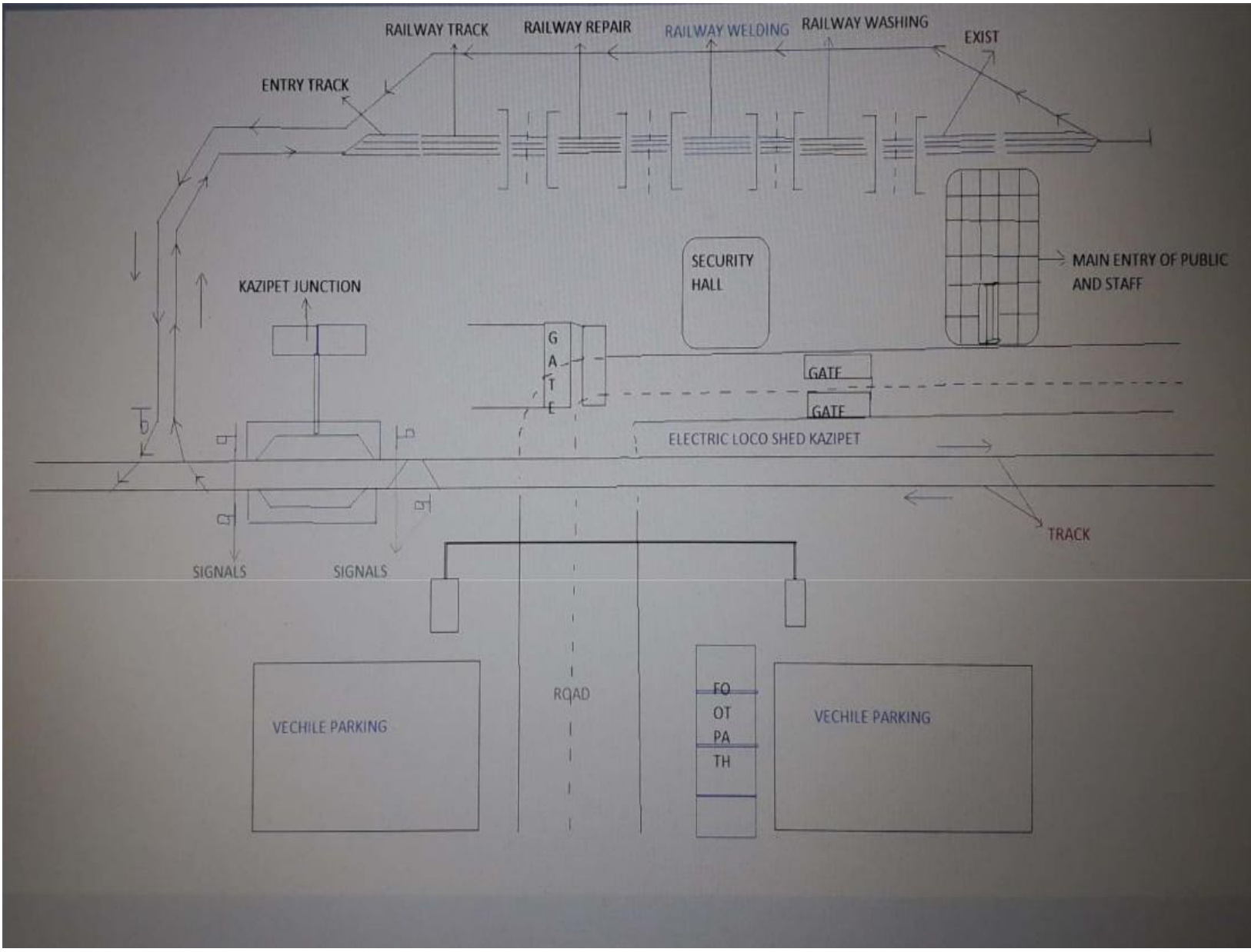


Figure-7 Movement to reach Kazipet Junction Layout

And we are showing the figure-8, same from the figure-7 but we drawn in the white chart with black pencil. And we are showing below.

