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Government of India, Ministry of Railways

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GREEN RIDE - RO-RO SERVICE ON INDIAN RAILWAYS

K.S. Chandra
CRSE/NWR, Jaipur

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Rail technology is a superior technology of transportation, in the sense that it consumes substantially less energy per unit of service (ton-km) compared to other modes.

Differential of energy consumed in road and rail transport for a heavy, long lead payload can generate sufficient savings to make piggy back ride of trucks on wagons viable. Further, annual cost of maintenance spares for the vehicles on Indian roads is nearly 15% of asset value. The same is only 4-6 % for rolling stocks on rail. This can be attributed to bad condition of our roads and fact that number of moving parts per unit of service (ton-km) is much less in rail transportation than in road transportation . Charging tariff to truckers equal to their cost of consumables for the service fetches railways almost same revenue per ton-km as exim containers. Mobile nature of payload allows off destination services via 'other' routes of railways, avoiding congested terminals. Faster turnaround brings more business to truckers, as well. Viability of the project increases with every rise in cost of diesel which is easily foreseen.

Concept of 'single wagon- single truck' adopted on Konkan Rly results in poor capacity utilization for the railways. The same has been modified to 6 road axles/wagon by designing a specific wagon for increasing rake throughput by about 40%. This would mean app. 62 tons of payload per wagon, according to permitted maximum of 10.3 tons per road axle by Motor Vehicle Act 1988. Low floor wagon design will enable operation as A class ODC at 75 kmph in both electrified and non electrified territory.

Saving of fuel leading to earning of CO_2 credits (CERs) has also been estimated in the article for RO-RO service between one set of destinations.

The service brings in additional traffic to railways without anybody losing it. It also projects Railways as a green organisation of society, giving it more visibility which could be of strategic importance for future growth.

1.0 Introduction

Our country has nearly 3 lakh route kilometers of highways (including state highways) and 67000 route km of railways. Share of diesel consumed by rail transport and road transport is 2% and 20% of total national consumption, respectively. Similarly Railways share in transport of national goods movement is 30%. The same used to be nearly 50% at the time of independence. Movement of goods by rails is technologically superior in the sense, it consumes almost one-fourth power for the same tonnage through same KM. Thus, it is in the interest of nation to transport more and more goods by rail after having invested in rail infrastructure. This can lead to significant savings of fuel/energy which is scarce in our country and also have benign effect on climate. It can earn carbon credits for the Railways.

In this article, one case of shift of movement from road to rail is being presented.

2.0 ROLL-ON ROLL-OFF Service

Roll on - Roll off service is a piggy back ride given to road trucks on railway wagons . It serves to burn less fuel due to change of technology of transportation , thus contributing less to pollution and warming of climate. Such a service is being operated for crossing of Alps range of mountains in Switzerland as well as crossing Amazon forest.

Fig-1: RORO operation on Konkan Railway.

On date, Roll on-Roll off (RO-RO) services are plying on Konkan Railway in India more on economic considerations.

Loaded trucks with gross weight upto 40 tons and maximum height upto 3425mm, are given piggy back ride on rail wagons between Kolad and Surathkal. Five mixed rakes of BRN and BOXN flats are plying on this service. The rake composition is mixed to cater to both 3 axle body trucks and 4 axle trailer trucks. Ratio of mix in the rake is based on practical study of arising of such trucks in the region. Distance between Kolad and Surathkal is nearly 720 km. A loaded truck weighing 35 tons consumes nearly 300 liters of diesel to cover the distance. Consumption of diesel for the same service (moving loaded truck) by rail has been estimated to be 110 liters per truck by Konkan Railway. Thus, a saving of nearly 200 liters of diesel per truck of gross weight of 35 ton is possible by having "RO-RO" system of transportation.

3.0 Perspective on Rail Technology and Heavy Haul

Rail technology, if looked through peep hole of past, starts with photo of a horse pulling big carts loaded with coal , on rails.

Fig-2:Horse Pulling Coal Carts.

This implies that rail technology enables lesser pulling power to work heavier loads. In fact, it is this principle which is in action in case of heavy haul trains. Heavy haul is reincarnation of the same technology scaled up thousands of time and is the appropriate use of rail technology, fetching all economic value. Passenger services almost everywhere in world are a loosing proposition, while introduction of heavy haul in early eighties turned around the US Railroads. Heavy haul is a profiteering business everywhere in world. In fact, high speed passenger trains are more a consequence of "Right of Way" than rail technology per se. Rail technology provides for poor acceleration and braking , a basic requirement of any high speed operation comparatively. TGV trains or heavy haul freight trains take 3-4 kms to stop.

RORO system of train operation too, capitalizes on this advantage of rail traction over road traction. In RO-RO application too, it's more economical to carry heavier truck loads (which are on increase now a days) through larger distance to generate enough cost differential making it viable. Even our fare structure for containers have been based on tonnage instead of TEUs which brings competitive advantage over road industry.

4.0 Cost of Rail Vs Road Operation

In order to appreciate the system of RO-RO service in our country , it is important to estimate the costs involved in rail and road operation for the same unit of service , say , a ton-km.

A 40 ton truck with a payload of 25tons consumes nearly one litre of diesel for 2.5 km of travel. For a 1000km travel (app Delhi - Ahmedabad) it would consume 400 lits of diesel. It burns nearly Rs2-2.5 lakh worth of tyres in a year. and nearly Rs 1 lakh worth of other consumables on wear and tear of other components . Thus, nearly 15% of asset value of truck is spent on maintenance spares annually, arising directly out of its operations. This converts to nearly Rs 4000/trip . Total cost of consumables (fuel and spares) for the operation is about Rs 20,000/ trip (assuming diesel price of Rs40/lit). It implies that a cost of Rs 0.80 per ton-km is incurred by road transport, exclusively on consumables to provide this service As per data available on internet , such a truck would be charging Rs 32000 for the service - equivalent to Rs 1.28 /ton-km.

5.0 Same Service Provided on Rails Would Cost as Given Below

A Diesel locomotive(WDG4) gives a fuel consumption of 1.9 lt/1000 gtkm. Therefore, a 40 ton truck carried atop a 20 ton wagon over a distance of 1000km would consume 114 lts of diesel. Annual Cost of consumables in case of rolling stocks is only about 4-6% of the asset value (based on calculations from budget figs of actual expenditure for yr 10-11 of NW Rly). Figures of maintenance towards material consumed by coaches add to Rs 13 cr on divisions and Rs36 cr for workshops for the year for a holding of nearly 2000 coaches which is nearly 5% of asset value. Similar figures can be worked for a diesel loco and wagons too. This is in sharp contrast to road industry which has an average of 15%. Same is expected since number of moving parts in a train is much less compared to road trucks per ton-km of service provided, as also use of superior technology. Therefore, maintenance cost per unit of service generated by rolling stocks is significantly less. This works to about Rs 1400 per trip of 1000kms giving a total cost of consumables Rs5960, say Rs6000 per trip against Rs 20000 of truck service - a clear benefit of rail technology ,further amplified by high cost of diesel in our country and bad condition of roads. The cost of consumables (fuel and maintenance spares) for the same service by rail comes to Rs 0.24 per ton-km.

- Indian Railways average Fare Charged/ton-km (figs from NWR statement) :-

Finished Steel -	Rs.1.08/-
Cement -	Rs.1.01/-
Fertilizer -	Rs.0.82/-
Food Grain -	Rs.0.72/-
Container(Exim) -	Rs.0.58/-

(Charge by trucker Rs 1.28/- . Out of this Rs0.80 is spent on consumables by him).

Thus, it can be seen that for Indian Rlys operating RO-RO service and charging only the amount spent on consumables by the trucker towards railway tariff , could be more profitable than containers, or even other commodities considering that this service would run loaded in both directions. For truckers it would only mean passing on their fuel and consumables cost to Rlys keeping their other receivables same as before. Truckers can even further their business by plying more trips due to fewer days to turnaround owing to faster average speed of railways. However, Rlys should admit only heavier trucks above 30t gross load and near 1000km service to maintain large differential between road and rail costs for viability purposes.

