DOCUMENT TITLE	**OPERATING & MAINTENANCE MANUAL**
PROJECT	**8 WHEELER DIESEL ELECRIC TOWER CAR WITH UNDERSLUNG TRANSMISSION**
CUSTOMER	**DIESEL LOCO MODERNISATION WORKS PATIALA**

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CG Power & Industrial Solutions Ltd.

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Doc. Ref. No.	CGPISL/DETC_US/MM/01	**Prepared**	B.S.RANA
Revision No.	00	**Checked**	L . K. TIWARI
Date	31ST JAN 2019	**Approved**	D. M. Nimje

PREFACE

This instruction book covers the operation & maintenance instructions for electric traction equipment supplied by Compton Greaves Ltd. to Integral Coach Factory, Chennai for DIESEL ELECTRIC TOWER CAR WITH UNDER SLUNG DUAL POWERPACK & AC/DC TRANSMISSION SYSTEM for Indian Railways.

The purpose of this instruction manual is to familiarise maintenance personnel with the procedures for operating and maintaining the electrical equipment.

This manual covers description of electrical circuits, general maintenance and data on control gear, electrical machines besides other general information. Instructions for auxiliary alternator, power rectifier are covered in separate manuals.

The instructions contain adequate details/information required for maintenance of equipment. Nevertheless, it is not practicable to cover all details and every contingency, which is likely to arise in service. Should any further information be desired or should particular problem arise, the matter should be referred to: CG POWER AND INDUSTRIAL SOLUTIONS LTD. Industrial Systems; D-5 Industrial Area, Mandideep, Bhopal - 462 046.

Continuous efforts on improvement in product design may result changes in details, which may not be covered in this manual. Although efforts are made to furnish all such changes to the user, it is advisable to consult CG for obtaining necessary assistance.

CG POWER AND INDUSTRIAL SOLUTIONS LTD.
TRACTION MACHINES & SYSTEM DIVISION,
D-5, INDUSTRIAL AREA, MANDIDEEP
BHOPAL - 462 046

CHAPTER I

INTRODUCTION

1.0 PERFORMANCE AND GENERAL DATA

2.0 LIST OF ABBREVIATIONS

CHAPTER I

INTRODUCTION

This manual covers operation & maintenance instructions of major power & control equipment used in Broad Gauge Diesel Electric Tower Car with Under slung transmission system (DETC/US). The equipment meets the requirements of ICF's spec. No. ICF/M/D/SPEC-300, for supply of complete electrics of DETC/US. The equipment includes Diesel Engine, Traction Alternator, power rectifier, traction motors, Auxiliary Alternator, motor switch group cubicle, all protective devices, and instruments for measurement & indication and auxiliary equipment.

DETC/US is a self-propelled unit used for periodic inspection, patrolling and maintenance of Over Head Electric Transmission Equipment of Electrified Routes. It is also used for attending sites of break down, restoration of damaged OHE equipment.

DETC facilitate the breakdown sites by restoring the damaged OHE. It is required to -

a) Reach the breakdown site in shortest possible time,
b) Attend & clear the Traction Over Head Equipment breakdown site,

This whole operation is to be accomplished in shortest possible time with least hindrance to regular rail traffic.

This is achieved by DETC, with following major facility -

i. To carry auxiliary equipment to facilitate OHE breakdown.
ii. Supervisors / attenders seating room and kitchen.
iii. Installed with high speed Dual Traction Power Pack & its controls.
iv. Driver desk & control cubicle on either side of the car.
v. Elevating Platform & Observation Dome.
vi. Pantograph for testing Over Head Cables.
vii. Room for OHE testing Equipment & Work shop.
viii. Tools & tackles to attend / clear the accident site

These power packs provide traction power to run the car unit (DETC) at high speeds up to 110 km/h. The under slung power pack free up the over board floor space for housing supervisory staff & to carry auxiliary equipment

Each power pack consists of following major components:

1. Under floor mounted:

- Diesel engine
- Traction Alternator
- Auxiliary Alternator
- Drive shaft for aux. alternator
- Exhaust Silencer for diesel engine
- Water Rising Apparatus for radiator

2. Equipments installed over board;

- Control cubicle.
- Driver's desk.
- 10 KVA capacity Diesel Alternator Unit.
- Air filters for diesel engine air intake.
- Hydraulic Oil Tank.

3. Over the roof

- Hydro Static Radiator Unit.
- Elevating platform
- Pantograph
- Observation dome

Above equipment with associated accessories are engineered to provide trouble free traction power with in built safety & protection equipment. The controls are developed to provide regulated traction power to match the demand from driver's console command while maintaining the safety checks all the time during traction.

All the healthy, operation & faults are brought to driver's console as indicating lamps for easy recognition of sequences happening in the traction system. A fixed time alarm (warning hooter) is also operated to alert the driver in case of any faulty / warning system activity.

Certain serious system faults not only indicate & warn the driver and also disable the traction power or shut down the diesel engine depending on the severity of the fault. Under such circumstances, there are certain "bypass safety" switches provided in the control cubicle. The use of these will enables the driver to run the traction system for short durations to clear the track for regular traffic.

The bypass safety function is not permitted to use on a regular basis or for longer periods. Use of bypass safety function for longer periods could lead to severe damage to the equipment or total failure of the affected unit connected equipment and severe injury or loss of life, because the bypass safety function disables systems automatic check function

User is strictly advised to familiarize about the complete equipment by use of this document provided for the purpose and follow the driving, operation & maintenance instructions.

The manual contains following information:

- System Description
- Equipment Description
- Circuit Description
- Fault Diagnostics
- Maintenance Instructions

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1.0 PERFORMANCE AND GENERAL DATA

GENERAL DESIGN FEATURES

1.	Track Gauge	:	1676 mm
2.	Minimum Radius of Curvature	:	175 m
3.	Maximum Super Elevation	:	185-mm
4.	Maximum Super Elevation Deficiency	:	100-mm
5.	Wheel Arrangement of Power Car	:	BO-BO(All axles independently Powered)
6.	Wheel Diameter	:	952mm (New), 914.5mm (Half Worn) 877mm (Fully Worn)
7.	AXLE Load	:	20 T (Approx.)
8.	Gear Ratio	:	20/91
9.	No. of power packs	:	Two
10.	Input To Traction	:	2 x 312 HP AT 37°C 2 x 298 HP AT 55°C
11.	Diesel Engine type	:	NTA-855R3 of Cummins
12.	Power Transmission	:	AC / DC Electric
13.	Traction Alternator	:	C1009A1 of CGL
14.	Traction Motor	:	TM2141C of CGL
15.	Auxiliary Alternator	:	8 kW, 122 VDC of KEL
16.	Maximum Operating Speed	:	110 km/h
17.	Clearance Above Rail Level	:	Minimum of 102mm with coaches fully loaded & wheels in fully worn condition.
18.	Reference Site	:	Ambient = 0 – 55° C Max. Temperature in sun 70° C Humidity = 40 to 100 % Altitude up to 1000 metres above MSL

