RESEARCH, DESIGN & DEVELOPMENT

Development of Electric locomotive with Head On Generation (HOG) facility

At present, a Power Car equipped with diesel generator capable of generating adequate power of 3 phase 50 cycle 415 V/750 V AC is provided at either end of the train rake to supply power to End on Generation (EOG) coaches of Rajdhani/Shatabdi Express trains. This system is not only highly inefficient but also creates noise and environmental pollution for the passengers and public.

In keeping with the worldwide practices of meeting power supply requirement of coaches in a passenger train by locomotives, known as Head on Generation (HOG) System, a WAP7 electric locomotive with on board centralised Universal converter of 2x500 kVA/750 V single phase input, 750 V single phase/3-phase output capacity has been developed. The locomotive hauling the train feeds power supply requirement of the complete train having AC/ Non AC coaches through Overhead Electric Equipment (OHE), transformer and converter in the locomotive without the need for having individual self-generating equipment in each coach.

Based on the guidelines issued by Railway Board for development of locomotives with hotel load facilities in their transformers, RDSO has taken action for the same on different types of electric locomotives namely WAP4, WAP5 & WAP7 for hauling coaching trains. On one WAP7 locomotive (30279), 2x500 kVA hotel load converter has been fitted and commissioned. Two power cars have been modified and actual commercial service with this locomotive having HOG system on KalkaShatabdi rake has been introduced in February, 2011. In this system, the hotel load winding of 945 kVA of transformer feeds power to two 500 kVA static converters which convert single phase 750 V supply into 750 V three phase supply. The three phase supply is transmitted to both the feeder of the existing EOG train through IV coupler.

Modification in brake rigging arrangement and upgradation of speed of WAP7 locomotives

Railways had been reporting breakages of brake hanger of TBU/PBU in WAP7 locomotives. It was observed that the breakages were taking place at higher speed due to higher level of vibration and higher weight of PBU/TBU. Worldwide, PBU/TBU is not in use on high speed passenger locomotives. The existing TBU arrangement in WAP7 locos can be replaced with brake system similar to WAG7 locos. Similar brake rigging arrangement has been in use in high speed WDP2 locomotive, which is working at a maximum speed of 120 km/h and fit to work up to maximum speed of 160 km/h.

Feasibility study done by RDSO in this regard revealed that the following modifications are required to be carried out in the bogie frame of WAP7:

- Removal of existing tubes and brackets from the bogies by oxy-cutting
- Grinding/finishing of the bogie surface.
- MIG welding of brackets, studs for mounting brake cylinder and brake levers and slack adjuster unit.
- Removal of existing pneumatic pipelines and relaying of pipelines suitable for WAG7 brake rigging.
- Stress relieving (normalizing) of bogie frame after welding at a maximum soaking temperature of 600° C.
- Drawing was prepared by RDSO for modification to be carried out in Brake rigging arrangement and issued to ECR with advice to take action on two bogies of WAP7 on a trial basis.

One locomotive with this modification was subjected to oscillation trial for service speed of 140 km/h which has been successfully completed and the speed certificate for operation of the WAP7 locomotive upto 140 km/h with modified brake rigging arrangement has been issued.
Upon recommendations of RDSO for implementation of this modification on all WAP7 locomotives after successful field trials with this locomotive, Railway Board has approved that the modification may be implemented in existing as well as new locomotives at the earliest.

**Development of high horse power locomotives for Heavy Haul Operation**

In order to meet the challenge of ever increasing originating freight loading, it has been decided to procure 800 nos. new generation electric locomotive during next 8 years through a new electric locomotive manufacturing unit being set up under joint venture at Madhepura, Bihar. RDSO has finalized the specification for the 12000HP high horse power new generation electric locomotive for the proposed dedicated freight corridor, to be procured from reputed manufacturers of the state of the art locomotive.

- Technical Specification No. RDSO/2006/EL/SPEC/0044 for 12000 HP, 8 axle IGBT base three phase drive freight electric locomotive for proposed Dedicated Freight Corridor has been issued and the same is expected to be ready after establishment of the new locomotive factory proposed in Madhepura.

- RDSO has also finalized the specification for the 9000HP high horse power new generation electric locomotive for the proposed western corridor, to be procured from reputed manufacturers of the state of the art locomotives. Technical Specification for IGBT based three phase drive freight electric locomotive for proposed western Corridor is under finalisation by RDSO.