6.0 Constraints of RO-RO Application on IR

- Maximum Moving Dimension:

The RORO system of train operation is functioning smoothly on Konkan Railway for few years now. It is operating under class 'A' ODC with Trucks to a minimum height of 3.425 m and therefore plying at a maximum speed of 75 KMPH. A truck with a height of 3.425 meter on BG flat wagon would become class 'B' ODC on Indian Railways, severely restricting its movement. Military specials with their accompanying trucks move as class 'B' ODC with a restricted speed of 40 KMPH. A commercial service at this speed will not be viable on Indian Railways for operations. Floor height of container flat wagons BLCA/B is 1000mm from rail level which is 273 mm(almost 11") less than our general flat wagons like BRN,DBKM . A flat wagon with a floor height of 1075 mm from rail level with modifications to suit truck loading can lower the class of operation from B to A class ODC as explained in Fig:3.

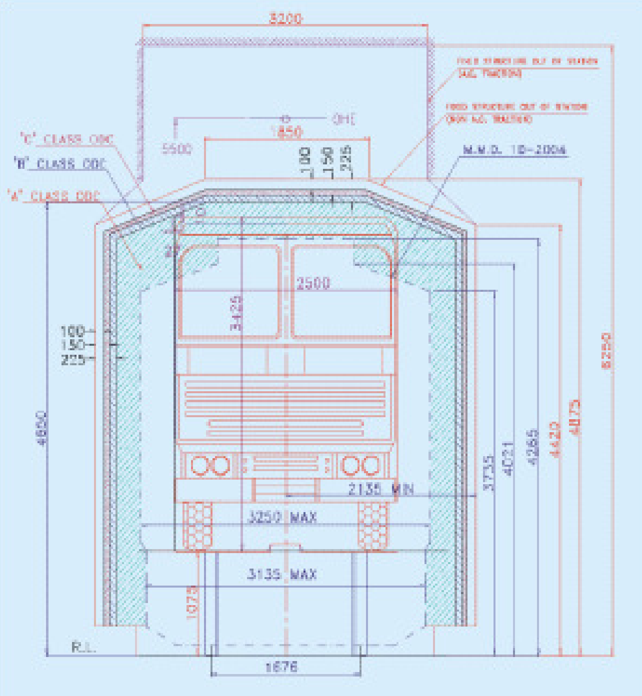

FIGURE-3: LOADED TRUCK IN MMD & FIXED STRUCTURE INSTALLATION GAUGE OF I.R. AS PER SOD-2004(REVISED)

This will enable the operations to be conducted at a maximum speed of 75 KMPH , acceptable for a goods train on considerations obtaining in field.

Indian Railway MMD & Fixed structure dimension in electrified and non-electrified territory is shown in Fig 4 where in general vertical and lateral clearances between fixed structure and MMD is 900mm and 510 mm, respectively.

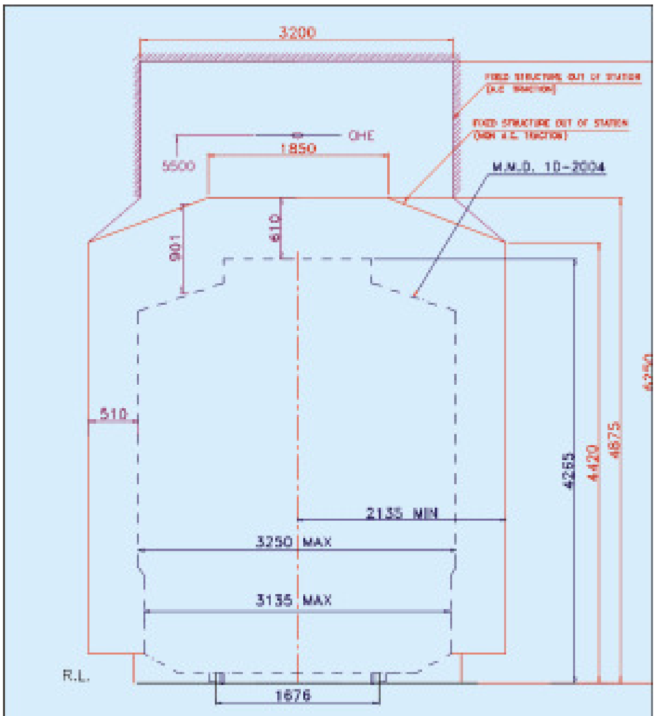

FIGURE-4: VERTICAL AND LATERAL CLERANCES BETWEEN FIXED STRUCTURE GAUGE AND MMD

It can be noted that vertical clearance is more than lateral clearance. This is difficult to explain. Kinematic profile of a rail vehicle would yield smaller envelope in vertical direction compared to that in lateral direction for the simple reason that vertical motions of vehicle will be abated by gravitational forces while the lateral are aided by it.

This can also in kinematic profile of UIC, Fig 5 where kinematic profile envelop has smaller increment in vertical direction than in lateral direction.

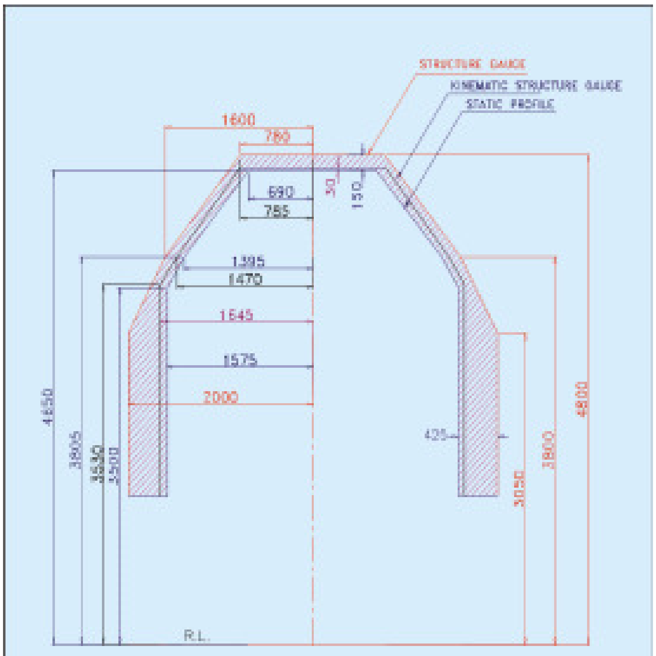

FIGURE-5: SUPERIMPOSED DIAGRAM OF STATIC-KINEMATIC-FIXED STRUCTURE GAUGE OF UIC AS PER UIC CODE-505-3 OR

Thus clearance between fixed structure & MMD should be smaller in vertical direction than that available at present. This would imply that for same fixed structure gauze, IR MMD gauze can be increased, particularly in vertical direction. This merits a kinematic profile study by RDSO. Thus IR may be able to operate taller vehicles if not wider for the same fixed structure gauze. This will also marry well with our Broad Gauze tracks which enable high CG payload operations.

Further, since operational costs on rails is significantly less and our trunk routes are nearing saturation, RO-RO services can adopt unsaturated marginally longer 'other' routes. They can also run off-destination service due to mobile nature of payload avoiding congested terminals. As an example, between Ahmedabad region and Delhi region the adjacent route can be via Viramgam- Samadari -Bhiladi - Jodhpur - Phulera - Rewari which is just about 90 Km extra compared to the direct route via Aburoad - Ajmer - Jaipur- Rewari. Off-destination service can be terminated at Rewari for trucks to move onto Delhi by road.

7.0 Conceptual Wagon Design

Konkan railway is following "one wagon-one truck" loading. This is underutilization of loading capacity and hence earning, of a 22.9t axle load wagon since loaded trucks weigh in the range of 25 - 40 tons.

As per MV Act 1988, trucks can carry 10.3 t of load per axle. Therefore, our wagons should be designed to accommodate 6 axles per wagon while accommodating different truck formats to give a loading of 60 plus tons payload, a figure closer to our payload capacity. Subject wagon can be of 15.5 m length sufficient to accommodate two 3 axle trucks (most popular truck format in India) of approx length of 7.5m length. Trailer trucks with 4 axles can be loaded in combination with another truck where axles of truck are shared between adjacent wagons. This should be possible with steering wheels and links free to position as per requirement of wagon body negotiating a track curvature. Wedges for steered wheels will need to be designed to permit small swivel to permit wagon body to steer the wheels on curve. This would lead to full utilisation of rake length for payloads (trucks) minimising loss of rake length due to wagon coupler gaps after ensuring required gaps between trucks .A rake of such wagons would consist of 40 wagons.