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2.0 LIST OF ABBREVIATIONS

- AAPR1-2 - AUXILIARY ALTERNATOR PROVING RELAYS
- ASS - LOAD AMMETER SELECTION SWITCH
- COR - CUTOUT RELAY
- DCS - DRIVER'S CONTROL SWITCH BOX
- ECS - ENGINE CONTROL SWITCH
- ECR 1-2 - ENGINE CONTROL RELAYS
- ER 1-2 - GOVERNOR CONTROL RELAYS
- FC21-22 - ENGINE TRIP RELAYS
- FLIL - FLASHER LIGHT INDICATION LAMP
- FLS - FLASHER LIGHT SWITCH
- FOLS - FOG LIGHT SWITCH
- HL - HEADLIGHT SWITCH
- HLEM - HEADLIGHT EMERGENCY SWITCH
- HLS - HAND LAMP SOCKET
- IL1 - INSTRUMENT LAMPS
- LCC - LOAD & SPEED CONTROL SYSTEM
- LED - LED INDICATION PANEL
- LRR1-2 - LOCAL RESET RELAYS
- MC - MASTER CONTROLLER
- MLS - MARKER LIGHT SWITCH
- R11-12 - HIGH COOLING WATER TEMP MONITORING RELAYS
- R21-22 - LOW HYDRAULIC OIL LEVEL MONITORING RELAYS
- R41-42 - LOW LUBRICATING OIL PRESSURE MONITORING RELAYS
- R51-52 - ENGINE OVERSPEED MONITORING RELAYS
- R61-62 - LOW COOLING WATER LEVEL MONITORING RELAYS
- R81-82 - LOCAL ENGINE ON/OFF RELAYS
- R91-92 - REMOTE ENGINE ON/OFF RELAYS
- RCFR1-2 - RECTIFIER COOLING FAILURE RELAY
- REG - DC/DC CONVERTER
- RR1-2 - READY TO START RELAYS
- S11-S12 - ENGINE ON RELAYS

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- SLS - SEARCH LIGHT SWITCH
- SR1-2 - SAFETY RELAYS
- TLS - TAIL LIGHT SWITCH
- GFR - GROUND FAULT RELAY
- GRCO - GROUND RELAY CUT-OUT SWITCH
- MCS1-2 - MOTOR CUT-OUT SWITCHES
- BIS 110V - BATTERY ISOLATING SWITCH 110VDC
- BIS 24V - BATTERY ISOLATING SWITCH 24VDC
- RCD1-3 - REVERSE CURRENT DIODES
- AFP1-3 - AUXILIARY FUSE PANELS
- EG - EQUIPMENT GOVERNOR BYPASS SWITCH
- BPCG - BRAKE PRESSURE CONTROL GOVERNOR BYPASS SWITCH
- PBG - PARKING BRAKE GOVERNOR BYPASS SWITCH
- AFR1-2 - AIR FLOW RELAYS BYPASS SWITCHES
- FLS1-CAB - FLUORESCENT LAMP SWITCH-1 CAB
- FLS2-CAB - FLUORESCENT LAMP SWITCH-2 CAB
- CLS - CENTRE LIGHT SWITCH
- FS1-CAB - FAN-1 SWITCH CAB
- FS2-CAB - FAN-2 SWITCH CAB
- VS1 - VOLTMETER (0-150VDC) SWITCH
- VS2 - VOLTMETER (0-50VDC) SWITCH
- S2-3 - BATTERY CHARGING LAMP SWITCH
- LRS1-2 - ENGINE LOCAL/REMOTE OPERATION SELECTION SWITCHES
- LOP1-2 - ENGINE LUBRICATING OIL PRESSURE GAUGES
- LOT1-2 - ENGINE LUBRICATING TEMPERATURE GAUGES
- WT1-2 - ENGINE WATER TEMPERATURE GAUGES
- RPM1-2 - ENGINE SPEED METERS
- BCA1-2 - BATTERY CHARGING INDICATION AMMETERS
- HM1-2 - HOUR METERS FOR ENGINES
- BIL1-2 - BATTERY CHARGING INDICATION LAMP
- TR11,21 - DIESEL ENGINE CRANKING SAFETY TIMERS
- TR12,22 - LUBRICATING OIL PRESSURE SWITCH BYPASS TIMERS
- BD1-2 - BLOCKING DIODES

- WLI1-2 - WATER LEVEL INDICATION GAUGES
- HOLI1-2 - HYDRAULIC OIL LEVEL INDICATION GAUGES

MCBs

110 VDC

- GOV-1 SPLY - GOVERNOR – 1 SUPPLY MCB 15A
- GOV-2 SPLY - GOVERNOR – 2 SUPPLY MCB 15A
- GOV-1 CTRL - GOVERNOR – 1 CONTROL MCB 5A
- GOV-2 CTRL - GOVERNOR – 2 CONTROL MCB 5A
- AAPR1 - AUX ALTERNATOR-1 PROVING RELAY MCB 5A
- AAPR2 - AUX ALTERNATOR-2 PROVING RELAY MCB 5A
- BM1 - BLOWER MOTOR-1 MCB 30A
- BM2 - BLOWER MOTOR-2 MCB 30A
- HL - HEADLIGHT MCB 10A
- L+ - LIGHTS MCB 10A
- EM+ - EMERGENCY LIGHTS MCB 10A
- VM1 - VOLTMETER (0-150VDC) 5A
- ML - MARKER LIGHT MCB 5A
- TL&FL - TAIL LIGHT & FLASHER LIGHT MCB 5A
- FL CAB - FLUORESCENT LAMP CABIN MCB 5A
- FL&CL CAB - FLUORESCENT LAMP & CENTRE LIGHT CAB MCB 5A
- FAN-1 CAB - FAN-1 CAB MCB 5A
- FAN-2 CAB - FAN-2 CAB MCB 5A
- SYS CTRL - SYSTEM CONTROL MCB 30A
- CTRL - CONTROL MCB 15A
- EXC CTRL - EXCITATION CONTROL MCB 10A
- ENG CTRL - ENGINE CNTROL MCB 5A
- COMP UL - COMPRESSOR UNLOADER MCB 5A
- LAMP TEST - LED INDICATIONS LAMP TEST MCB 5A
- ALT. EXC - ALTERNATOR EXCITATION MCB 5A
- RTS - READY TO START MCB 5A
- FAULT IND - FAULT INDICATION MCB 5A
- PB - PARKING BRAKE MCB 5A

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24 VDC

- ENG-1 PROT - ENGINE –1 PROTECTION MCB 15A
- ENG-1 SAF-1 - ENGINE-1 SAFETY-1 MCB 5A
- ENG-1 SAF-2 - ENGINE-1 SAFETY-2 MCB 5A
- GOV-1 SPLY - GOVERNOR-1 SUPPLY MCB 5A
- ENG-1 GAUGE- ENGINE-1 GAUGE MCB 5A
- ENG-2 PROT - ENGINE –2 PROTECTION MCB 15A
- ENG-2 SAF-1 - ENGINE-2 SAFETY-1 MCB 5A
- ENG-2 SAF-2 - ENGINE-2 SAFETY-2 MCB 5A
- GOV-2 SPLY - GOVERNOR-2 SUPPLY MCB 5A
- ENG-2 GAUGE- ENGINE-2 GAUGE MCB 5A
- SL - SEARCH LIGHT MCB 5A
- FOL - FOG LIGHT MCB 5A
- VM2 - VOLTMETER (0-50VDC) MCB 5A