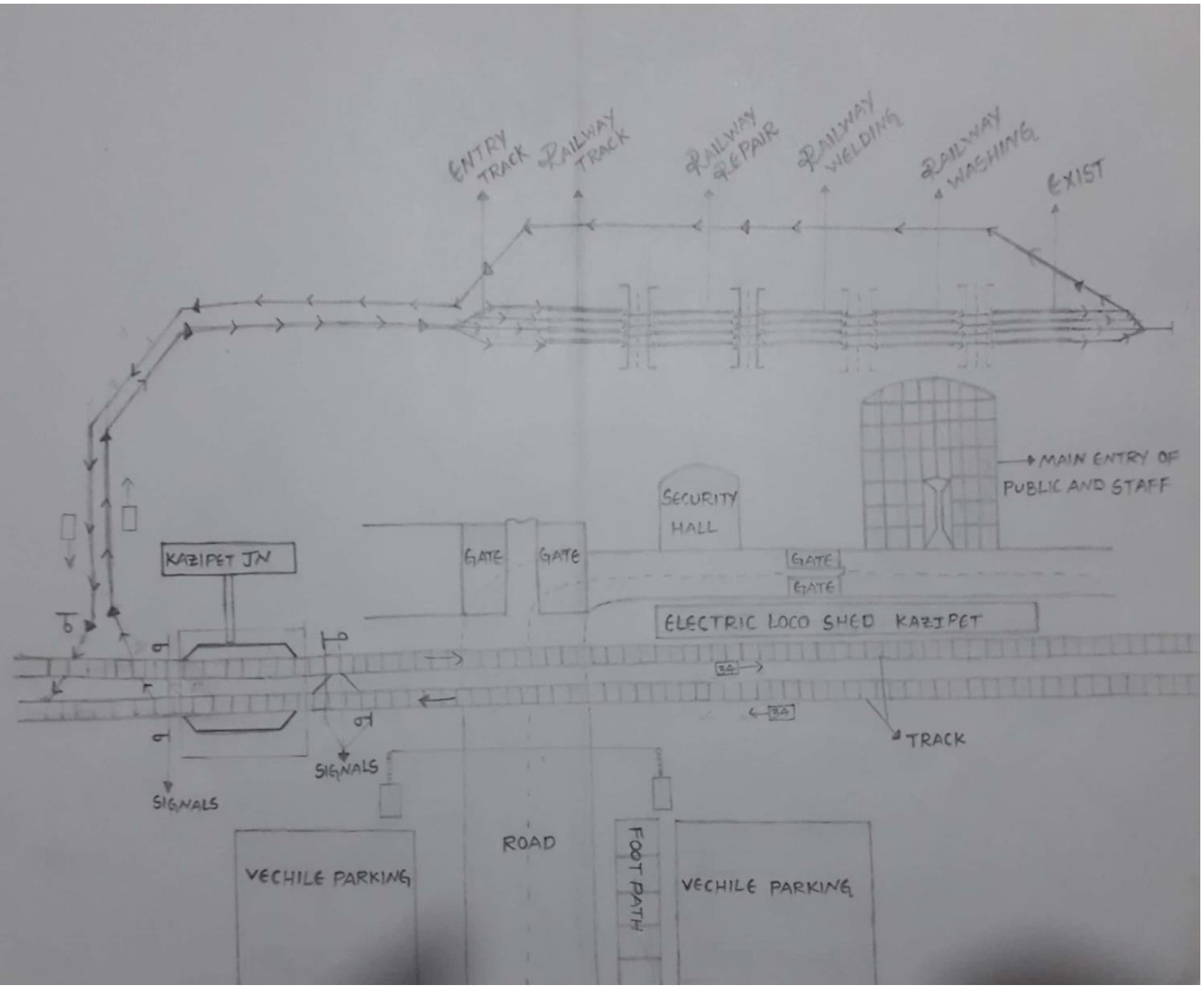


Figure-8 drawn in the white chart with black pencil

6. Indian Railway Network Map

Therefore, From railway routes of Indian map we have the indicates by the colour lines in the figure-9, There are:

- Important broad gauge line.
- Other broad gauge line.
- Meter gauge.
- Narrow gauge line.
- Under gauge conversion.
- Under process.
- Major Railway junction.
- Other stations.

Therefore, Indian we have 29 states and im showing the total railway network system in Indian map below.

India railway zonal map, we have 17 zones of Indian railways and major railway junction.

Indian Railways has been divided into 17 zones and 69 divisions.

Indian Railways is one of the world's largest railway networks comprising 115,000 km of track length over a route of 67,312 km. That means, if the tracks of Indian railways were to be laid out, they would circle the earth almost 1.5 times.

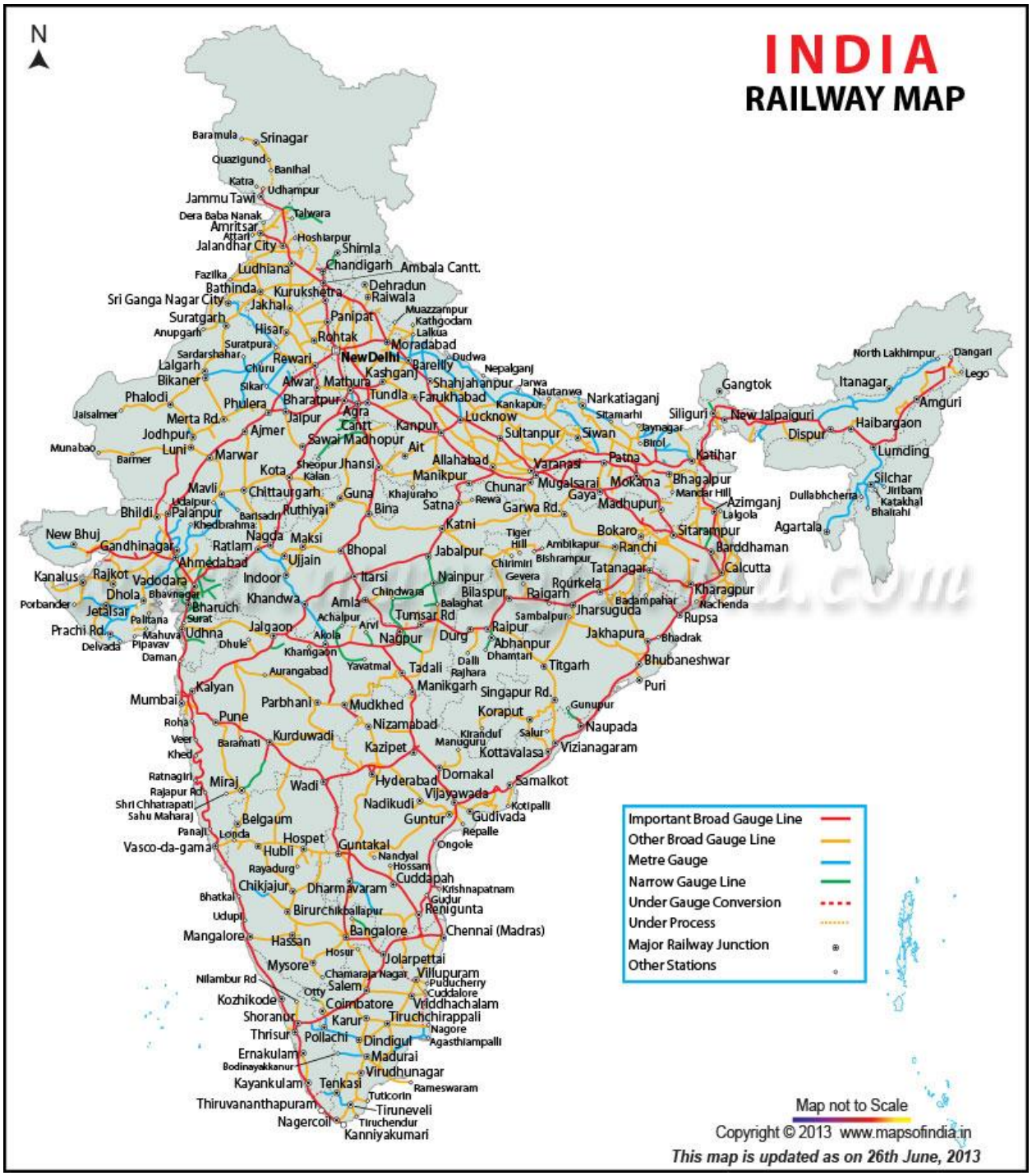


Figure-9 Indian Railway Network Map

6.1. Around Kazipet Junction

The Kazipet Junction Around the railway networks routes are taken from the google maps. And we are showing the railway network routes around the Kazipet junction and it the south Indian junction part are shown below figure-10.