- Technical Specification for manufacturing, assembly and supply of body/shell, IGBT based three phase drive propulsion system and other equipments of WAG9 and WAP7 Electric Locomotives to be made at upcoming Electric Loco Assembly and Ancillary Unit, Dankuni, West Bengal has been prepared and sent to Railway Board.

**Upgradation of WAP5 Locomotives for Service Speed of 200kmph**

As decided in 28th Governing council meeting held in RDSO, this development has been taken under mission 24. In this regard test trial of WAP5 locomotive along with LHB coaches on the upgraded track of a Rajdhani route section at test speed of 225 kmph will have to be done.

For increasing service speed of WAP5 loco from 160 kmph to 200 kmph, the transmission system of the locomotive is required to be changed as per design detail submitted by M/s BT in the TOT. Rly. Board has approved for manufacturing of two WAP5 locomotives by CLW with modified transmission system. CLW has been advised in this regard. PO has been placed on M/s Henschel for two loco sets of material, which is expected shortly.

**Development of Driver’s Vigilance Telemetric Control System (DVTCS) for electric locomotives**

To monitor the alertness of locomotive crew and assist them in this regard, DVTCS system has been developed which directly measures and analyzes variations in biometric parameters such as variations in skin’s galvanic response of the driver to determine the state of alertness and also predict likely hood of the driver falling into state of relaxation.

It is divided in three parts i.e. transmitter, Receiver-cum-Indication Unit and Controller. The transmitter (one bracelet and one ring) is worn by the driver on the wrist like a wrist watch and ring on finger. Receiver-cum-indication unit is mounted in the locomotive cabs in the visibility of driver to receive the RF signal from transmitter and display the level of driver’s alertness in an LED matrix bar graph display. It also generates audio alarm when driver’s alertness falls below threshold level. Controller is mounted at a suitable location inside the locomotive and is connected with the receiver-cum-indicator unit in driving cabs. Initially DVTCS have been provided on trial in SCR and ECOR in 05 locos each.
Development of Vigilance Control Device for conventional electric locomotives

A Vigilance Control Device to monitor the alertness of the driver exists in three phase drive locomotives. AC tap changer locomotives are not provided with Vigilance Control device (VCD) previously. However VCD is now has been developed for AC tap changer locomotives. The VCD is for monitoring alertness of the engine crew through a multi-resetting system which gets reset by specified normal operational activities of the crew, in addition to acknowledgement of the vigilance check by pressing a push button or pedal switch provided for this purpose. Absence of the normal driving functions and the acknowledgement at specified intervals activates vigilance control system to flash an indication which if still not acknowledged causes audiovisual warning. If audiovisual warning is also not acknowledged, it results in emergency brake application. This also takes care of problem of operation of locos by unauthorized persons getting into unattended loco cab.

It is divided in two parts i.e. Main unit and Cab display units in each cab. Main unit has been provided in machine room to sense the normal driving function inputs and cab display unit is provided for indication to the driver. Push button is also provided on cab unit for Asstt driver to push the same within 60 sec. So far 350 units have been provided on I.R.

RDSO has developed oil free compressors for electric locomotives owing to its superiority over the conventional lubricated type compressors. The merits of the oil free compressors include reduced maintenance cost and down time of Locos, eco-friendly due to oil free air, longer service life of air dryer and other pneumatic valves/components, low vibration and low noise, reduced start up energy requirement, low life cycle cost, no fire hazard.

Two units of M/s. Knorr-Bremze make (2000 LPM) have completed field trials. The performance of the oil free compressor was found to be satisfactory. Further, development & prototype type testing of 1000 LPM compressors of M/s. Anesta Iwata Motherson Ltd., Noida & M/s ELGI has also been completed. 02 units of each firm are under field trial.

Development of Force cooled roof mounted DBR

RDSO has carried out detailed study on provision of Roof mounted force cooled Dynamic Braking Resistors for AC Electric Locomotives. Trials of force cooled roof mounted DBR fitted in WAG-7 have been done by RDSO and test parameters were found in conformity with specifications. Maximum hot spot temperature observed was in the range of 350 °C at braking current of 900 amps which is very much on the lower side. Considering the energy efficiency, improved reliability and better design of force cooled roof mounted DBR on electric locomotives, Railway board has advised CLW to make provision of force cooled roof mounted DBR on 50% of new locomotives manufactured by CLW.
Development of Air operated pantograph

RDSO has finalized specification of direct air operated Pantograph & around 40 pantographs of M/s. Schunk Metal & Carbon India are in service.