A tabular comparison of rake throughput of Konkan Rly rake and proposed rake is given below :

Rly	No of wagons in rake	No of axles per wagon	Max Tonnage /wagon	Rake throughput in tons
Konkan Rly	1. BOXN– 30 2. BRN – 20	3 4	30 40	900t 800t Total – 1700t
Ind Rlys	BLCX(say) - 40	6	60	2400t

Thus, it can be seen that an increase of over 40% in rake throughput is possible over Konkan Rly format by adopting a dedicated wagon design with above parameters.

Considering requirement of 'RO-RO' service to be 'A' Class ODC over IR, smaller diameter wheel bogie LCCF 20, in place of Casnub bogie will have to be adopted for this service to give a floor height of 1075 mm. With a truck height of 3425mm, it will give a total height of 4500mm making it possible to operate it as 'A' class ODC. CBC

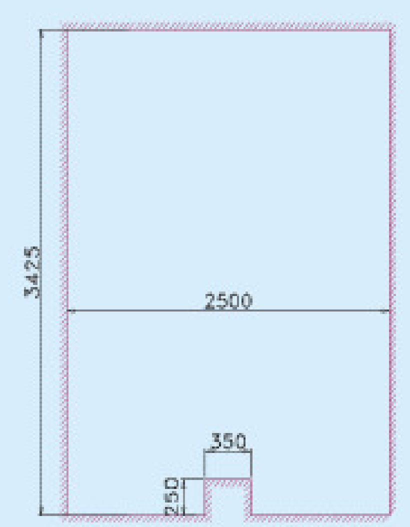

FIGURE-6: QUALIFING TRUCK BARRIER DIAGRAM

connection of BLCA wagon has a height of 330 mm over wagon floor. Height of differential gear casing of trucks and its front axle from road level is nearly 280mm. In order to clear the differential gear casing and front axle of truck, a clearance of 325mm over wagon floor is required so that the truck can negotiate the CBC hump of BLCA wagons. A qualifying barrier for the trucks will need to be placed at the entry of 'end on' loading of the rakes. Fig 6 shows sketch of such a barrier.

Wagon will have to have stronger sole bars to carry the point loading of truck tyres. BOX section design for sole bars will have to be selected for less weight with more bending strength.

Wagon will have to have stronger solebars to carry the point loading of truck tyres . Box section design for solebars will have to be adopted for less weight and more bending strength. The side bearers for the wagon can be contact-less roller design to reduce wagon bogie turning resistance caused by steering wheels of trucks.

8.0 CO_2 Emission Reduction (CER) Credit

Rail technology is a green technology. It consumes nearly 1/5 of energy for enabling same unit of service compared to road. When energy is saved for generation of same service using better technology , it results in releasing of less carbon into atmosphere .This reduction in carbon emission has been turned into a tradable unit in international emission market . This unit is called Certified Emission Reduction (CERs) by UNFCC (United Nation Framework Convention on Climate Change.)

1CER = 1ton of CO_2 eqv released into atmosphere

Following is the carbon released into atmosphere per unit of generated energy :

-App 1kg of CO_2 / kwh for coal generated electricity

- App 0.65kg of CO_2 / kwh for diesel generated electricity

- App 0.5kg of CO_2 / kwh for gas generated electricity

- App 0.01kg of CO_2 / kwh for hydro generated electricity

- App 0.005kg of CO_2 / kwh for wind generated electricity

- App 0.005kg of CO_2 / kwh for nuclear generated electricity

(source www.parliament.uk)

CERs are purchased by organizations (generally located in developed world) who exceed their quota of emission and is sold by organizations (generally located in developing countries) who have saved (earned credits) carbon release through use of superior technology . The price of CERs is determined through market mechanism of demand and supply of CERs in the international market.

When RO-RO service is introduced in a particular stream of road traffic, large amount of fuel/diesel saving accrues on continuous basis. This can earn credits for Railway which can be sold in international carbon trading market and earn foreign currency, simultaneously saving energy for the society/nation. The saving can be substantial depending on number of such services introduced by the Railways.

9.0 Model Calculation of Carbon Credit Earning For Delhi -Ahemdabad Route

Delhi - Ahmedabad distance = 1000 Km app.

Diesel consumed by a 40t gross weight truck (payload 25t) @ 2.5 km/litre is 400 litres.

Disel consumed by a diesel loco to carry the same truck atop a wagon (gross wt 60 tons including truck) is 116lt @ 1.94 lt/1000 gt km.

Estimation of saving of CO_2 emission by train operation in place of truck operation for providing the same service.

Diesel fuel saved = 284 liters/truck

CO_2 emission per litre of diesel burnt = 2.668 kg /lit

(source www.iea.org)

Equivalent CO_2 emission saved - 284 x 2.65 = 0.742 tons of CO_2 per carried truck. A train would carry 50 such trucks .

Saving of CO_2 emission per train - 50 x 0.742t = 37.1t

Approximate current rate of CER (certified emission reduction) credit is 12 Euros per ton of CO_2. .

Credit earned is Rs12 x 70 x 50 x 0.742 = Rs31,164 per train

If three such trips of trains each way is made every day, annual earnings of CO_2 credits would be

Rs 31164 x 6 x 365 x 0.91 6 = Rs 6.2 cr (Geographical weightage factor for India as per UNFCCC is 0.916)

Thus, this is a win-win-win situation for trucker, train operator & climate.

10 Strength of Indian Railways For Running RORO Service

Required rail Infrastructure is already in place. By carrying out the operation via marginally longer routes, not much extra cost is incurred while a new 'door to door' traffic is captured. Our strength lies in comparatively higher diesel price in our country and lower trucking cost. Higher the price of diesel, more viable does this service become due to increased value of the saved diesel. This implies that the service is viable even in longer run.

The condition of roads in our country is generally bad which causes more wear and tear to trucks, adding to their operational cost. Nearly 15% of the cost of asset (truck) is spent on consumables while in case of Railways. it is only 4-6% of the asset cost. Number of moving components which would wear and tear are much less per unit of service (ton-km) delivered compared to roads .

Higher average speed of rail service would mean faster turnaround time for trucks, which in turn would mean more business for the truckers.

Railways has been losing certain segments of freight due to its "station to station" nature of its service while the customer desires "door to door" service . By having a RO-RO service, Railways is being complementary to a door to door service. This means that there is possibility of wining back such traffic without anybody loosing it.

RORO service will also project Railways as a green organization of the society, giving it more visibility which could be of strategic importance for future growth.

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STRAY CURRENTS MITIGATION, CONTROL AND MONITORING IN BANGALORE METRO DC TRANSIT SYSTEM

Anil Yadav
General Manager / RITES
General Consultants to Bangalore Metro Rail Corporation

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This paper places emphasis on the Bangalore Metro Rail Corporation, (BMRCL) stray current mitigation, control and monitoring system. Bangalore Metro operates on a DC traction power system utilizing a high rail-to-earth resistance return path. This system operates at 750 volts direct current (DC) with substation spacing of up to two Kilometres. If the rail system is not properly insulated from earth, stray current from the traction system can cause damage by corrosion to the infrastructure owned by the transit system as well as facilities owned by others. BMRCL, like most modern transit systems, incorporates stray current mitigation, control and monitoring measures to insure that the DC traction return current travels along the running rails and does not stray onto surrounding metallic structures and cause excessive stray current corrosion.

1.0 INTRODUCTION

The Bangalore Metro is a Direct current (DC) electrified-traction system feeding 750 V to the third rail. The DC required to operate the train traction motors is received by the train current collection device from the third rail and the current then returns to the traction substations via the wheels of the train and the unearthed rail track system. The third rail is positive with respect to the rails (the third rail is dc positive and the two running rails are the dc negative return).