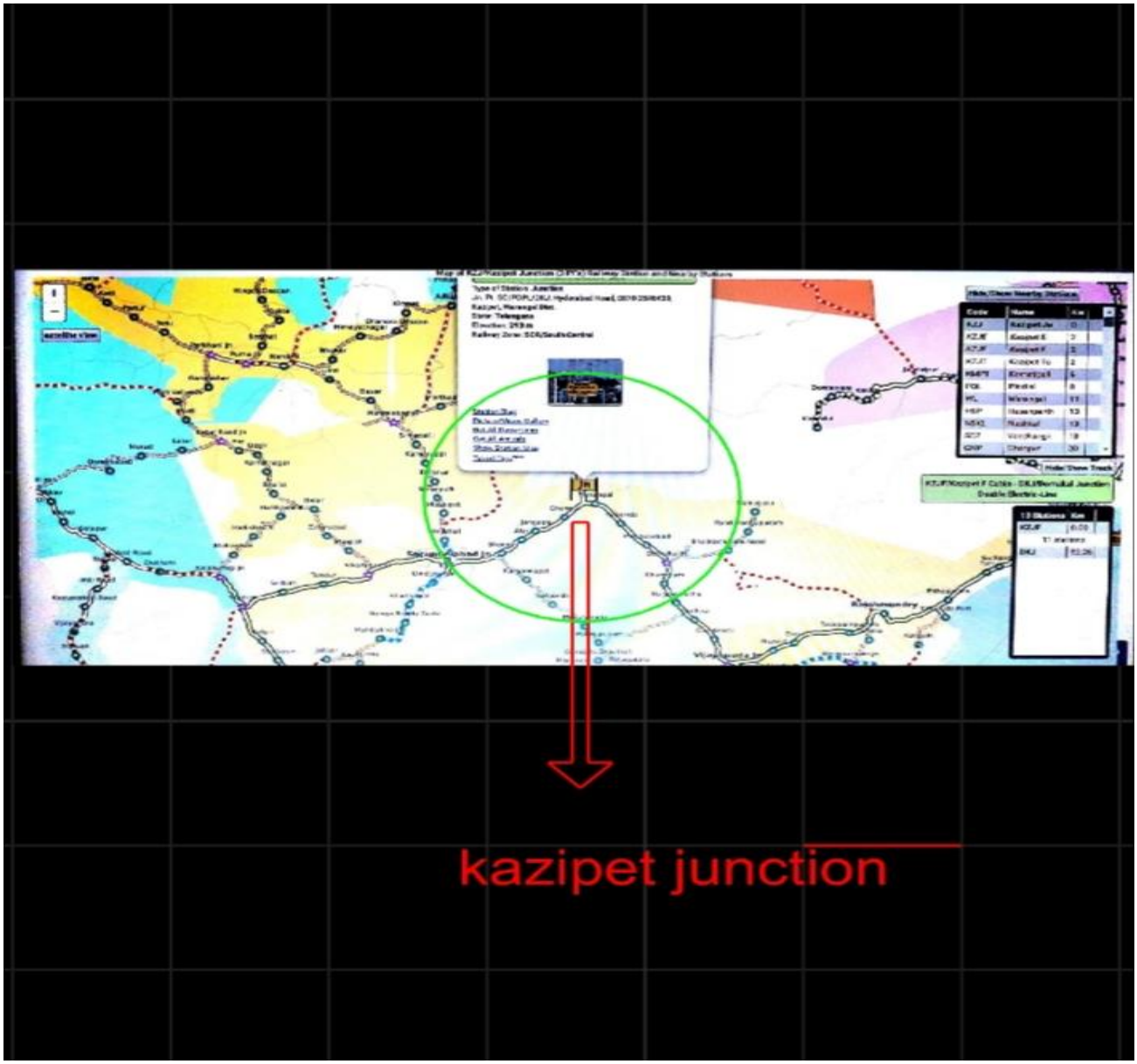


Figure-10 Railway Network Around Kazipet Junction

7. Organisation of Kazipet

From organisation of Kazipet we are showing the main department of electric locomotive shed of engineers from Telangana government are in figure-11.

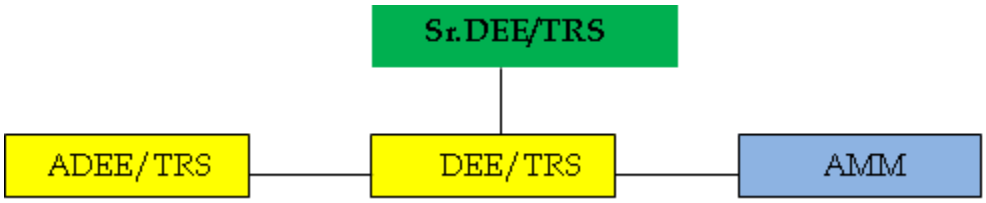


Figure-11 Organisation of kazipet

- Sr.DEE/TRS-Senior director of electrical engineer
- ADEE/TRS-Additional director of electrical engineer
- DEE/TRS-Director of electrical engineer
- AMM-Additional manager of machinery

And as well as total maintenances strength, Supervisors, Skilled, Un-Skilled, Ministerial staff, Available man power of loco, Indian railway average are shown in the below table-3.

Total maintenance staff strength	411+33*
Supervisors	46+4*
Skilled	254+24*
Un-skilled	111+5*
Ministerial Staff	9
Available man power per loco	2.56
Indian railway man power per loco average	3.6

Table-3-Total staff of Kazipet loco shed

8. Activities of the Kazipet shed

The activities of the Kazipet shed are listed below.

- Minor schedules IA, IB, IC
- Major schedules AOH & IOH
- Trip schedules & yard attentions of foreign locos
- Tower car AOH schedules
- Un schedule repairs of all locos and
- Night stabling Inspection of two MEMU rakes.

Description of work

Minor schedules IA,IB,IC:

1. Clean the antenna mounted on the roof top and verify the antenna connectors.
2. Check the tightness of all the connectors of CCU, DIU, BIU units on BD Panel.

   CCU-Control and communication unit

   DIU-Driver interface unit

   BIU-Brake interface unit

3. Check all the pneumatic connections for leakages and conditions of pressure sensors.
4. Check the tightness of notch encoder fitted on the SMGR manual driver inside the machine room (applicable to conventional loco only).
5. Check the touch functionality of the DIU and calibrate if required.
6. Verify the emergency switch functionality from both DIU.
7. Update the wheel diameter of loco in software DPWCS.(Distributed power wireless control system).
8. Downloading of logged data and clearing of memory.

9. Check the grouping and various working modes of lead/remote loco (if available in shed).

Major schedules AOH & IOH:

From the minor schedules the process was same and the remaining process of major schedules AOH & IOH are show in below:

1. Visual inspection of PCBs for its healthiness and suitable cleaning with brushes and do conformal coating.
2. Check the battery of (Control Process Unit) CPU cards/Radio and replace if required.
3. Cleaning of air filters of BIU, heat sinks of all modules.
4. Replacement of panel gaskets in IOH schedules.
5. Replace all the churning fans of DPWCS during IOH.
6. Check continuity IR values for all the data/electrical cables.
7. Do calibration test electronic pneumatic value of BIU.
8. Do calibration sensors.