Direct air operated Pantograph have distinct advantages of light weight, improved dynamic behaviour, practically maintenance free operation over the conventional metallic spring operated Pantographs. It has completely addressed the major reliability problems of breakage of springs, servomotor failures and jamming of plunger being faced in conventional Pantographs. The direct air operated Pantograph uses state of art air spring and does away with more failure prone components such as servomotor and the metallic spring of the conventional Pantograph. There is provision of Auto dropping device to protect pantograph from external hitting. Improved dynamic behavior of air operated Pantograph also results in better current collection.

Development of Distributed Power Wireless control System for Tap changer based 25 KV AC electric locomotives

RDSO has developed specification No RDSO/2008/EL/0074 Rev (0)-Dec 2008 for Distributed Power Wireless control System for Tap changer based 25 KV AC electric locomotives. One loco set of the system was procured by SCR as per this specification from an indigenous firm M/s Lotus Wireless Technology Pvt Ltd, Visakhapatnam. The system has been fitted on WAG7 loco No 27426 & 27428 of ELS/KJZ/SCR and has been put under field trial after testing by RDSO and the same is reported to be working satisfactory. The system comprises of Control & Communication unit (CCU), Driver Information unit (DIU) and RF & GPS Antenna.

System is capable of working in any configuration of locos i.e. remote locos can be placed anywhere within train consist. Remote locos can also be independently controlled from lead loco. This provision will facilitate train working even when lead loco has failed. Distribution of locos within train consist will reduce the coupler forces thereby reducing the incidences of train partings. Further, the brake application and release time will get reduced thereby enabling faster acceleration of train after instances of braking. Besides this, the system has huge potential for saving of crew as only one crew (as against two) is being kept in remote locos. One crew is being kept in remote locos to primarily take care of exigencies of fire in loco and other mechanical defects.

Development of indigenous transformer tank for 3-phase electric locomotives

The transformer used on 3 phase electric locomotives
type WAP5/WAG9/WAP7 is provided with tank made of special alluminum alloy, facilities for manufacturing/fabrication of which did not exist earlier with any of the industries in India. So far this item was being imported by transformer manufacturers at a very high cost.

Due to the initiative taken by RDSO, this aluminium tank for transformer has been got developed through a firm in India. The development involved close monitoring of the stage inspection by RDSO during selection of material, fabrication and manufacturing process of the tank. After satisfactory completion of field trial of a few transformers provided with this indigenous tank, the same has been cleared for regular use by transformer manufacturers. This development will result in substantial saving of foreign exchange by Indian Railways and overall reduction in the production cost of 3-phase electric locomotives.

The failures of different types of PCB cards of 3-phase locos were causing concern.

**Improvement in Reliability of PCB cards**
The failures of different types of PCB cards of 3-phase locos were causing concern.

The action taken by RDSO for improving the reliability of PCB cards are summarised below:

- RDSO has issued instruction for rehabilitation of cards after six years by changing electrolytic capacitors and other components such as EPROMS and fibre optic components. RDSO has also issued guideline (no. EL/G/2008/01, Nov’08) for rehabilitation of these cards.
- The electrolytic capacitors, which are prone to failure, have been identified for replacement with better rated capacitors having better operating life. RDSO has approved Proposals of M/s BTIL & M/s BHEL for using such capacitors on cards for two loco sets vide this office letter No. 11.5.5/5 dated 14-05-09.
- Apart from the above, different specific actions have been taken to reduce failures of Different types of cards in power convertor, auxiliary convertor and control electronics.
- RDSO has issued report No.RDSO/2009/EL/IR/0141 Rev.’0’ in Nov’09 on dust accumulation and less pressurization in Machine Room. The report highlight actions already taken by RDSO to overcome this problem and actions need to be taken by CLW & RDSO further on this issue.
- Functionally equivalent power supply card (KUC 153 A01) of auxiliary convertor has been developed indigenously by BHEL and M/s BTIL and is working satisfactorily in field for the last one year. Similarly, power supply card of traction convertor (KUA 915 B01) is also under
development indigenously. After development of these indigenous cards, the problem of failures of these cards will be eliminated.

- RDSO has issued SMI/0263 dated 27.07.10 for testing of Gate Unit of traction converter.
- To avoid failure of 24 V read relay in digital I/O board, modified cards with reed relays having 2 N/O interlock in series and improved RC network along with diode across resistance are running successfully on trial in Lallaguda shed since May/June, 2009. TOT partners have been advised to cut in cards with modified reed relays and RC networks for relay K250, K251, K247, and K253 from 31-08-09.