Ideally, all current should return through the rails, but due to the resistances of running rails and resistances of rails to ground, there will be a portion of the return traction current that deviates from the running rails. These current will 'leak' from the rails and return to the substation through the ground. This is called 'stray current' or 'leakage current'. The part of a current which follows paths other than the intended paths is defined as Stray Current (EN 50122-2). These currents deviate from their intended path primarily because the resistance of the unintended path is lower than that of the intended path, or the parallel combination of the two allows part of the current to take the unintended path. The major effect of stray current can be corrosion and subsequent damage of metallic structures, where stray currents leaves the metallic structure.

The return traction current flowing in the rails causes a longitudinal voltage drop along the length of the rails. Although the rails are nominally isolated from the main mass of earth there is inevitably a distributed leakage resistance causing a varying potential difference with respect to earth. The resulting potential difference is generally 10-70 V, which is not dangerous but can cause stray currents in the system

Stray currents are associated with the railways having DC traction system as several decades of experience have not shown any evident corrosion effects from AC traction system. DC which is usually used in urban rail transit projects has the potential to deviate from the intended path. BMRCL like all modern metros uses a three pronged strategy as regards to Stray currents. These can be classified as:

- Stray current mitigation system
- Stray current collection system and
- Stray current monitoring.

This paper explains all the above system adopted and implemented by Bangalore Metro.

2.0 Bangalore Metro Transit System Design

The power supply system of BMRCL is explained as per the flow chart given in Fig.1. The power is received from the utility service provider (BESCOM) at 66 KV at the BMRCL receiving substation. Where it is stepped down and distributed at 33 KV to the traction substations (TSS) and the auxiliary substations (ASS) and to the Depots.

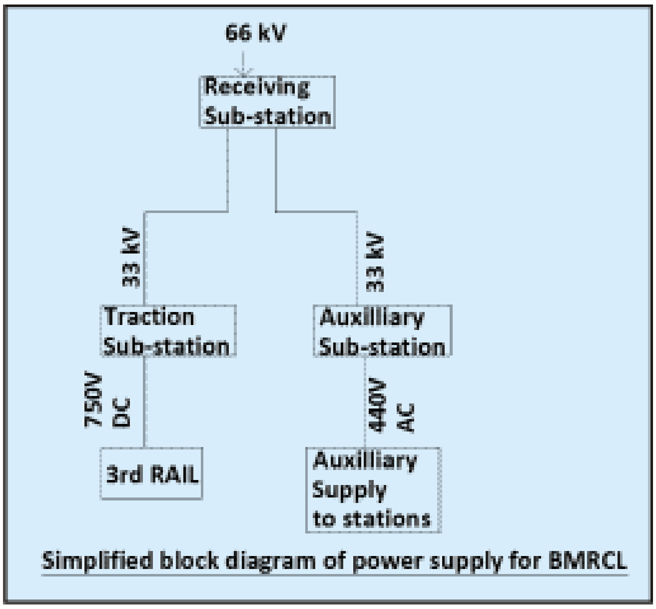


Fig. 1

The rectifier transformers in the TSS step down the voltage for the supply of the 12 pulse rectifier to ±292 V. The rectifier is a series connected 12 pulse rectifier which converts ±292 V to 750 V DC. The substation supplies 750 V DC and upto 4000 amperes of current, depending on the frequency of the train and the number of cars. Traction power substations are not more than 2 km apart to prevent large voltage drops along the traction power feeder. Since a return feeder, or negative return, is needed, the two running rails are used to return the current back to the substation.

The auxiliary transformers step down the 33 KV AC supply to 415 V AC supply for all the auxiliary loads at the stations and depots.

3.0 Stray Current Mitigation System

Stray currents are those that have deviated from their intended path. They deviate from their intended path primarily because the resistance of the unintended path is lower/ comparable to that of the intended path, The stray current mitigation scheme is so designed as to meet the requirements of EN 50122-2. A metro transit system satisfying the requirements of this standard is assumed to be having stray currents within acceptable limits.

In general, the control/mitigation measures can be arranged into two broad categories;

- Decreasing the rail-return circuit resistance and
- Increasing the leakage path resistance to earth Both these points are further discussed in detail.

3.1 Decreasing the Rail-Return Circuit Resistance

Three specific measures used to decrease the resistance of the rail-return circuit are:

i. increase the rail size or cross-sectional area,

ii. provide adequate rail-to-rail bonding, and

iii. decrease the distance between traction power substations.

3.1.1 Increase the Rail Size or Cross-Sectional Area

Stray-current leakage is a result of the resistance relationship between the rail-to- earth return path and the running-rail return path. A high resistance of the running-rail negative return increases the voltage drop along the rails and, therefore, makes the rail-to-earth return circuit a more favourable path for the return current, thus causing stray-current leakage. The size of the rail is internationally standardised and increase the cross sectional area for reduction of stray currents is not an option available. 60 kg UIC Head Hardened rail grade 1080 is used in BMRCL. The rail resistance was measured in accordance to EN 50122-2 (Annex A, section A1), A voltage source of 12 V is applied to the rail and voltage and current passing through the rail is measured as per the set up shown in Fig 2. The theoretical value of electrical resistance for UIC 60 rail is 30 mΩ/km at 20ºC. The rail resistance when measured at an ambient temperature of 34ºC was found to be 35 mΩ/km, considering the ambient temperature the value measured is acceptable.

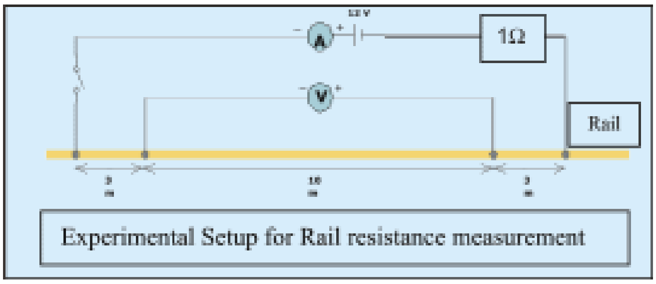


Fig. 2

3.1.2 Provide Adequate Rail-to-Rail Bonding

The second important measure to decrease the running-rail resistance is to maintain a continuous electrical path for the negative current return. This is accomplished by using continuously welded rails, or by using welded cable bonds between discontinuous section of track. BMRCL uses continuous welded rails and hence maintains a continuous electrical path for the negative current.

General Principle	Specific Measures	Other Details	Remarks
Decreasing the Rail-Return Circuit Resistance	• Increase Rail Size		• 60 kg UIC Head Hardened rail grade 1080 • R=35 mΩ /k
	• Rail Bonding	• Continously Welded Rail	• Provided for in BMRCL
		• Cross Bonding Running Rails	• Provided for in BMRCL wherever required
	• Decrease Substation Distance	• Decrease Substation to 1-2 Km	• Max in E-W is 1.382 and 1.676 in N-S

Table 1

3.1.3 Decrease the Distance Between Traction Power Substations.

As can be seen from the table 1 the maximum distance between two station in BMRCL is 1.67 km, this decreases the length of the positive feeder and the negative return circuit, and thereby reducing the voltage drop and making stray-current paths less favourable.

In BMRCL a traction power substation coincides with a passenger station, which provides added benefit in reducing stray-current, since the current requirements of the trains are the highest during acceleration of the trains, but the running rail return circuit voltage drops are the smallest due to the short length of track.

Table 1 summarises the measures taken under the general principle of deceasing the rail return circuit resistance in Bangalore metro.

3.2 Increasing the Leakage-Path Resistance to Earth

Specific measures used to increase the leakage-path resistance are

i. Maintaining an ungrounded negative return circuit,

ii. Increasing the rail-to-earth resistance,

iii. Isolating the yard track and

iv. Segregating sections of the mainline track.