Trip schedules & yard attentions of foreign locos

In this trip schedules & yard attentions of foreign locos are same of minor and major schedules we explain about the paragraph.

Therefore, The main activities of the electric loco shed was the minor and the major schedules are work in the Kazipet shed.

8.1. Unique features of Kazipet loco shed.

- This shed is holding unique 160 WAG-7 type locomotives which is considered as work horse of Indian Railways.
- Have lowest man power ratio 2.56 Men/Loco compared to all full-fledged working Electric Loco sheds over Indian railways.

9. Hypothesis of a new Indian Railway Service.

From this hypothesis we are calculating the distance from Khammam to Hyderbad with electric locomotive WAG-9.and we are showing the example process below.

9.1. Khammam to Kazipet to Hyderabad.

Calculation of distances

- From Khammam to Kazipet =160Km
- From Kazipet to Hyderabad=140Km

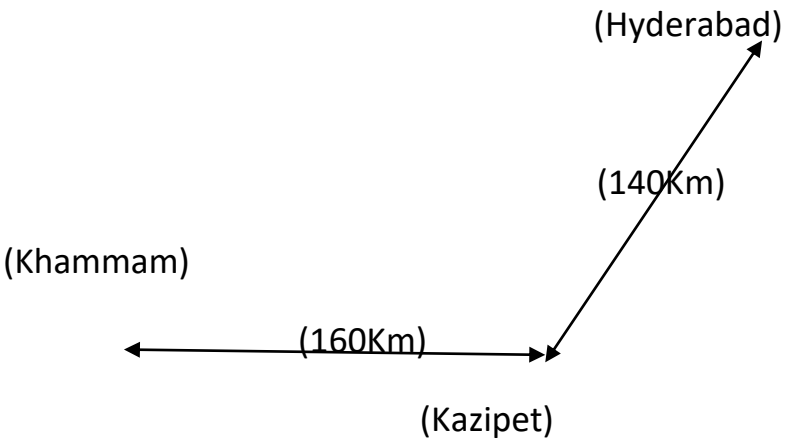


Figure-12 distance between Khammam to Hyderabad map

- From Khammam to Kazipet =160Km

By the electric locomotive WAG-9

WAG-9 Power=2500kW

Mass loco =90t

Mass car =40t

Hypothesis of the traction characteristics before constant traction after constant power.

Formulae

T*V=P

(T-Traction,V-Speed,P-Power)

T=Power/Speed

Speed[km/h]	Traction[kN]
0	178
50	178
80	112
100	89
120	76
150	59

Table-4

Therefore,

Total Mass =90+40(16)=730T

Total Weight=Total Mass*Gravity

=730*9.8=7154KN

RESISTANCE(R)

R=3N/KN=3(7154)=21462=21.5KN

Formulae

T-R=M*a

(T=Traction,R=Resistance,M=Total Mass,a=Acceleration)

a=T-R/M=178-21.5/730(1+0.08)=0.23m/s2

a=0.23m/s2

Speed[km/h]	Distance[m]
0-50	426
50-80	13000
80-80	146081
80-0	493

Table-5

From table-6, we are taken the values below.

	V1	V2	ΔV	T	R	a	d	Total distance	t	Total time
Units	[Km/h]	[Km/h]	[Km/h]	[KN]	[KN]	[m/s2]	[m]	[m]	[s]	[s]
Part 1	0	50	50	178	21.5	0.23	426	426	61	61
Part 2	50	80	30	145	21.5	0.15	13000	13426	55	116
Part 3	80	80					146081	159507	6691	6807
Part 4	80	0	80			0.5	493	160000	44	6851

Table-6

- From Kazipet to Hyderabad=140Km

From table-7, we are taken the values below.

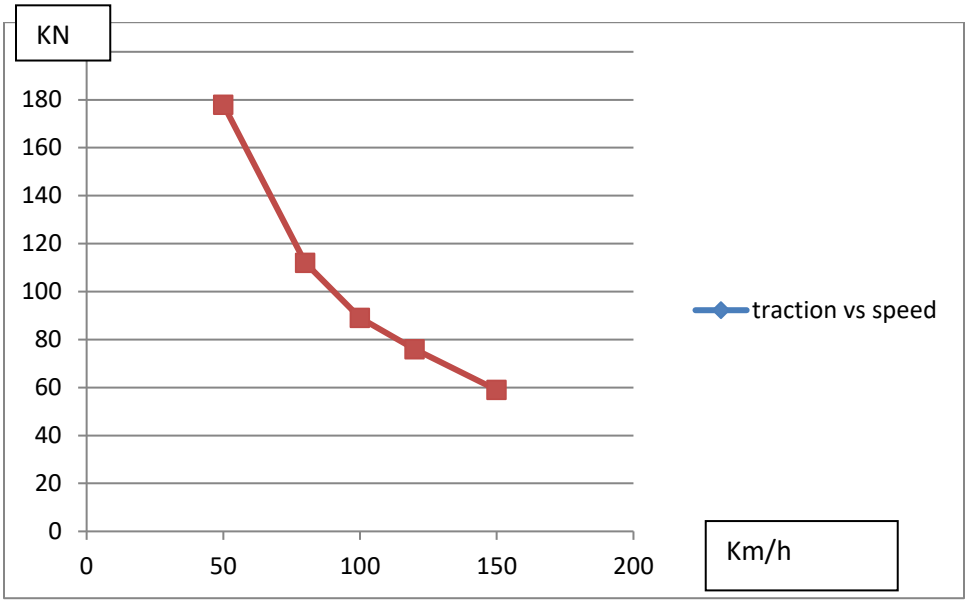
	V1	V2	ΔV	T	R	a	D	Total distance	t	Total Time
Units	[Km/h]	[Km/h]	[Km/h]	[KN]	[KN]	[m/s2]	[m]	[m]	[s]	[s]
Part 1	0	50	50	178	21.5	0.23	426	426	61	61
Part 2	50	80	30	145	21.5	0.15	13000	13426	55	116
Part 3	80	80					126081	139507	5678	5794
Part 4	80	0	80			0.5	493	140000	38	5832

Table-7

From Khammam to Kazipet the Graph are taken below from table 4.