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NOTES

CHAPTER II

POWER PACK ARRANGEMENT

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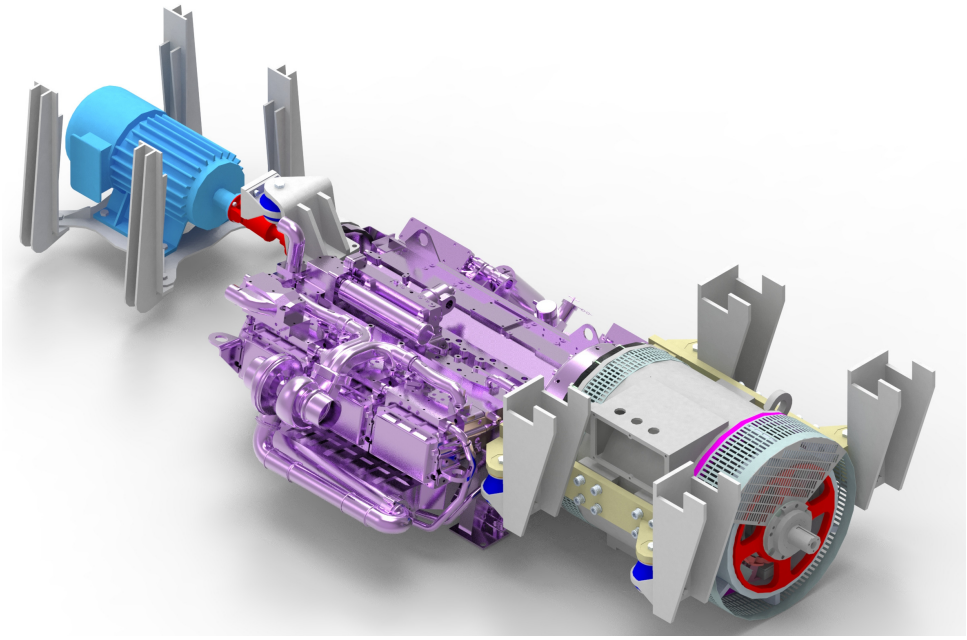
POWER PACK ARRANGEMENT

1. Introduction

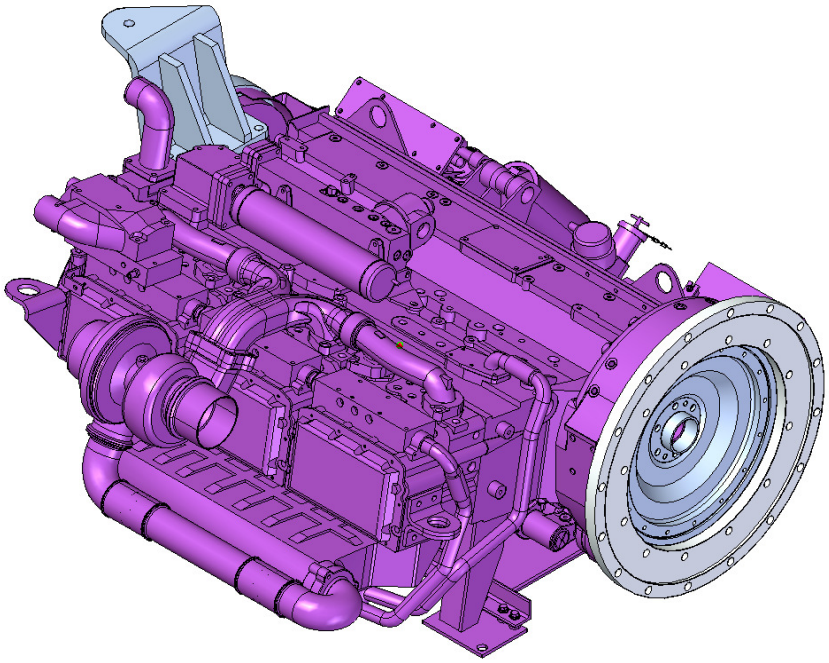
The **Diesel Electric Tower Car (DETC)** is equipped with two set of under slung mounted Power packs. Each Power pack consists of one under slung Engine (NTA-855 R), one Traction Alternator – 230 kW (C1009A1) & one auxiliary alternator connected by a cardan shaft and flexible coupling. The car consists of two bogies (4 axles), each axle is powered by the traction motor. The engine flywheel is directly coupled with Traction alternator with the help of flex plates. These flex plate couplings are used to compensate Axial, Angular and radial displacement of connected machines. Flex plates are provided to absorb shocks on torque, by which it will minimize vibration, and transmits the power. The output power of alternator is rectified to DC & fed to the traction motors.

These two Power pack units are synchronized & regulated to provide total traction power as a single system when controlled from either cabin. Two cabins one on each end is provided for the purpose. Provision also exists to isolate any of the power packs and run the vehicle. Driver's desk mainly consists of controls for Engine, Alternator and Pneumatic Brakes, Indication lamps, Gauges, switches, speed-time-distance recorder etc., which will be functioning in conjunction with control cubicles. The complete power pack is attached beneath the under frame.



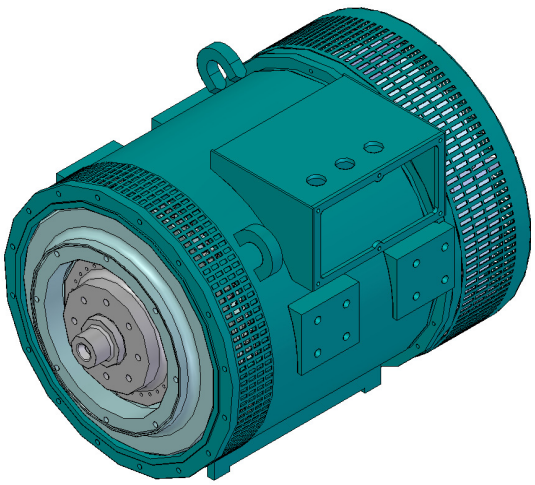
2. Major components of power pack

2.1 Engine



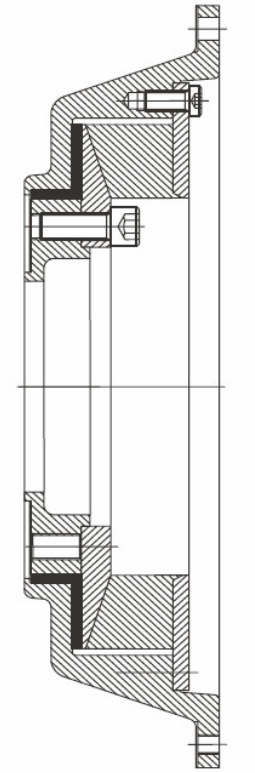
The model of the engine used in the equipment is NTA - 855R manufactured by M/s CIL, Pune. It is a horizontal version engine suitable for under slung mounting. The specification of the engine is provided in the specification section. This engine is supported at three points, viz, one support at front end (vibration damper side) and two supports at rear end (Flywheel side). All the three supports are bracket mounted with Anti vibration units.

2.2 Traction Alternator



The alternator used in the car is C1009A1, manufactured by M/s CG, Bhopal. This alternator caters to supply electrical power for main Traction. It is under slung mounted with suitable brackets and is driven from engine directly through the flex plates. The specification of the alternator is provided in the specification section. This alternator is supported on four points. All the four supports are bracket mounted, consisting of two Main Brackets which positively holds both the coupled engine and alternator together. These brackets rest on four Anti vibration units. The AVM's are pre-compressed in the assembly position. The mounting fasteners for these AVM are torque tightened and locked with split pin.