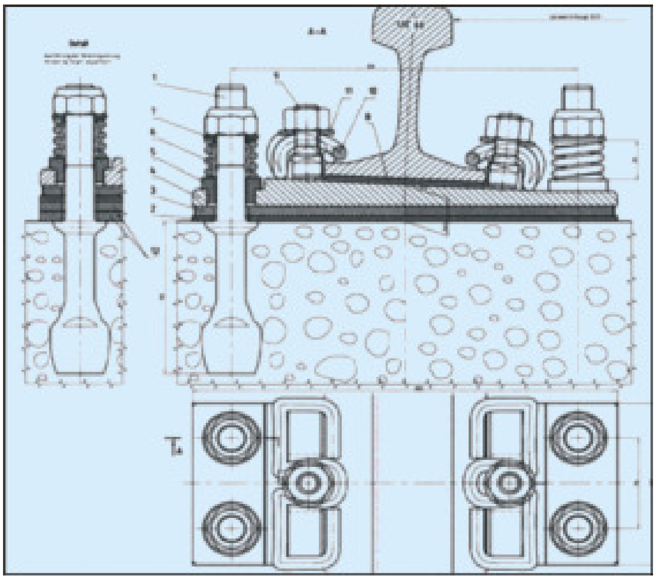
3.2.1 Maintaining An Ungrounded Negative Return Circuit

First and foremost to increase the resistance of leakage paths to earth is to use an ungrounded, or diode-grounded traction power system. In general, transit power systems can be designed to be either solidly grounded, diode-grounded, or ungrounded. Each type of system has advantages and disadvantages. Solidly grounded systems were historically used on older transit systems, Modern Metros do not use Solid-ground systems as stray-current corrosion occurs frequently on the transit rails, rail fasteners. tunnels. bridges and other transit structures. The only advantage of a solidly grounded system is that the negative return voltage is at the same voltage as the earth ground,

Ungrounded systems represent the other extreme of traction power system design. Modern Metros either use an ungrounded or a diode grounded traction power system. BMRCL uses ungrounded traction power system. An ungrounded system has no direct metallic connection between earth and the rectifier bus at the substations. The one disadvantage of an ungrounded system is that sufficiently high electric potentials can develop between track and platforms. Fortunately, improvements in high speed breakers, overvoltage protection equipment, and platform insulation procedures have considerably reduced the risk of hazardous electric potential being present. In BMRCL a high insulation sheet is spread on the platform thereby reducing the risk of touch potential for the passengers. Further a short circuiting device(SCD) also known as OVPD is provided at each station to ensure that potential of the running rail is not increase beyond 60 V. As per EN 50122-2 no damage in the tracks is experienced if the average stray current per unit length does not exceed 2.5 mA/m (average stray current per unit length of a single track line)

3.2.2 Increasing the Rail-to-Earth Resistance

This is the most influencing variable for stray currents leaving the tracks. Rail fastener insulation is important so that high, rail-to- earth resistances are maintained. In theory, stray currents from an ungrounded system should be low as long as rail is not earthed along the line. Practically, however, because of the thousands of fasteners in parallel on the system, an earth ground does exist. By increasing this resistance, the stray-current path is less favorable than the running-rail return path, resulting in less stray current. Today, state-of-the-art track design utilizes insulated track fasteners on concrete track plinths.



Vossloh rail fastening system 336

Fig. 3

The insulated fasteners used in BMRCL are Vossloh rail fastening system 336 (Fig.3). The value of these fasteners has been measured to be greater than 100 MΩ under dry condition and greater than 1MΩ under wet condition.

To ensure that the rail to earth resistance is within the stipulated limit the conductance per length between running rail and structure is measured. As per EN 50122-2 the conductance of the running rail should not exceed 0.5 S/km per track. The experimental set up as per Annex A, section A2 of EN 50122-2 for measurement of the rail conductance is as shown in Fig.4 The current is injected between the depot and the main line across the IRJ. The current is determined by means of a potential drop measurement over 10 m rail length and a rail resistance value of 33 mΩ/km. The results obtained for Reach 1 of BMRCL was in the range of 0.04 S/km, which is much less than the prescribed norm of 0.5 S/km.

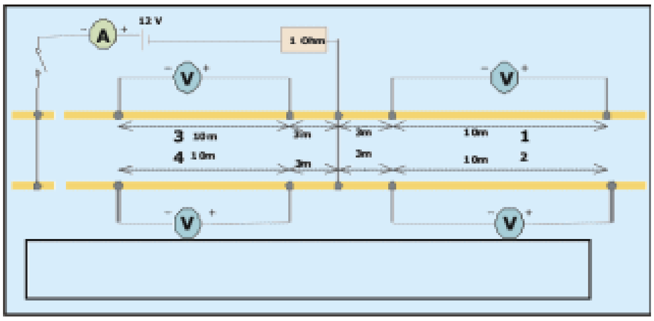


Fig. 4

3.2.3 Isolating the Yard Track

The tracks in depots and workshops are concentrated on small area, no major voltage drop arises in this area. Isolation of depot track results in smaller overall track sections which increases the rail-to-earth resistance in these areas. Electrical isolation of depot track from the mainline track prevents the higher running rail voltages from being imposed on the depot track which are normally at lower voltages as the depot track is solidly grounded. The depot track is solidly grounded to the earth. The advantage of a solidly grounded system is that the negative return voltage is at the same voltage as the earth ground,

General Principle	Specific Measures	Other Details	Remarks
Increasing the Resistance of the Leakage Path to Earth	• Increase Rail to earth distance	• Insulated track fasteners • Concrete track ties and clean ballast	• 100 MΩ in dry condition • 10 MΩ in wet condition • Vossloh fastening system 336
	• Remove Solid Grounding	• Ungrounded system or Diode grounded system	• Ungrounded system • In case the volage of the running rail increases beyond 60 V it is drained to the ground
	• Depot isolation		• IRJ of 25 MΩ provided between mainline and Depot.
	• Main Line Segregation	• Isolate main line into small section	

Table 2

which eliminates the hazard of having electric potentials develop between rail and the earth ground.

The glued insulated rail joint provided in BMRCL to segregate the mainline track from the depot track is approved by RDSO of Indian railways and has a value of greater than 25 MΩ in dry condition when measured with a 100 V DC megger. The measuring arrangement of Insulating rail joint is shown in Fig 5 which is as per EN 50122-2 (Annex A, section 5).A current is injected by a 12V battery and the potential drop over a length of 10 m is determined at the four locations according to the arrangement shown. This allows to determine the total potential drop in the direction of the main line and in the direction of the Depot. Based on this the functionality of the insulation rail joint is calculated. As per the values obtained this glued insulated rail joint provides a functionality of 98.5 % against the benchmark of 95% as given in EN 50122-2. If the measured values of IRJ is less than 95% it indicates that a galvanic connection across the joint exists or that the insulation rail joint is faulty.

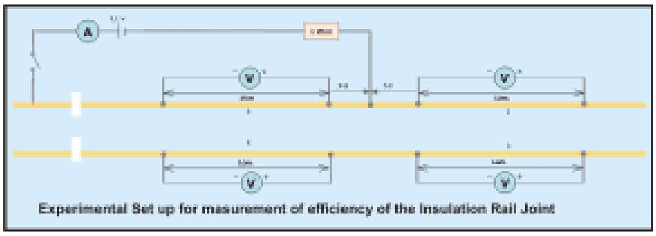


Fig. 5

3.2.4 Segregating Sections of the Mainline Track

Isolation of track results in smaller overall track sections which increases the rail-to-earth resistance in these areas.

Table 2 summarises the measures taken under the general principle of increasing the leakage path resistance to earth in Bangalore metro.

4.0 Stray Current Collection System

The measures described above are all utilised in the mitigation of stray current in the transit system. Though the stray currents may be low in the system after the implementation of above measures, even than a stray current collection system is desirable. It is necessary that a stray current collection system should exist in the system as over a period of time due to wear and tear of rail and fasteners the stray currents in the system are bound to increase. If a stray current collection system is not provided, considerable corrosion of the supporting infrastructure and of third party infrastructure may occur.

Though during the initial period the stray currents will be low due to high resistance of fasteners however it may not be possible to maintain the rail to earth insulation at the high initial values due to accumulation of dust and metallic dust from rail over a period of time.

To avoid stray currents from damaging the infrastructure a stray current collection mesh is provided in the concrete bed below the rails in the track plinth on the viaducts/ tunnels. This collection system is a part of the reinforcement in the track plinth as well as the reinforcement in the viaduct. This reinforcement is bonded along its length to provide a continuous and relative low resistance path. This mat is finally connected to a bare earth copper cable to increase the overall conductivity of the stray collection circuit compared to any other alternative path. Fig. 6 shows the arrangement as adopted in BMRCL. The stray current leaking from the running rails flows into this collection system and finally gets discharged into the earth through a 200 mm2 bare earth copper cable.