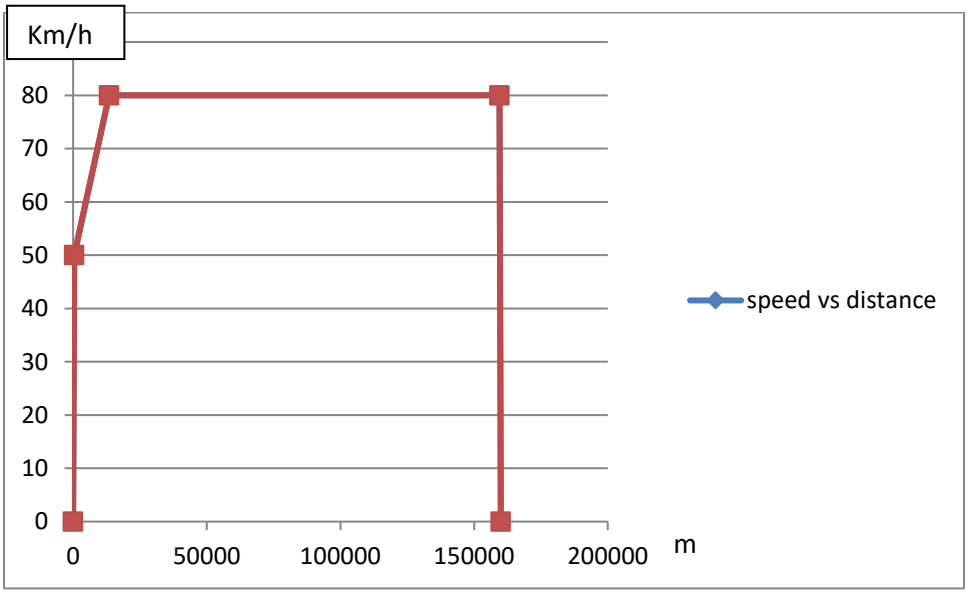
9.2. Traction vs Speed

The Traction of Locomotive vs Speed graph 5.



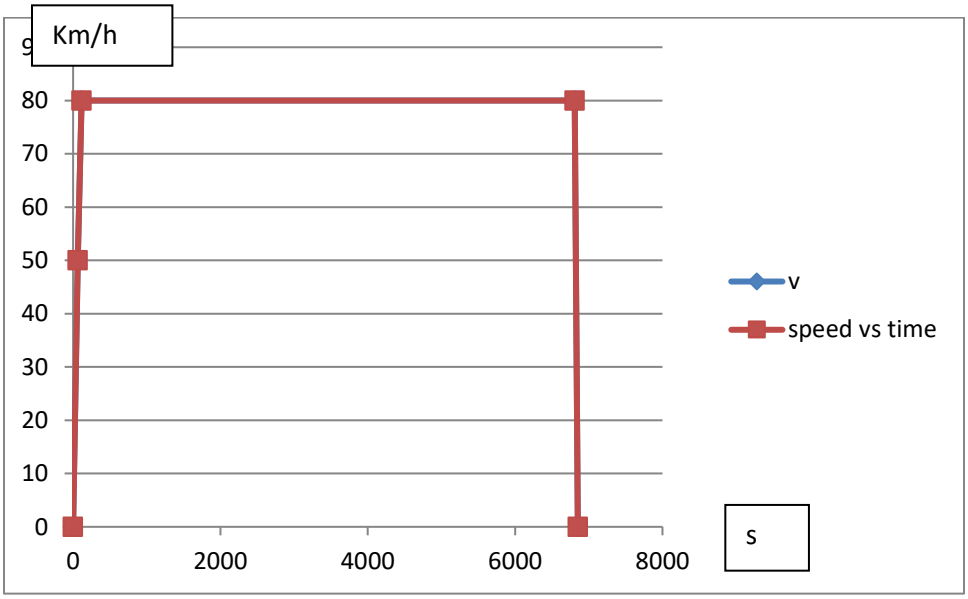
Speed vs Distance

The Speed of locomotive and the Distance graph 6.



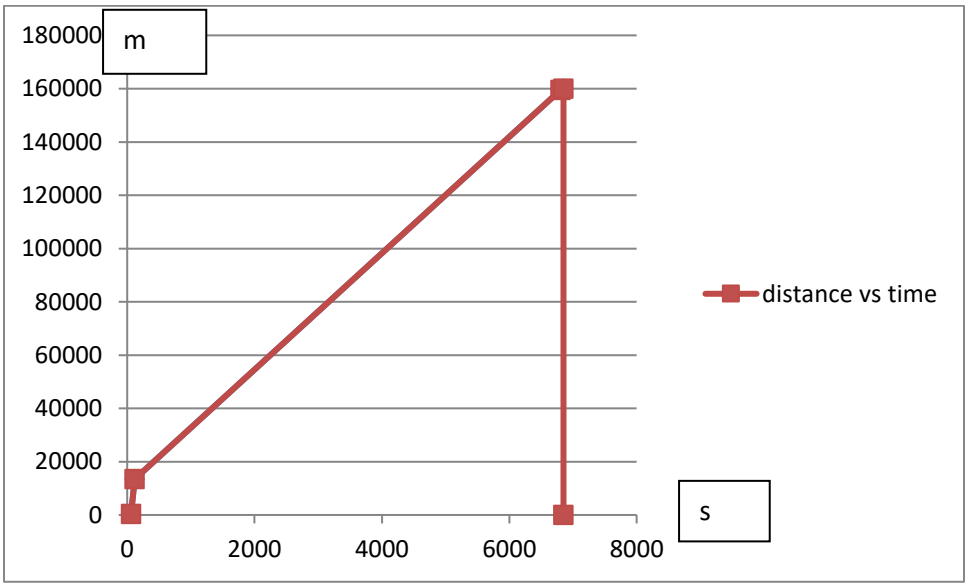
Speed vs Time

The Speed of Locomotive vs Time graph 7.