2.3 Flexible Coupling

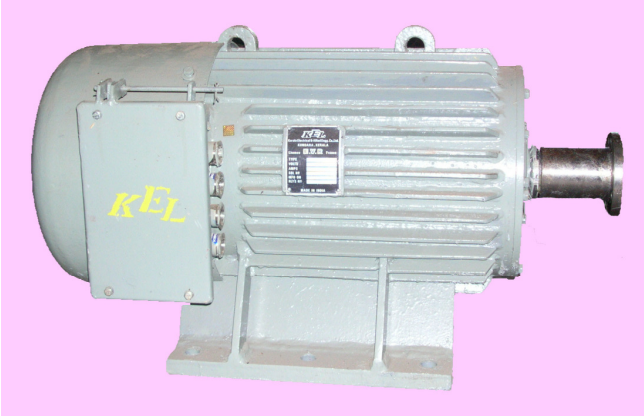


In this power pack, the flexible coupling is used to connect the engine to auxiliary alternator through a XLO cardan shaft. This coupling is manufactured by M/s.Vulkan. This coupling is selected to suit maximum torque & speed of Auxiliary Alternator. These highly flexible couplings are guided radially & axially. All the transmitting parts are arranged without clearance so that no wear will occur during the rotation. The rubber element is suitable for temperature between -40°C & +90°C & is internally vulcanized to the ring. The permissible angular coupling displacement is 0.5°.

2.4 Auxiliary Alternator

Two 8 KW, 110V DC. Brush less, foot mounted Auxiliary Alternator is provided in the DETC, one each for power pack. These alternators caters to supply electrical power for Battery charging & Control source

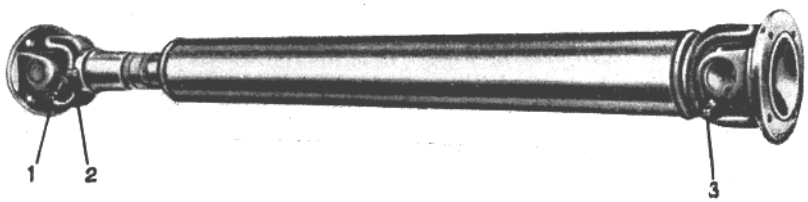
Supply, coach lights, fans, cab & head lights, tail lights, flasher lights etc. It is under slung mounted with suitable brackets and is driven from engine vibration damper through a cardan shaft.



A static regulator cum rectifier unit rectifies the three-phase AC alternator output. A constant voltage of 122 Volts DC (65% regulates DC output at a maximum load current of 65 Amps @ idle engine speed of 700 rpm) is utilized.

2.5 Cardan Shaft

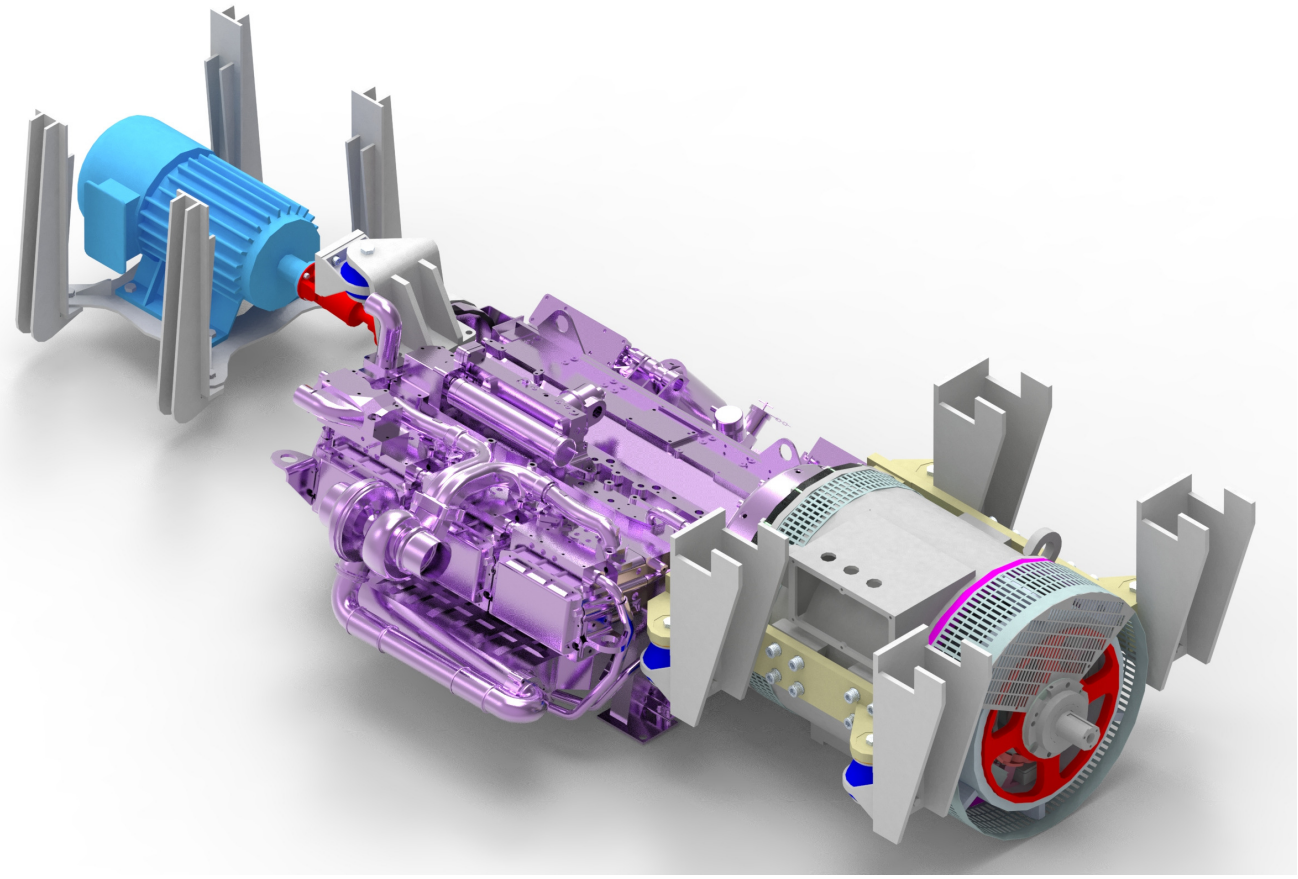
Cardan shaft is used to connect the flexible coupling mounted over the diesel engine to the coupling flange mounted over the auxiliary alternator.