The stray current control mats in BMRCL are constructed into the Track plinth reinforcement. The track plinths have a length of 4 to 5 m (approx.), these track plinth mats are continuously welded between all track plinths between a viaduct span. The start and end of the plinths at the viaduct spans is electrically connected with a cable.

5.0 Stray Current Monitoring System

EN 50122-2 provides for either continuous monitoring or Discontinuous monitoring of the stray currents in a DC transit system. BMRCL has adopted the continuous method of monitoring the stray currents. The track potential indirectly determines the stray currents in traction network. For the continuous monitoring the rail potential is registered at dedicated locations along the line i.e. at the substations. A reference average potential over a period of 24 hrs is taken and this reference is compared continuously to examine the presence of stray current in the system. If there is a change in the average rail potential, a change in the rail to earth conductance could have occurred raising concerns for increase in stray current.

It is also necessary to monitor the impact of the structures. A voltage shift of the structure versus earth is an additional criterion which needs to be monitored. The average value of the potential shift between the structure and earth in the peak traffic hours should not exceed +200 mV.

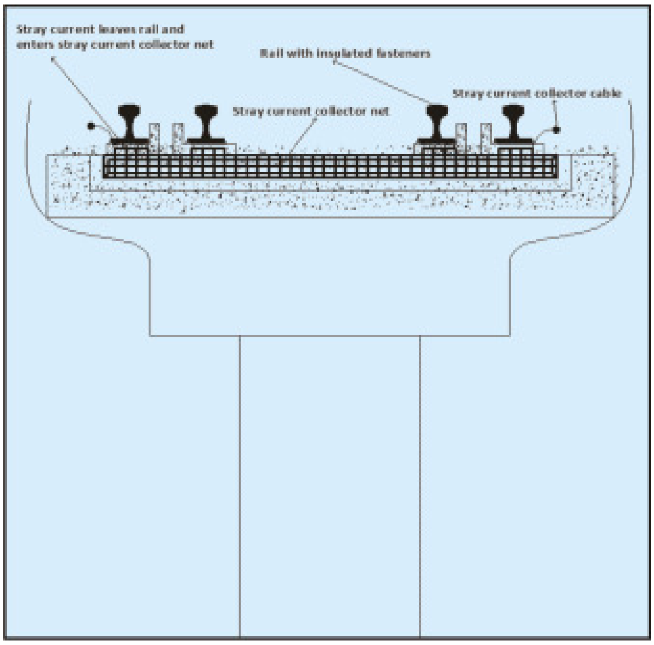


Fig. 6

6.0 Conclusion

An ungrounded/floating system is the preferred system of DC traction all over the world today as the stray currents are minimal in this system. Under normal system operation there is no direct intentional electrical connection between the DC negative and the ground. However the ungrounded system establishes reference to ground through leakage resistance of the running rails. The thousands of fasteners in parallel make an alternative low resistance path. If the average stray current per unit length does not exceed 5 mA/m (for double track line) the infrastructure is considered to be safe from stray current effects(EN 50122-2). The value of the fasteners provided in BMRCL is more than 1 GΩ resulting in an excellent track conductance value of 0.05 S/km. The value of 0.05 S/km is obtained against a benchmark of 1.0 S/km as per EN 50122-2 (open formation double track line).

Reducing stray current is a multipronged strategy and is controlled by factors such as substation spacing, rail to earth resistance and rail resistance. Ultimately the rail to structure earth potential is dependent on the current flowing in the running rails and the longitudinal resistance of the running rails which creates a voltage drop. This voltage drop is the driving potential that forces stray leakage current from the running rails to railway infrastructure and nearby utilities. Therefore by providing low resistance return path and a highly insulated support system stray current will be encouraged to follow the designed path to earth and not seek alternative routes.

However if after a period of time the factors effecting the mitigation of stray current deteriorate than the role of stray current collection mat becomes considerable in avoiding damage to the utilities.

All these measures need to be measured on real time basis so that any excess stray current in the system can be tackled before leading to a catastrophic situation.

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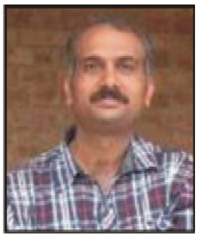
WDM2G - AN ENERGY EFFICIENT MULTI GENSET LOCOMOTIVE FOR SHUNTING TRAFFIC

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RDSO, NREC and DMW in a collaborative project have designed and developed state of the art, Multi Gen Set, AC-DC transmission, Equipped with Cummins QSK-19, N-Gen II type diesel engine 2400 HP WDM2G Diesel Electric Locomotive. The design was taken in hand in Oct 2010. The prototype Locomotive was manufactured by DMW in April 2013. This paper deals with salient features of WDM2G Locomotive.

1.0 Background

RDSO has been working on the project to develop pollution free and energy efficient locomotives to meet the emerging requirements arising out of environmental concerns as well as depletion of fossil fuels.

A multi power plant locomotive is inherently fuel efficient, as the locomotive produces variable power depending upon the requirements. This is achieved through powering two or more, smaller engines in place of a single big power pack; this results in conservation of fuel as well as lower emissions. This will go a long way towards contributing to the energy security of the country. It is estimated that a 'Multi-genset' locomotive shall result in around 30% saving in fuel over a present locomotive of equivalent power and service besides resulting in substantial reduction in NOX emissions and carbon credits under the Kyoto protocol.

2.0 Design & Development of 2400 HP Multi-Genset Locomotive for Indian Railways

i. RDSO has designed and developed 2400 HP energy efficient Multi-Genset locomotive named as WDM2G. This locomotive has three 800 hp genset power plants. WDM3D locomotive underframe has been used with some modifications to accommodate new equipments of this locomotive. This locomotive is fitted with high adhesion bogie (HAHS) and brake system IRAB-1 similar to WDM3D loco.

ii. The WDM2G Loco General Arrangement and Bogie General Arrangement are as per RDSO Drg. No. SKDL-4764 & SKVL-460 respectively. A prototype WDM2G locomotive has already been manufactured at DMW, Patiala as per RDSO Specification No. MP.0.2402.23 Rev.00.

iii. This locomotive is equipped with (a) Cab, (b) Chopper, (c) Three multi-genset , (d) Three Cylinder Air Compressor, (e) Cooling Hood with cooling fans, and two radiators, (f) Dynamic Brake Grid, (g) Draft Gear and Couplers, (h) Two three motor, three axle bogies, (i) Anti-Climber, (j) Cow Catcher, (k) Two Main Reservoirs, (l) Blower Motors and (m) two nos. HAHS bogies etc.

iv. This locomotive has similar axle load, location of C.G. and brake arrangement as WDM3D.

3.0 Operational Capability

The locomotive has been designed for the following duty-

- Coaching shunting up to a speed of 15kmph with 24 coach load (16 hours duty and 8 hours rest)
- Coaching shunting on mainline with 24 coach load up to a maximum speed of 35 Kmph (16 hours duty and 8 hours rest)
- The noise and emission level reduction in the locomotive to the extent 80 to 90% below that on the existing mainline diesel locomotives.

4.0 Locomotive Operation

The main sources of power for the locomotive are the diesel engines. A separate 24 volt DC power system is arranged to provide necessary battery power for starting the diesel engines. This 24 volt battery is isolated and separated from all other control system circuitry including the 64 volt battery system. This allows the 64 volt battery system to provide necessary battery power for control system, lightning, air conditioning, and heating without draining the starting battery.

Once the engine is started, it supplies the power to drive its own main generator. This main generator then provides necessary electrical power to drive the air compressor, equipment blower, cooling fan, and provides 3-phase AC power for battery charging. The air compressor is a rotary screw type compressor driven by a multi-stage three phase AC electric motor.

The equipment blower provides cooling air for the traction motors, DC choppers, and low voltage power supply, air conditioning inverter, and electric cabinet pressurization and is driven by a variable speed 3-phase AC electric motor.

The genset is equipped with its own cooling fan driven by a variable speed three phase AC motor. A Low Voltage Power Supply (LVPS) is provided to convert power from the main generator to 74 volts DC for the 64 volt battery charging and 27 volts DC for the battery charging.