Distance vs Time

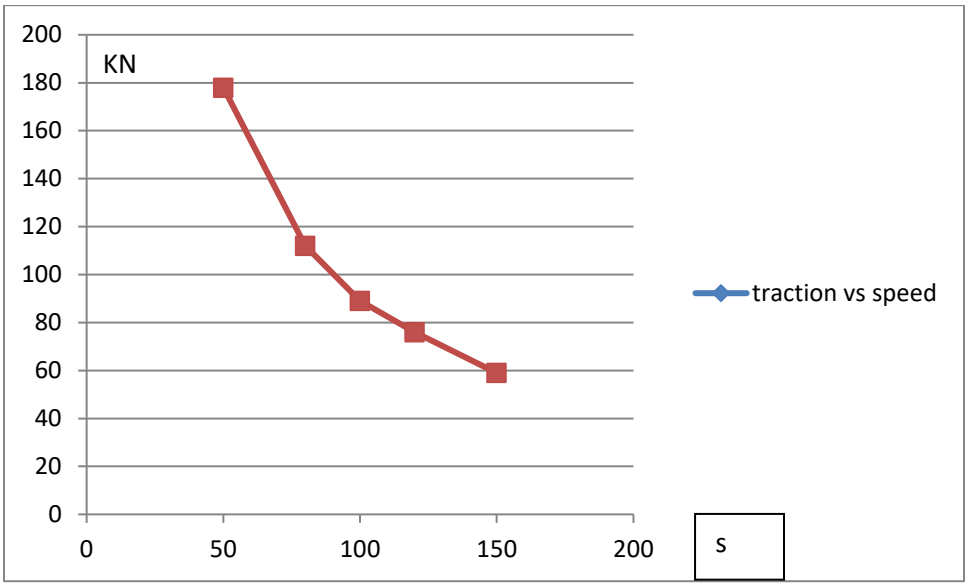
The Distance of locomotive vs time graph 8.



From Kazipet to Hyderabad the Graph are taken below from Table 5.

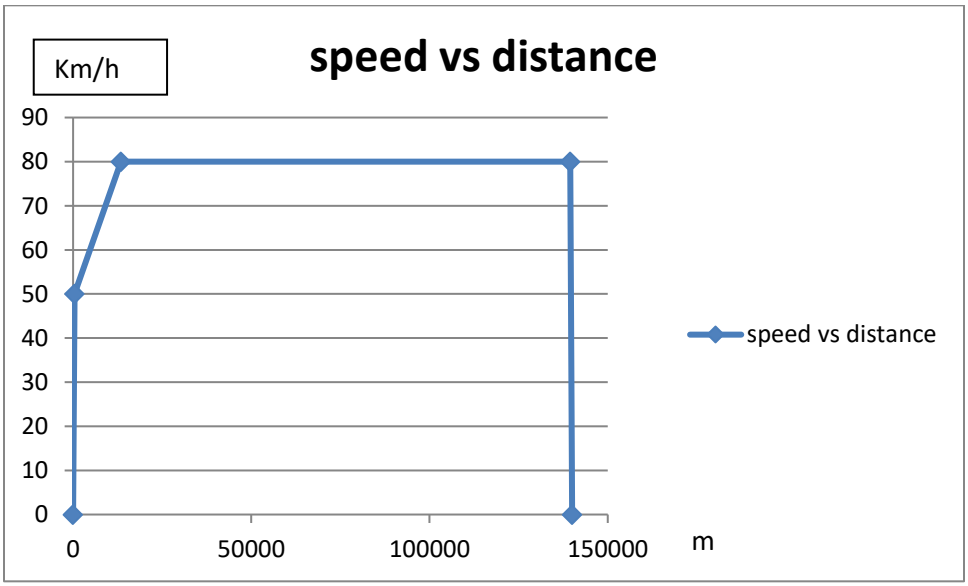
Traction vs Speed

The Traction of locomotive vs Speed graph 9.



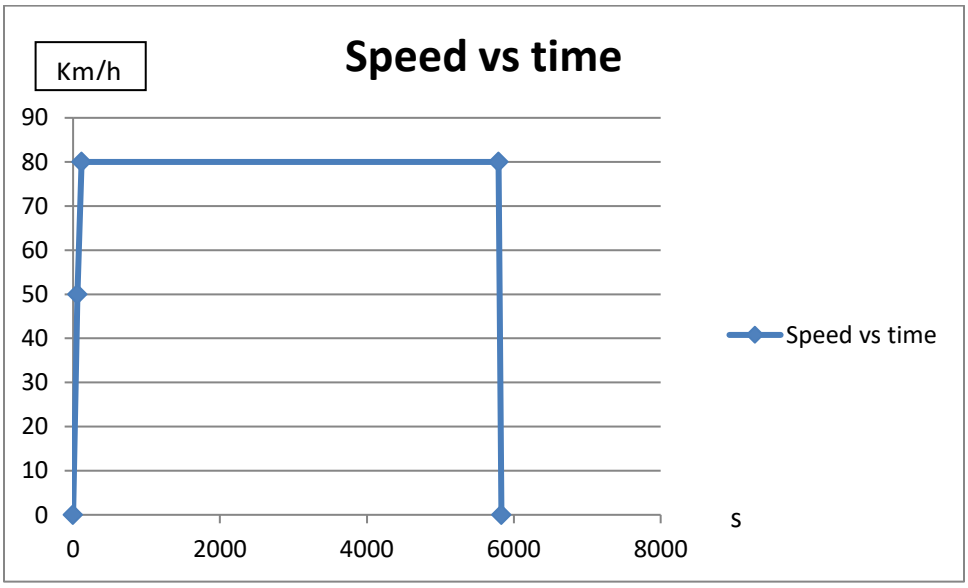
Speed vs Distance

The Speed of locomotive vs distance graph 10.



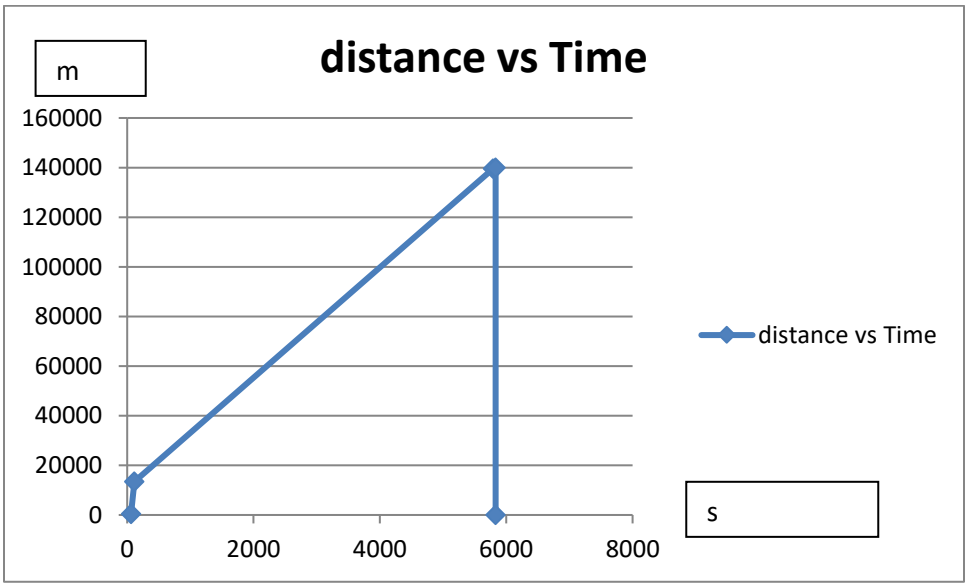
Speed vs Time

The Speed of locomotive vs time graph 11.