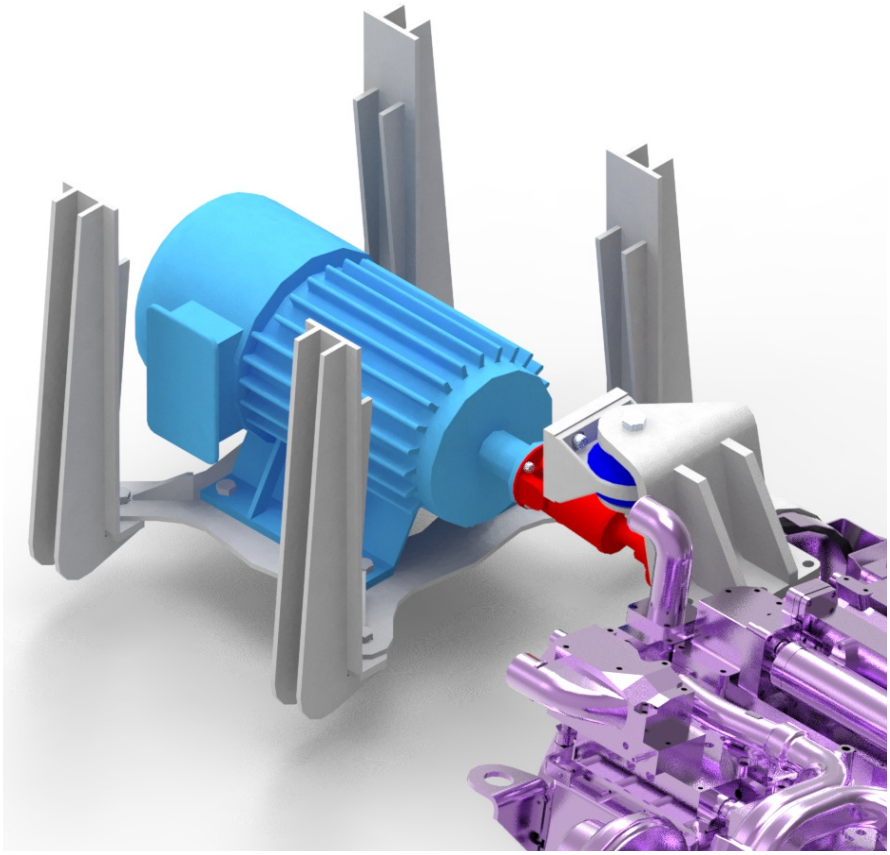
Maintenance and service related procedure for cardan shaft is explained in detail in Annexure 1 of this document.

3. Power Pack Mounting

The Engine and Alternator (with the flex plates) are coupled together and positively held by two main brackets at three points on either side of engine & alternator. Along with this, the auxiliary alternator end of the Engine is held by a 'Z' Bracket. This whole power pack assembly has five suspending points, which rests over anti vibration mountings, held rigidly by vertical brackets welded to under frame structural members. This arrangement has low vibration transmissibility to the under frame. For details of mounting, refer power pack drawing.

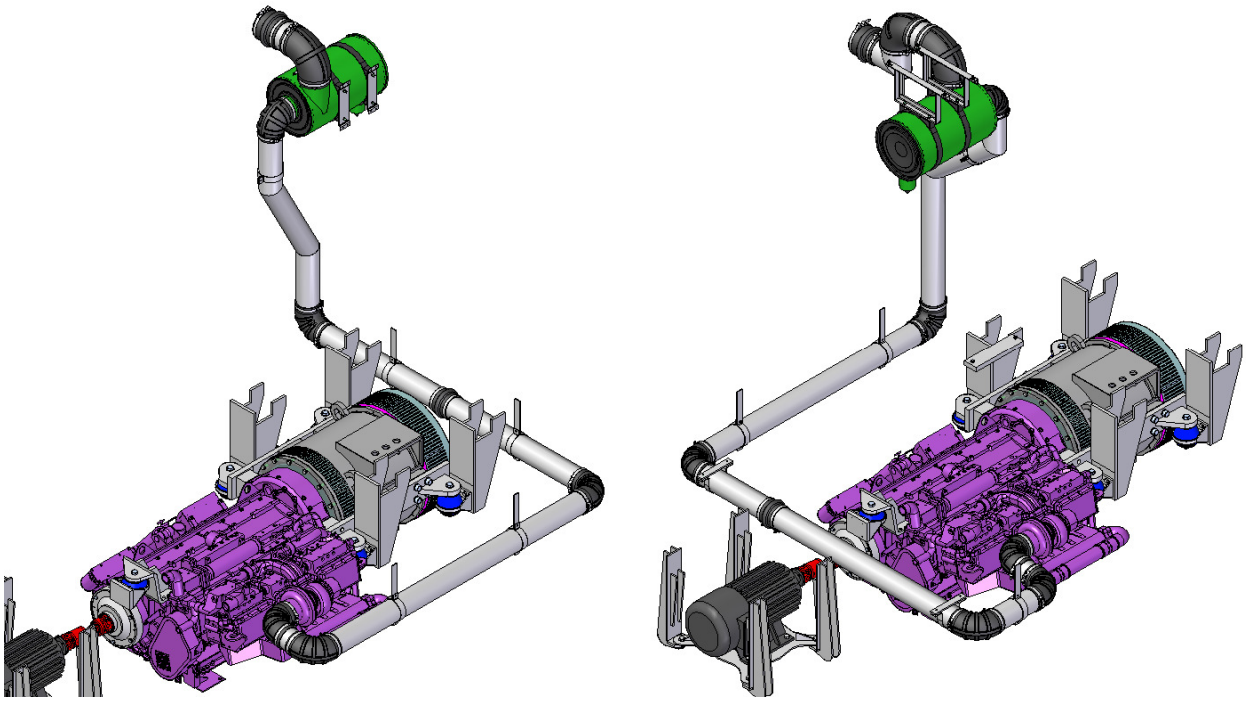


The auxiliary alternator is then mounted over a bracket held by four vertical brackets, which are fabricated from the under frame structure. The Aux. alternator is driven by an XLO cardan shaft through a flexible coupling. For more details refer power pack arrangement drawing.



4. AIR INTAKE ARRANGEMENT

Air cleaners are positioned inside the coach as shown in the Drawing No. 45831110. Air cleaner sucks the fresh air from atmosphere through a conical arrangement mounted on coach side wall, outlet pipe is routed below the floor to the engine air inlet point. Suitable clamping is done to support the pipes at required places. Below picture shows the air intake routing for either side of the power packs.



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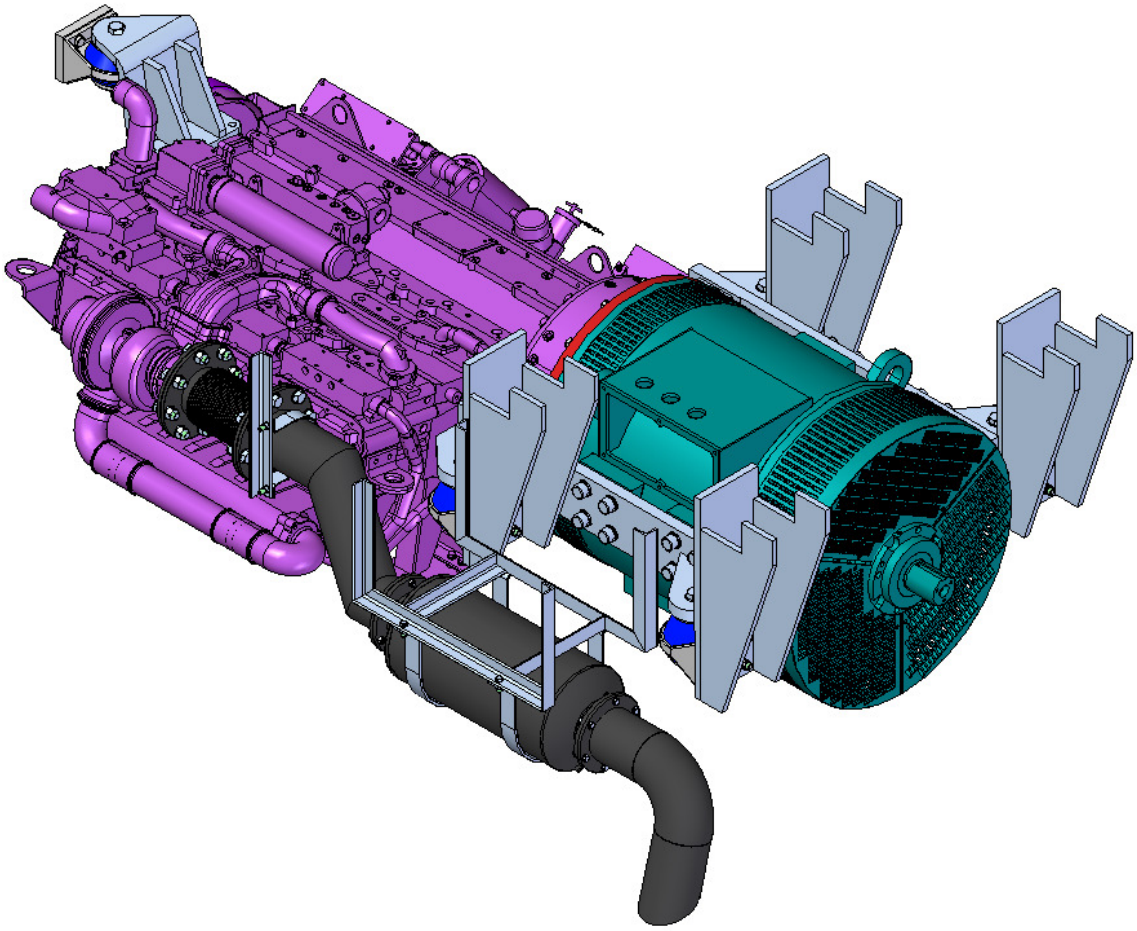
5. EXHAUST SILENCER ARRANGEMENT