A DC to AC inverter is provided to convert battery power to 115 volt AC power to operate the heating and ventilation units in the operator's cab.

The main generator rotates at engine speed and provides AC to a rectifier assembly which then delivers high voltage DC power to the common bus. DC choppers provide power from the DC bus to a pair of traction motors that is directly geared to an axle and a pair of driving wheels. The trucks, which house the motor and wheel arrangements, support all of the locomotive weight, and provide for flexibility to turn the locomotive and absorb many of the shocks while maintaining maximum traction for the wheels.

5.0 System and New Equipments

5.1 Genset

The genset is a diesel engine and generator assembly that is mounted on a dedicated frame work. This framework contains all cooling and lubricating apparatus needed to support the engine and generator as a self-contained unit. Mounting the engine/ generator assembly in such a frame work enables quick engine change-outs for increased maintenance efficiency.

The genset produces DC voltage for the traction system and AC voltage for the locomotive auxiliary system. The design intent of the locomotive is to start and run only those gensets required to move the train. For example, in low notches, only one genset will be started and run. As the throttle is increased and more power is required, the control system will start and run the remaining gensets as necessary.

This method of operation maximizes fuel economy and minimizes air pollution.

The genset contains the following items.

- Diesel engine
- Generator
- Radiator and fan assembly
- Fresh oil supply tank
- Fuel filter and pump assembly
- Air cleaners
- Engine block heater
- Circuit breaker panel
- DC rectifier

5.2 Fuel System

Each genset contains its own fuel system (pump, filters, ect.) located on the diesel engine. Each genset engine is connected separately to the fuel tank with its own fuel supply and return line. A fuel filter, electronic fuel quantity display panel, and fuel level sight glass are located on each side of tank. Also included on the tank are retention tank lines and a fuel tank water drain.

5000 ltrs. Capacity fuel tank similar to WDM3D is used for this locomotive. The fuel system is the consist of emergency fuel cut-out switches , draining condensate from fuel tank, filling of fuel, retention tank

5.3 Air System

- **Ventilation / Cooling Air System**

Air is taken into carbody (equipment compartment) of the locomotive to supply air to the following components and area:

i. Traction motor
ii. Main electric cabinet (MEC)
iii. DC choppers
iv. Low voltage power supply (LVPS)
v. Rectifier
vi. Inverter

Ambient air enters the equipment compartment through the filters . Outside air is drawn through the filters into blower. The blower distributes the air into main air duct located on the floor of underframe.

- **Compressed Air System**

Compressed air is used for operating the locomotive air brake system (IRAB-I) and auxiliary devices such as sander, horn and windshield wipers.

- **Compressor**

Air is compressed by an air cooled, single stage, oil injected screw compressor. The unit is comprised of the compressor element, an enclosed cooling fan, an oil separator, air and oil cooler, gear box and flexible coupling. The compressor element houses two rotors mounted in a special bearing arrangement. The module is driven by a motor through the flexible coupling. Oil is injected to lubricate and seal the rotors as well as to absorb heat.

Equipments involved in brake system are similar to WDM3D locomotive accept compressor.

5.4 Electric Equipment

- **Main Electric Cabinet**

The main electric cabinet is a portion of the back wall of the cab, and houses the Low and high voltage electrical devices necessary for the operation of the locomotive.

Main electric panel consists of Engine control panel, Operator control panel, Circuit breaker panel, Battery switch compartment and other main electric cabinet devices. These panels contains various devices such as traction motor cut-off , emergency fuel cut-off & engine, dynamic brake cut-out, ground relay cut-out etc. which are used in operation of locomotive.

- **Electric Hand Brake**

The locomotive parking brake is an automated, electric motor driven system. The primary operator interface is a control panel incorporating two push buttons : SET & RELEASE. In the event unavailability of electric power , the brake can be operated using a manual interface.

In automatic mode, the force in the chain is initiated by the electric motor and delivered through a gear train to output chain sprocket.

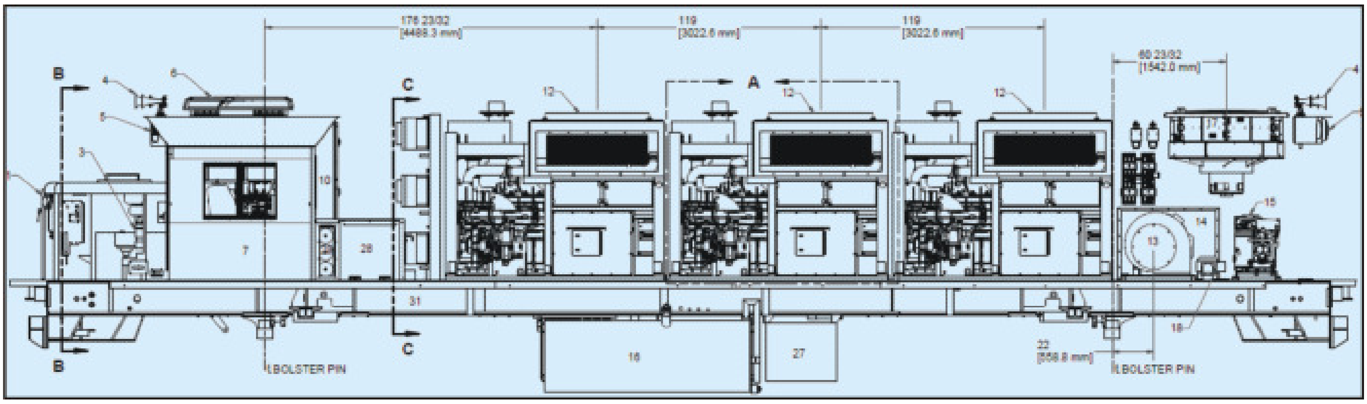
5.5 Power Electronic Equipment

- **Chopper Module**

The DC chopper modulates the DC bus voltage, from the rectifier modules to required level to control the traction motor speed.

- **Low Voltage Power Supply (LVPS)**

The LVPS is comprised of a rectifier and two inverters. The AC output from the generators is first rectified to DC, then changed to AC before being transformed and rectified down to a low voltage DC level for the purpose of battery charging.



Locomotive Equipment Layout

6.0 Conclusion

Development of WDM2G locomotive of 2400HP was a pilot project to gain experience with the multi gen set concept. Possibility of development a 3000/ 4000 HP multi gen set loco is now being studied.

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FDCOM: AN ONLINE AID TO SIGNAL MAINTAINER IN DIAGNOSING REAL CAUSE DURING SIGNAL FAILURES

Sachin Shukla
Sr. DSTE(Co)/JBP

,QMhdke foQyrk unkfudh vkj lpkj i.kkyh] ,d MkVk ykxj ,o th,l,e ekMe bosUV fVªxj vkèkkfjr vkuykbu vIyhds'ku g] tk flxuy dh foQyrk dk fu/kkfjr djrh g vkj foQyrk vkj blds fu/kkfjr lHko dkj.k dk flxuy eUVuj] lD'ku flxuy fujh{kd] flxuy fujh{k.k d iHkkjh vkj mPp vf/kdkfj;k dk blds lpuk rjr Hkstrk gA flxuy foQyrkvk d nkjku mldk okLrfod dkj.k tkuu e flxuy eVuj dk ;g ,d vkuykbu lgk;rk gA

nk"k dk lgh dkj.k fu/kkfjr djr g, foQyrk d iR;d ekeys e ;g fVªxj gk tkrk g blfy, lHkh foQyrkvk ij vko';d /;ku fn;k tk ldk g vkj iR;d ekeys e le; ij Mk;Xukfll dju vkj mle lHkh ij dk;okgh dju d QyLo:i ^^jkbV vkVk^^] ^^uk QkYV QkmUM^^ o ^^VLV fd;k vkj lgh ik;k^^A

FDCOM, Failure Diagnostics and Communication System, is a data logger & GSM Modem event trigger based online application to pinpoint signal failure when it takes place and relay the failure and its pinpointed possible reason to Signal Maintainer, sectional signal inspector, sectional in charge signal inspector and higher officers immediately. This is an online aid to Signal Maintainer in diagnosing real cause during signal failures.