Distance vs Time

The distance of locomotive vs time graph 12.



From {Khammam to Kazipet to Hyderabad} And From{ Hyderabad to Kazipet to Khammam} The Graph are taken below from Table 6 & Table 7.

Distance vs Time

The total distance vs total time graph 13.

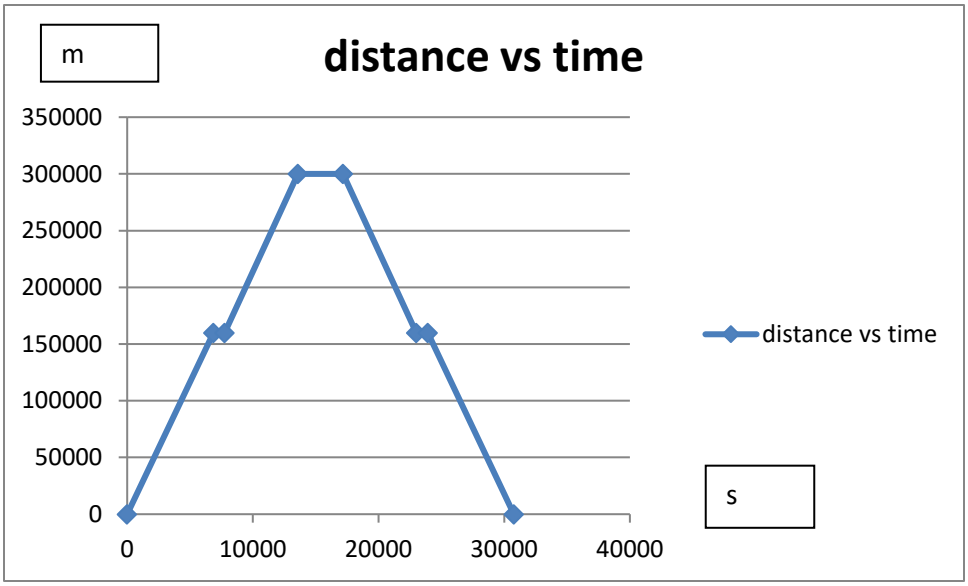


TABLE -8

Name of junction	Distances (M)	Time(s)	Time(m)
Khammam-------Kazipet	160000	6851	114
Kazipet Stop		900	15
Kazipet--------Hyderabad	140000	5832	97
Hyderabad Stop		3600	60
Hyderabad-------Kazipet	140000	5832	97
Kazipet Stop		900	15
Kazipet--------Khammam	160000	6851	114
Khammam Stop		3600	60
TOTAL	3000000	34366	572

Table-8

From table-8, we are showing the name of junction and distances as well as time.

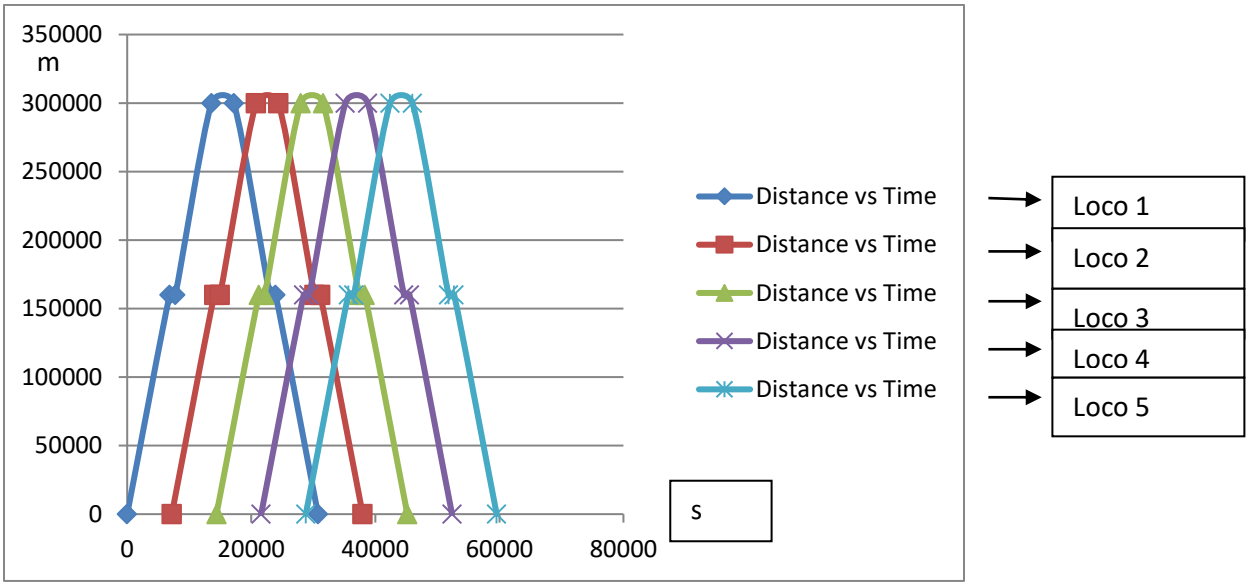
ΔT=120Min=7200Sec

Number of LOCO =Total Time/ΔT

=34366/7200

=5 LOCO.

Calculation of LOCO (Distance vs Time) Graph 14.

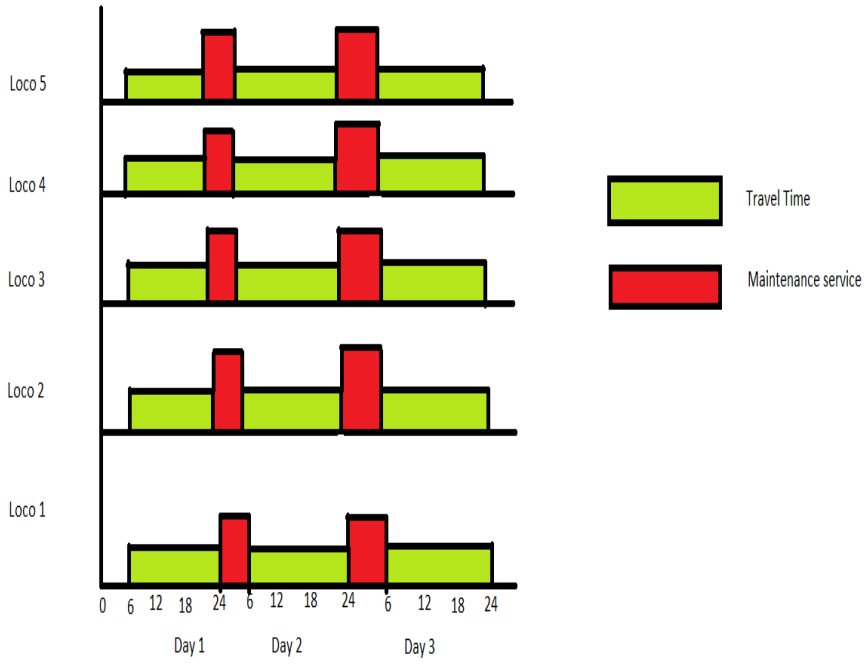


Graph-14

From graph-14, we are showing the each loco distance and time from Khammam to Hyderabad.