Exhaust silencer is mounted under slung and exhaust smoke will be let to atmosphere through the muffler from the engine outlet. Thermal Insulation for the pipes provided with cladding the appropriate material from Q-shield to avoid exposure to hazardous hot surfaces at the time of maintenance.



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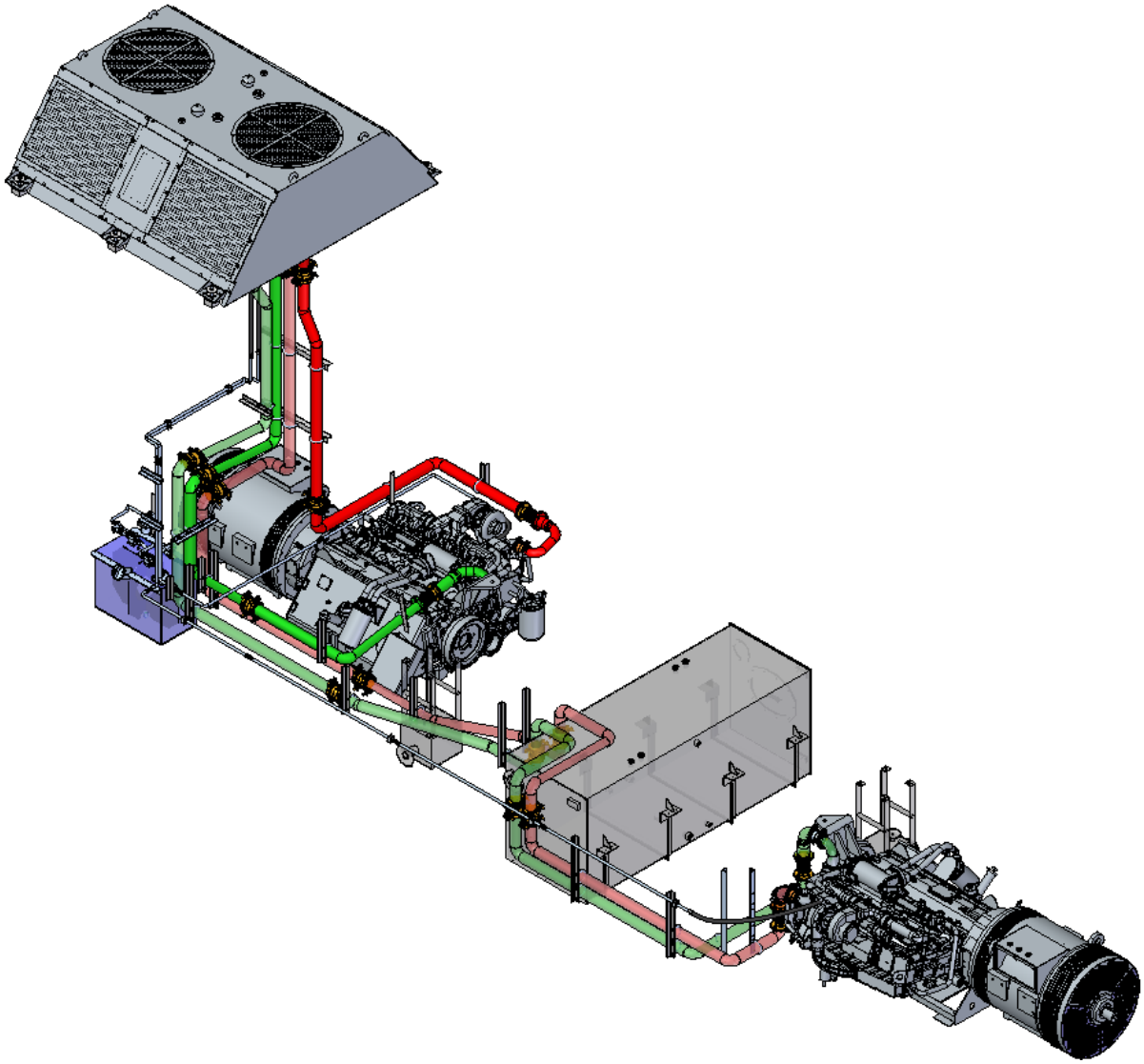
6. RADIATOR MOUNTING & PIPING ARRANGEMENT

Radiator unit is mounted on roof of the coach. A single radiator unit is provided for both the engines. This radiator unit is mounted on AVM to damp vibrations. The sucker type fan is used in the system; it sucks the air through the radiator core and blows to the atmosphere to cool the water circulating inside core. The fans are driven by hydro static motors.

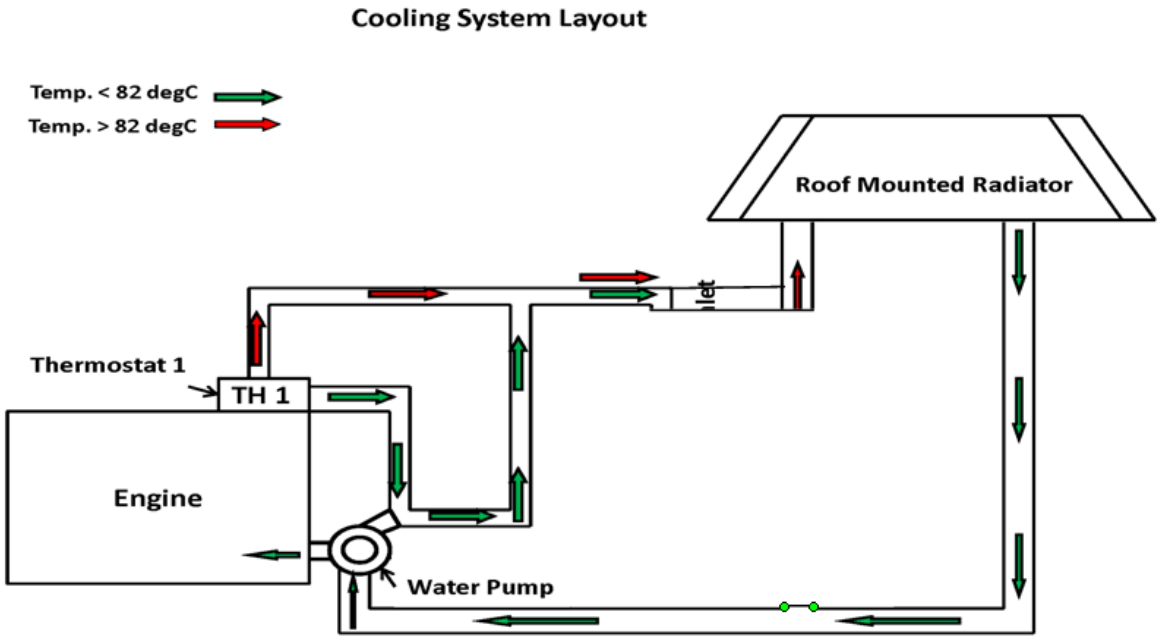
Pipe routings from both the engine passes beneath the under frame at intricate conditions, passing through the floor (suitable cutouts are provided) and connects the radiator.