This is triggered in each case of failure pinpointing the fault precisely. Therefore, all failures get necessary attention and cases of "Right Auto", "No fault found" and "Tested & found okay" are eliminated by timely diagnosis & action in each such case.

1.0 Present System

Present system of reporting signal failures is totally dependent on correct reporting by Deputy Station Superintendent to Signal Maintainer. Deputy Station Superintendent tries to take off signal on receiving message from control/ reception from next station. He then tries to take off signal by pressing necessary signal and route buttons. If signal is not taken off due to any reason, then he reports the failure to Signal Maintainer and explains symptom of failure as per his observation and knowledge.

Signal Maintainer then takes a note of indications available on panel and tries to pinpoint failure based on his experience to OUTDOOR reasons like cable, adjustment, fusing of LED etc or INDOOR reasons like power supply, relay, button etc. Many times, he misjudges the possible reason and takes a wrong direction in pinpointing signal failure. This increases the duration of failure. When train movement is affected adversely for longer duration, then section controller reports signal failure to signal control. Signal control analyses it through data logger, guides S.M. verbally and provides necessary assistance of men and material by movement through nearby stations/ depots.

Many "Right Auto", "No fault found" and "Tested & found okay" failures are left unattended in system due to no reporting and improper diagnosis in this system. Many times, these failures get repeated and turn into major failures.

2.0 New System with FDCOM

FDCOM, Failure Diagnostics and Communication System, is a data logger & GSM Modem event trigger based online application to pinpoint signal failure when it takes place and relay the failure and its pinpointed possible reason to S.M., sectional signal inspector, sectional in charge signal inspector and higher officers immediately. This will be an online aid to S.M. in diagnosing real cause during signal failures.

This will be triggered in each case of failure pinpointing the fault precisely. Therefore, all failures will get necessary attention and cases of "Right Auto", "No fault found" and "Tested & found okay" will be eliminated by timely diagnosis & action in each such case.

3.0 Main Features of FDCOM

3.1 Following are main features of FDCOM

FDCOM Pre-check Sequence: A pre-check sequence is programmed for each route of selection table in FDCOM. This pre-check sequence is used to validate operation of taking off signal for correctness of operation.

FDCOM Timer: A Timer is programmed for each route of selection table in FDCOM. This Timer defines the available window for normal clearance of signal. This has to be programmed as per number and type of relays in route. It has been experienced that British pattern Q series based IBS circuits need a longer timer than other circuits at stations like Maihar, Hardua etc.

FDCOM Diagnostic Sequence: A diagnostic sequence is programmed for each route of selection table in FDCOM. This diagnostic sequence is used to compare with faulty sequence in failure cases and pinpoint fault by identifying FIRST NOT OPERATED RELAY in faulty sequence.

4.0 Working of FDCOM

If a valid operation is performed as per FDCOM Pre-check sequence and signal is not taken off by the end of FDCOM Timer, then an event is triggered in data logger. FDCOM then compares the faulty sequence operated in this event with FDCOM Diagnostic Sequence and relays failure message along with FIRST NOT OPERATED RELAY in this event through GSM modem to S.M., sectional signal supervisors and related field officers. S.M. can now use failure message and FIRST NOT OPERATED RELAY message to pinpoint real cause of failure.

This message is also relayed to signal control, which is manned 24 hours. Thus, signal control is immediately informed of such failures. He can inform to all concerned and provide necessary assistance accordingly, especially during night hours when sectional staff will not be available on duty.

Thus, FDCOM pinpoints signal failure when it takes place and relays the failure and its pinpointed possible reason to S.M., sectional signal inspector, sectional in charge signal inspector and higher officers immediately. This online aid to S.M. helps in diagnosing real cause during signal failures and reducing MTTR by online & correct pinpointed failure message.

5.0 Progress in Jabalpur Division

Jabalpur station has presently MACLS with networked data loggers at 92 stations out of 106 stations. FDCOM was dedicated at 50 stations of Jabalpur on 1st March, 2013 by GM, WCR Shri Sunil V. Arya at Mahroi station during Annual Inspection of Katni-Singrauli section in Jabalpur Division. FDCOM has been programmed at all Panel stations of Jabalpur Division departmentally using existing Fault entry and route entry utilities of Data logger on 10th April, 2013.

6.0 Experiences in Jabalpur Division in Last Two Months

FDCOM Timer has generally been kept as 10 seconds for PI stations and 15 seconds for RRI stations.

FDCOM identifies each case of signal failure, when the operation is valid as per FDCOM pre-check sequence. Therefore, 5-6 cases of premature release of buttons are being relayed daily. FDCOM used to relay a failure message in such cases, with FIRST NOT OPERATED RELAY message based on duration of pressing of buttons. This problem was solved by using another application, which relays message of "Premature Release of Buttons" in all such cases to guide sectional staff clearly.

FDCOM has identified intermittent failures at newly commissioned route setting type PI stations of Katni-Singrauli like Gajarabahra and Mahroi.

FDCOM has identified failed/ hanged Digital cards in Datalogger which are not detected normally by any other method. Data sequences of these cards get interrupted and are identified immediately.

FDCOM is helping in signal failures at stations by pinpointing faults in cases of signal failures. MTTR Data comparison on a longer time frame can further confirm its utility.

7.0 Suggestions for Further Improvement

CUG Sims should be proliferated to all S&T maintainers, so that FDCOM messages can reach to field level staff members, who first attend most of the failures.

Number of inputs allowed in pre-check sequence should be increased from present limit of 9 in data logger to 15 on optional basis. This will make logics of longer sequences like home signals more precise. This can be done by increasing limit of "Extra Conditions" utility and making it usable with "Route Entry" and "Circuit Entry" utilities of data logger.


Route Failure Pop-up
SMS window
Detail of first failed relay in sequnce send in SMS
Realys failed in sequence shown by Red colour
Fault Alarms
Show This Month Faults
Close
Save In File
Save Fault Buffer

8. Team involved in Development of FDCOM and Compilation of this Article

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Instructions for the guidance to the authors in the preparation of articles and other contributions to the Indian Railway Technical Bulletin

To stimulate interest in technical authorship, Railway Board have sanctioned the grant of four annual cash prizes of Rs 2000/-, Rs 1500/- and Rs 1000/- (two numbers) for the article adjudged as first, second and third (two numbers) published in any calendar year in the bulletin and have decided that authors (other than RDSO) of the remaining articles will be paid Rs 400/- for each article depending on its merit.

Contributions, having merit on the following subjects are acceptable for the bulletin.

- Articles on engineering, transportation, commercial, accounts, statistical and other allied subjects having a bearing on railway working.
- Short notes on handy gadgets or practical hints on care, maintenance and operation of equipment, method of construction and organisational problems encountered in railway working.
- Comments and criticism in the form of 'Letters to the Editor' on articles which have appeared in earlier issues of the bulletin.

The Editor can also be addressed to seek information or opinion on the design and maintenance of railway equipment.

Two copies of each contribution with soft copy should be typewritten to double spacing on the one side of the paper with a margin of the left hand side of 40 mm and addressed to the Executive Director (Administration & EMS), Research Designs and Standards Organisation, Manak Nagar, Lucknow- 226011, whose decision regarding suitability for publication will be final.

Author's full name and designation should be given. All articles should begin with a synopsis not exceeding 100 words. References should be quoted numerically in a bibliography at the end of paper. Footnotes should be indicated by sub-script numbers to be presented in the order of their appearance. Standard or well recognised notations should be used and personal reference and lengthy quotations should be avoided. An article should not normally exceed 3,000 words. The authors should certify that the articles sent for publication in the Indian Railway Technical Bulletin have not been sent elsewhere for publications.

Black/Colour Illustrations and photographs should be the minimum required to explain the article. Diagrams and tables should normally be of ISI metric size A4 (297x210 mm) with margins of 13 mm at the top, bottom and right-hand side and 20 mm on the left hand side. Larger diagrams should be on sheets 297 mm deep but should not exceed 420 mm in width as far as possible. In case of diagrams larger than 297x420 mm, lettering should be such that when reduced in size, it remains legible.

Line diagrams should be in black/colour ink on tracing cloth or on tracing paper or soft copy having smooth white surface with lettering reduced to the minimum.

If author makes a request, tracings and photographs will be returned after printing.

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