Report No. RDSO/2009/EL/IR/0141 Rev’0’ on ‘Dust accumulation and less pressurisation in machine room of three phase locomotives and Remedy’ has been prepared and sent to CLW and Railway Board. In this regard MS/0385 dated 15-12-09 has been issued for partial blocking of opening duct of back side of auxiliary converter to improve front side cooling of power modules.

- In order to test and repair WRE modules of auxiliary converter, SMI/0261 (Rev. ‘0’), Dated.15.12.2009 has been issued to zonal Railways holding three phase locomotives.
- To arrest the failure of IC:14C88 in NS/AS controller card, a Modification Sheet has been issued for ungrounding Pin No. 8 & 11, which should be implemented. This modification needs to be implemented through M/s BTIL. Loco sheds should pursue it with M/s BTIL and get it implemented at the earliest.
- To avoid premature failure of QFBR1478C in gate unit of power converter, a SMI (SMI/257) has been issued by RDSO for checking of dB level of output of the fibre optic transmitter. Similarly to avoid shorting of gate and cathode terminal of gate units, a Modification Sheet (MS/0378) has been issued by RDSO for inserting an insulated plate between gate and cathode.
- The cover of electronic module of auxiliary converter have been modified to have more air circulation to avoid intermittent failure of power supply card. RDSO has issued the instructions for implementation in field vide modification sheet no. MS/0372.
- The reason of failures of gate driver card of WRE module of auxiliary converter has been identified. RDSO has issued a Modification Sheet (MS/0372) and letter No. EL/11.5.5/2/BT to TOT partners for doing the following modification in this card:
  - Indigenisation of hybrid card
  - Improvement in rating of zener diode
  - Use of perforated cover on gate driver card
  - Working the cooling fans continuously on by shorting thermostat

- RDSO has issued SMI No. 0256 for testing of gate driver of WRE module of auxiliary converter, by which any suspected gate driver card can be tested. Fibre optic transmitter can also be checked as per this SMI to avoid failure of GTOs in WRE module.
- To maintain the pressurisation in machine room of three phase locomotives, RDSO has issued SMI No. 255 for measurement of air velocity at various locations inside the machine room by sheds and to take necessary corrective actions. RDSO has also benchmarked the values of air velocity at various locations inside machine room and at ventilators for newly built locomotives at CLW, which has been advised to CLW vide letter no. EL/11.5.5/5.
- To improve the pressurisation of machine room in WAP7 and WAG9 locomotives and to avoid dust ingress in the machine room, RDSO has issued Modification sheet No. 0380 to block two centrally located ventilators in WAP7 and WAG9 locomotives.

**Improved cooling arrangement for Electronic cards**

There are failures of electronic cards on account of high temperature experienced around the cards, which results in failure of certain components such as electrolytic capacitors after 4-5 years of service. RDSO conducted measurement of temperature near cards and found that temperature in power converter cards rises 15 degree C above ambient as compared to 9-11 degree C rise in Aux Converter and VCU. The failure of cards is also maximum in power converter. Following actions have been taken by RDSO to eliminate electronic cards failures in three phase locomotives due to high temperature.

To reduce the temperature near the cards of power converter, the design of heat exchanger of traction converter electronics have been modified for better cooling. The manufacturers of converters have been advised to cut in this type of cooling radiator in their future production considering its superiority. Also Railways have been advised for retrofitment of this cooling radiator.

For improvement of cooling of electronic cards, a 3 ton air conditioner has been provided in one loco at GZB shed at machine room blower outlet on experimental basis. Further extensive trials are planned in 03 WAG9 locos at AQ and 02 WAP7 locos at GZB. Another trial with Thermo Electric cooling Module (TECM) based on the principle of 'Peltier effect' has been tried in one Loco to lower the temperature rise around the cards. The trial has been successful and has shown a reduction of 6-8ºC in temperature rise. Further extensive trials are planned in 05 WAG9 locos at GMO.