Maintenance Service Level-1 Graph 15.

In this maintenance service we have the five loco service in Kazipet junction and we are showing the each loco travel time and maintenance service by three days in the below graph 15.



Graph-15 Maintenance Service level-1.

From graph 15, The loco-1 start from the 6am to 24pm (day-1) and the maintenance service are from 24pm to 6am of day-1, And the same process for the day-2 and day-3 loco.

But the each loco time differents of 2hrs, time to start the loco from the starting point. And we have indicates the travel time and the maintenance service in colour boxes to appear clearly.

9.3. Maintenance Program of the locomotive

In this maintenance program of the locomotive was showing the traveling time was calculated accurately and we showing below table-9.

Level	From (Khammam)	When (Kazipet)	Where (Hyderabad)
Level 1	1 Day (300 km)	1hr 90mins	3hr 52mins

Table-9 Maintenance Program of the locomotive

Initial From Khammam to Kazipet 1hr 90mins in 1st day with a wagon speed of 300 km, From Kazipet to Hyderabad it takes 1hr 62mins, overall wagon takes 3hr 52mins.

For every electric locomotive there are the schedules for driving the locomotive drivers.

We have five electric locomotive that are shown in graph-14, in the schedules the drivers are taken charge by one of one for each locomotive, therefore 12 members of drivers are taken charge by electric locomotive.

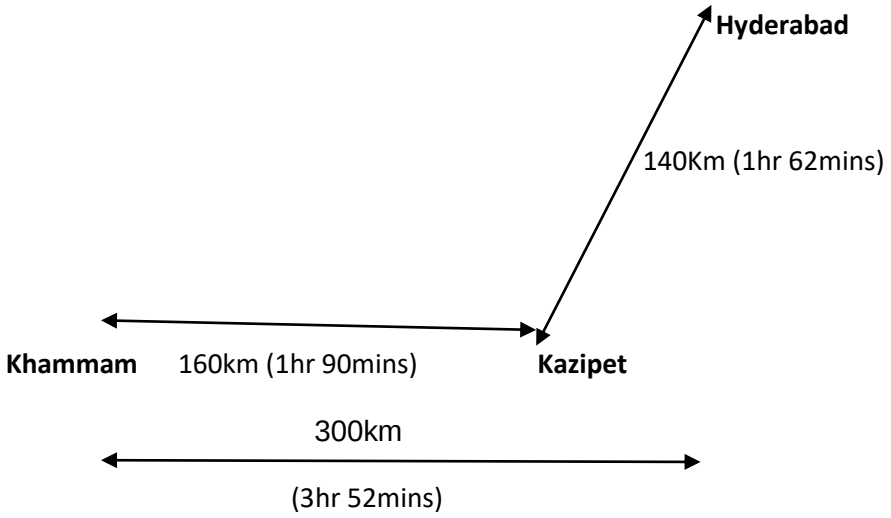


Figure-13 label of distance from Khammam to Hyderabad

In figure-13, we clearly mention the distance and we calculate the time are shown in table-9.

10. Electric Loco Shed Kazipet Maintenance

The workshop now handles Maintenance of 200 Locomotives. It has highest reliability of engineers with a meagre manpower of 2.56 persons Per Loco.

The electric loco shed of the South Central Railway, Constructed Initially at a cost of Rs.25Crore (3107039 Euros) here, Completed 20years of operations. Starting with an initial holding of 72 Locomotives, It now handles maintenance of 200 Locomotives that Includes both passenger and good trains, Each with a Power of a whopping 6000 horsepower.

Also Included in the list of trains are Rajadhani, Duronto and Sampark Kranthi Express Service , Mr.Agrawal said the shed, With a head count of about 700 persons was able to carry out maintenances of locomotives with best practies on the Indian Railways with the highest reliability of engineers with a meagre manpower of 2.56 person per loco.

The shed takes care of wide area multipurpose (WAM), Wide area passenger (WAP), and wide area goods (WAG) engines with a schedule of one full maintenance onces in three months. It was transformed into a workshop to handle maintenance of electric engines.

These all are the maintenance of electric loco shed Kazipet.

11. Suggestions to people.

When we are enter in the electric loco shed there have highly security to check the people and enter in to electric loco shed.

1) 30% of the respondents are not identified for new assignments so extend their assignments by providing proper training to the employees.

2) 30% of the respondents are dissatisfied due to lack of recognition and rewards. A positive recognition for work boosts the motivational level of employees. Recognition can be made explicit by providing awards like best employee of the month.

3) Provide opportunities for career personal growth through training and education, challenging assignments and more.

4) Identify the key performance areas of the individuals and conduct training program to develop their skills and knowledge.

5) Immediate resolution of the grievance is necessary otherwise it will effects the Productivity of the organization so immediate actions should be taken to resolve the grievance of the employees.

12. Conclusion.

- ✓ Main objective was to learn electric locomotive in railways.
- ✓ Electricity is used to eliminate smoke and take advantage of the high efficiency of electric motors.
- ✓ We calculate the value of electric loco locomotive WAG-9 components, weight, volume.
- ✓ As well as we proof the power supply of electric locomotive WAG-9.
- ✓ We proof the calculation part about, and by showing the graphs, at last we find the new railway service.
- ✓ We prove the new railway service, Travel time, Time table, Locomotives, Maintenances.
- ✓ By the electric locomotive I learn the components of locomotive & I got lot of experiences to research the electric locomotive by the process.

13. Acknowledgement.

- ✓ I am thankful to the supporting people of the electric loco shed Kazipet.
- ✓ I thankful to one by one who was helpful in my thesis by step by step.
- ✓ I thankful to my prof.Gabriele Malavasi**,** he was support a lot me & At last I was completed my thesis work, I got a good experiences to understand electric locomotive as I present above.

14. Reference.

By Professor RK (Rama Krishna) KLU University.

Thank you