The radiator unit has following pipe connections:

1. Inlet
2. Outlet
3. Vent
4. Over flow
5. By pass line

The hot water that is pumped out from the engine is connected to inlet port of radiator. The hot water enters from the top most point of the core. Hot water flows through the core, gets cooled and comes out through outlet pipe at bottom most point of the core. This outlet pipe from radiator unit is connected to water inlet port of Engine and cools the engine, water jackets after cooler, compressor and exhaust manifold while circulating inside the engine. Water is pumped to the Thermostat housing on the engine; this senses the water temperature in the system and controls the water flow to the radiator.

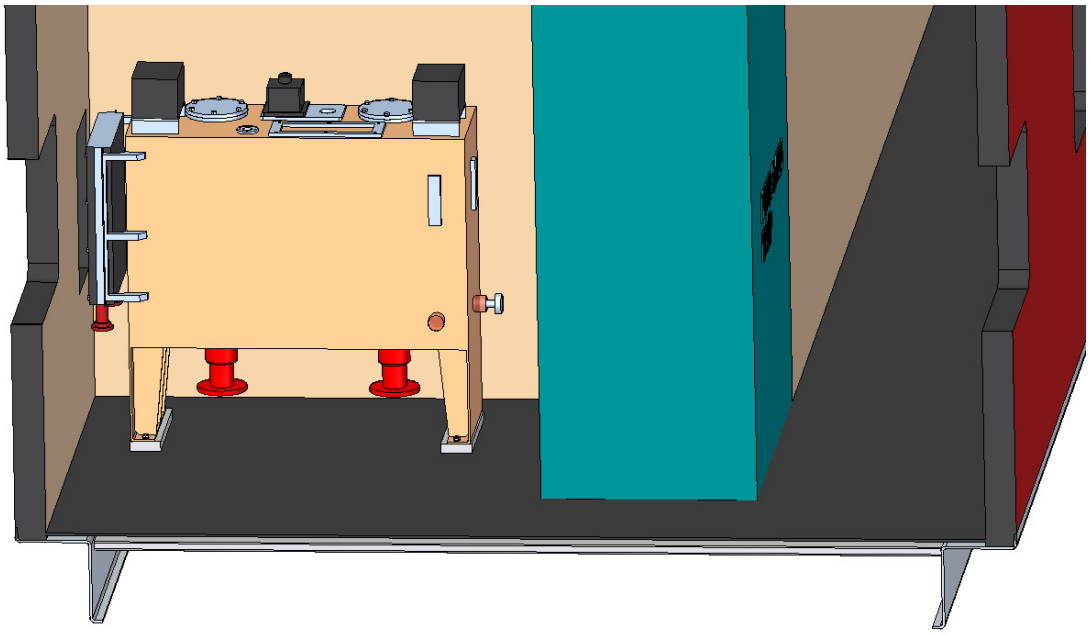


7. HYDRAULIC TANK AND HYDRAULIC CIRCUIT

A single common hydraulic tank is provided for both engine's Cooling system, it is located inside the coach. This tank is equipped with filling cap, sight glass, manifold blocks, oil cooler, return filter ect., on it.

The system has radiator fans driven at variable speeds depending upon the radiator water temperature. It is a Hydrostatic system in which two fans are driven by independent hydraulic motors from variable flow delivered by a respective engine driven hydraulic pump. Independent Thermatic valves are mounted on the water manifold block at the each engine water outlet, where the hot water exits for onward routing to the radiator.

The Thermatic valve senses the temperature and regulates pressure on the pump's flow control port. This action affects the hydraulic pump's output flow rate according to the water temperature. It increases with increase in water temperature. The variable flow connected to motor regulates the variable speed of motor according to the water temperature. Thus, the entire hydrostatic fan drive system forms a closed loop control system.



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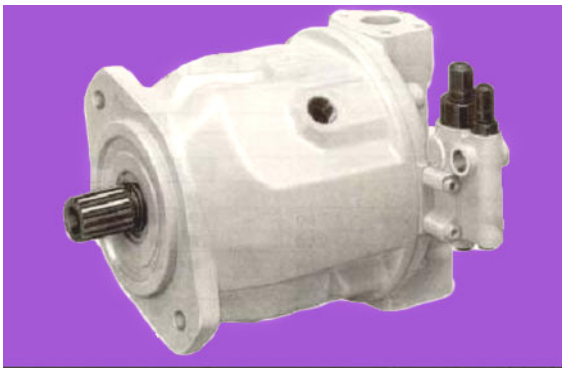
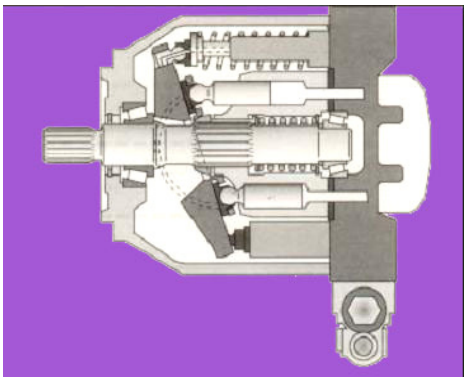
7.1 Hydraulic pump

A variable displacement pump is mounted on the engine and it is directly driven by engine gear drive from gear case cover. This hydraulic pump has swash-plate design.





Flow of hydraulic oil is proportional to drive speed required. Fluid Displacement is infinitely variable by adjustment of swash-plate angle. By adjusting the position of swash-plate, it is possible to smoothly vary the flow. It has a pilot control valve, which controls the position of swash-plate, which in turn regulates delivery of fluid flow of the pump after receiving feedback from remote position. Thermatic valve forms the remote sensing & feedback element for the control.

7.1.1 Working of Variable displacement pump:

1. Hydraulic pump has multiple cylinders whose movements are obtained from rotation of drive shaft.
2. Cylinders suck & deliver liquid by their reciprocating motion proportional to stroke length (displacement) of the cylinders.
3. These strokes are directly controlled by inclination of the swash plate whose position is governed by Pilot control valve
4. Pilot control valve receives feed back from remote control (Thermatic valve).
5. Remote control valve is also called as Thermal Relief / Thermatic control valve (as its feedback is translated on the basis of rise in engine coolant temperature).
6. Hydraulic pump has a leakage return line back to hydraulic tank.