RDSO has identified a paint 'ozo protect RW' which has helped in reducing the temperature rise by 8-9 degree Celsius during day time but increases the temperature...
rise by 6-8 degree Cesius during night time due to non-dissipation of heat through roof. However it has over all benefit of maintaining the temperature below 55 degree Celsius during hot sunny time and less than 50 degree Celsius at other times of the day. Another paint ‘OzoProtect KR’ having reflecting capability but very less thermal insulation properties has been applied in one loco at Ajni. However measurements during day time under Sun are yet to be done due to prolonged monsoon season

**Standardization of maintenance/fitment practices of Equalizer and Compensating Beam Pins and Cotters in WAG7 locomotives**

It was observed that different railways are following different practices on the maintenance/fitment of Equalizer and Compensating Beam Pins and Cotters in WAG7 locomotives. On analysis, it was observed that this practice was not only non uniform leading to different maintenance practices but also unsafe. Accordingly, a workshop was held at ELS/TKD in May, 2010 and after taking into account, the suggestions of different railways, Special Maintenance Instruction No .RDSO/2010/EL/SMI/0264 ‘Rev O’ has been issued to all the railways specifying uniform maintenance/fitment practices for the above items by the Railways.

**Issue of guidelines for use of AOH/IOH/POH kits and rehabilitation of tap changer on conventional electric locomotives**

Hitherto there was only one source for supply and maintenance of tap changer used on conventional electric locomotives. Maintenance kits for AOH/IOH/POH as well as rehabilitation of this tap changer after 18 years of service was being done on proprietary basis. With the development of additional source for this item, railways were facing difficulties in procurement of maintenance kits as well as its rehabilitation. A Committee consisting of SAG officers from RDSO, WR, & ER nominated by Railway Board studied the problem and recommended uniform guidelines for undertaking maintenance and rehabilitation of this item by Railways. On the approval of same by Railway Board, these guidelines have been issued to Railways.

**Publishing of Articles in International Journals**

Frequent failures of PCBs and their electric components on 3 phase electric locomotives are being reported by Railways. RDSO conducted detailed analysis of the failures and after a series of meetings with Zonal Railways, CLW as well as the manufacturers of these components, had evolved an action plan to reduce these failures. These failures have now started showing a reducing trend. In this regard, an article titled 'Getting to the Heart of Propulsion Failures' was written by S/Shri R.N. Lal, former Sr.EDSE and Sandeep Srivastava, DSE which has been published in the August, 2010 issue of Railway Gazette International of United Kingdom.

**Reliability of SIV Fitted Locomotives**

The performance of 180 KVA Static converters has improved considerably over past few years due to continual improvement endeavors of RDSO. During the initial years, failures were quite high. The FRPCPY of M/s. Autometer and M/s. Siemens was in the range of 502% and 103% with population of 40 & 25 units respectively in year 2002-03. Stringent monitoring of the performance of 180 KVA Static converter, failure analysis & regular interaction with user Railway and OEM has resulted in the improvement of performance of 180 KVA Static converters. FRPCPY of vendors viz. M/s Autometers & M/s Siemens has come down to 38 % and 17 % with population of 593 and 508 respectively during year 2010 -11. The implementation of identified modification action plan has paid good dividend in this regard. A series of meetings have been conducted with the Railways and different manufacturers and manufacture-wise modifications plan have been formulated, stage-3 modification have been completed in all units and stage-4 modification is under implementation. It is expected that with implementation of these identified modifications in the equipments of various makes, performance of 180kVA Static Converter will improve significantly in the next financial year.

**Development of Hall Effect Speed Sensors**

Due to poor output pulse and poor reliability of Weigand speed Sensors, problem of wheel slipping and poor adhesion is being encountered in field. Active hall effect speed sensors have been developed and were put on trial on WAG9 locomotive at ELS/GMO since Jan ’08. Field trial results were found to be encouraging, as the tractive effort fluctuation has significantly reduced from 30-40% to 5-10%.

Further, two rounds of trials of Doppler Radar in conjunction with Hall effect sensors were done at GMO during Oct/Nov 09 in association with CLW & M/s. ARC/Bangalore and the efficacy of the system was established. Modification in software/hardware has
been done by M/s. ARC to interface the same with hardware (Doppler radar based sensor) and the same provided on few locomotives for extensive field trials.  

**Development of Indigenous Sources for IGBT Based Propulsion System**

Indian Railway has decided to develop indigenous sources for IGBT based propulsion system with a view to phasing out the obsolete GTOs and develop in-house technology in the country, thereby generating competition among the vendors for improving the quality of the propulsion system at a competitive cost.  

RDSO has finalized the specification and design for the propulsion system for the three phase electric locomotives. The order for 30 loco sets have been placed on BHEL.  

**Action Plan to Address the Problem of Low MR Air Pressure in Duronto Trains**

Railways have been reporting problem of MR pressure drop on line ever since ‘Duranto’ train was introduced on Indian Railways while working with WAP1/WAP4 locomotives due to use of air springs and discharge toilets system in these trains.  

RDSO has carried out detailed study. It revealed that the duty cycle of compressors in WAP-4 locomotives while working ‘Duranto’ train is more than 90%. It is also observed that when the driver controls the train by application of brake for observing speed restrictions particularly while passing through ‘ghat’ section, the MR pressure drops up to 5.3 Kg/cm². In the conventional rake since control toilet discharge system and air springs are not available, therefore, this type of problem is not observed while working the train with WAP-4 locos.  

Enhanced air requirement of LHB rake can be met out either by increasing the capacity of existing compressors or by making provision of additional compressor.  

RDSO has conducted series of trials on locomotive and on the basis of successful field trials, RDSO has issued modification sheet for provision of additional on board compressor of 1000 lpm along with additional reservoir of 203 litre for WAP-4 locomotives having segregated pneumatic valves and also exploring the possibilities of providing higher capacity compressor in the existing envelop size of WAP-4 locomotives. Type testing of higher capacity compressor of 1750 LPM is under progress.  

**Development of Modified Design of Spring Catcher for Pantograph**

Railways have reported that spring catcher provided as per RDSO Modification Sheet No. RDSO/WAM4/155 issued in year 1986 is not effective as in case of breakage of spring near the anchored location, the contracted length of broken portion is short enough to evade the top spring catchers and it could come and fall on loco roof after springing back.  

RDSO have studied the above problem in detail and had interaction with the manufacturers of pantograph. RDSO has developed design of modified spring catcher and carried out its fitment trials at the works of manufacturers & at ELS/CNB. In the event of breakage of main raising spring, the modified catchers will not allow the broken spring to fly off and it will rest over existing horizontal spring catchers. These will element the line failure due to earth fault by the broken spring.  

RDSO has issued modification sheet No. RDSO/ELRS/EL/MS/0389 Rev. '0' dated 31.08.2010 for provision of modified spring catcher over yoke assembly of main raising spring of pantograph.  

**Maintenance of Traction motor support plate and Bogie nose to prevent crack/ breakage of Traction motor support plate (Holder for Traction motor suspension)**

Railways have reported crack/ breakage of TM support plate from lug hole portion in WAP-7/WAG-9 electric locomotives. On detailed study it was observed that the fillet radius which is R-8 as per the CLW drawing No. 1209-01-118-002 was very less in some of the TM supporting plates.  

The failure of TM support plate in fatigue manner was due to sharp edges at lug hole portion which had acted as notch for fatigue initiation. Development of crack and subsequent failure of TM mounting lug is due to stress concentration at the lug portion due to sudden change of profile. Accordingly a SPECIAL MAINTENANCE INSTRUCTION No. RDSO/2011/EL/ SMI/0269 (Rev. '0') Dated: 18.05.2011 has been issued to all the railways and CLW on the subject with following instructions:-  

- One round in situ DPT should be conducted on all TM support plates near lug portion and TM mounting bogie nose of all WAP-7/ WAG-9 locomotives. DPT should be conducted on TM support plate lug portion as well as TM bogie nose of WAP-7/WAG-9 during MOH/IOH/POH schedule.
A modified design of TM support plate to reduce stress concentration at lug portion is as below:-

The TM support plate should be procured with increased fillet radius (R-12) at lug portion. For this purpose CLW/CRJ should revise its drawing no. 1209-01-118-002 to increase fillet radius at lug portion from R-8 to R-12. The fillet radius should be measured in IOH/POH or any other opportunity. TM support plate should be replaced if fillet radius is found less than 8 mm.

As a precautionary measure 12 mm safety sling should be provided around the TM plate upper bolt and with bogie transom to prevent falling of Traction motor on track in case of breakage of TM supporting plate or TM bogie nose in WAG-9. The sling should be of 12 mm dia. 2300 mm long (For Traction motor no. 1, 2, 5 and 6) and 2700 mm long (For Traction motor no. 3 and 4) as per IS 2762:1982, 6x19 construction with steel core, double crimped at one end and fastened with 3 no. 'galvanised forged wire rope clip' 12 mm on other end.

The safety sling should be provided only on those WAG-9 locomotives where TM support plate fillet radius is less than 8 mm. After replacement of TM support plate with fillet radius 8 mm or 12 mm, safety slings need not to be provided.