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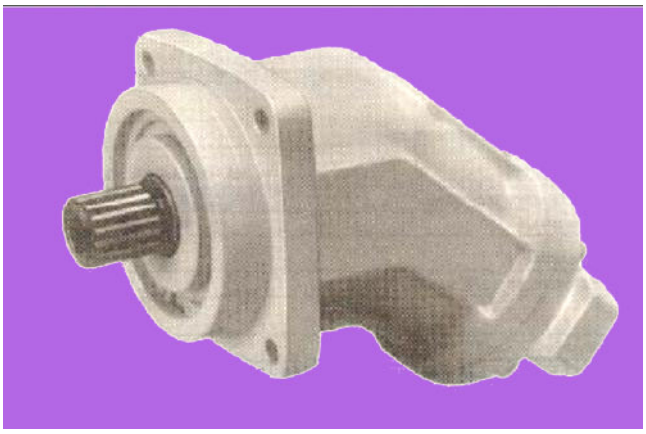
7.2 Hydraulic motor



The Hydraulic motor is used in this system is of bent axis design with fixed displacement of cylinders. The pressurized oil, which is pumped from hydraulic pump, routed as inlet to the motor & develops the torque and speed of motor. Hydraulic motor rotational speed is directly proportional to flow of the pump; and pressure of the liquid is directly proportional to the torque developed by the shaft. Hydraulic motor also has a return line flowing freely back to tank. Supply & return lines to the motor are routed through a manifold block.

7.3 Pressure relief valve

Pressure relief valve is always connected in main delivery line of hydraulic pump (pressure line) to limit the system pressure to set value.

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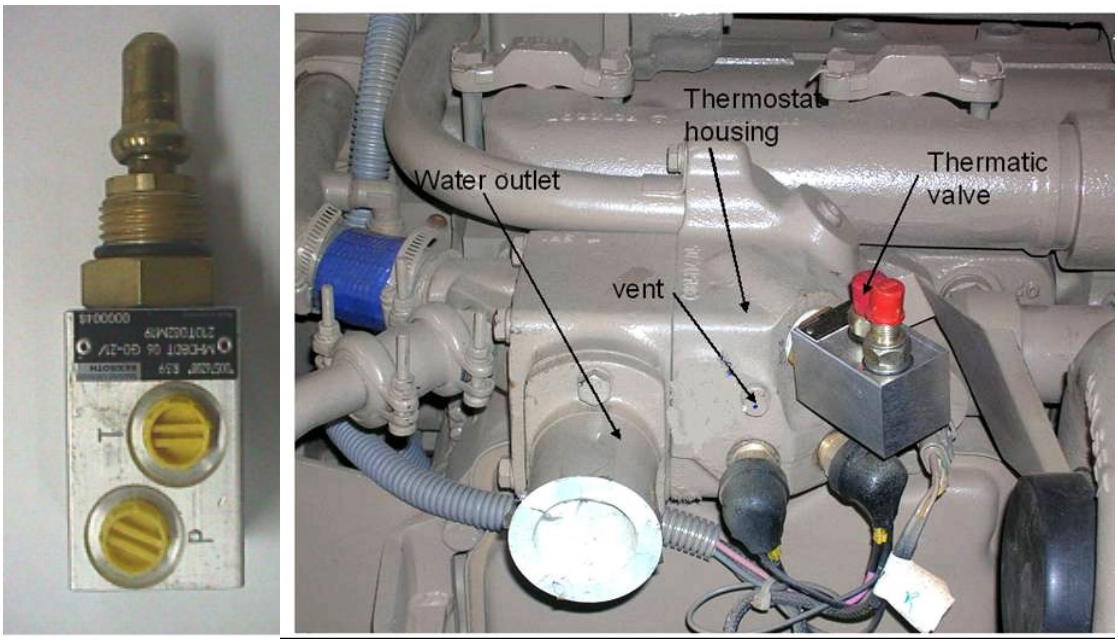
7.3.1 Operation of Pressure Relief Valve:

1. System pressure acts on the main spool.
2. At the same time pressure acts via a pilot line fitted with jets, on pilot poppet.
3. If the system pressure exceeds the value set with the spring, the pilot poppet opens and pilot oil is allowed to flow back to the tank.
4. The jet combination causes sufficient pressure drop across the main spool.
5. The main spool is lifted from its seat and opens the pressure line connection to tank while operating pressure is maintained, as desired.
6. The spring tension on poppet valve can be adjusted by setting knob to any desired pressure, from 0-250 bar (set pressure around 160 to 180 bar).
7. The pilot control port should be connected to receive flow for pilot poppet valve.

7.4 Thermal Relief / Thermatic Valve:



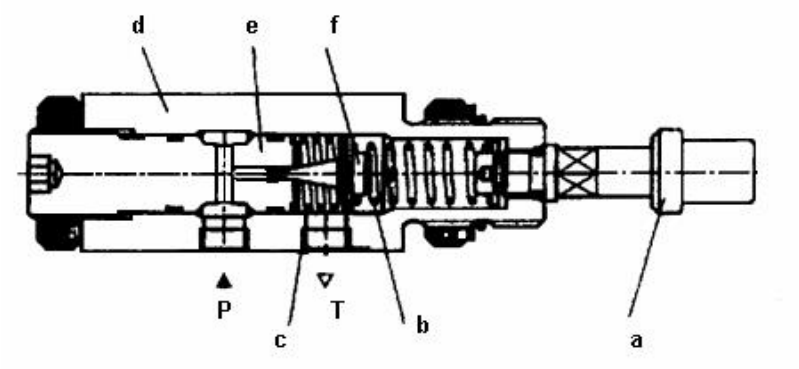
Thermatic valve is a direct operated relief valve of poppet-seat design, where the nominal pressure is proportional to the temperature sensing with in set limits. It is mounted on engine's water outlet connection. It senses the temperature of engine water outlet and functions.

Main elements of Thermatic valve are:

1. Thermal Element
2. Control Spring
3. Reset Spring
4. Valve Housing
5. Valve Seat
6. Poppet

P. Pressure port

T. Tank return port



7.4.1 Operation of Thermatic Valve:

1. When Engine outlet water temperature is below 82°C, hydraulic oil from hydraulic pump pilot valve freely passes through the pressure port 'P' of valve assembly to tank through Tank return port 'T'.
2. When temperature rises above 82°C, thermal element 'a' expands and starts moving its plunger against control spring 'b'.
3. This moves poppet ' f ' towards valve seat 'e' and creates restriction to incoming flow and generates backpressure.
4. This backpressure is treated as feedback by pilot control valve, which now starts controlling inclination of swash plate for more delivery coming out of hydraulic pump.
5. When the temperature drops below 82°C at the thermal element 'a', control spring 'b' is released and reset spring 'c' allows pressurized hydraulic oil to drain to tank.

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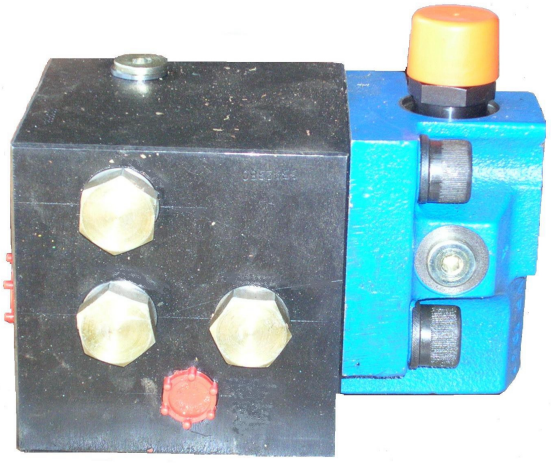
7.5 Manifold block

Manifold block is used primarily for two purposes

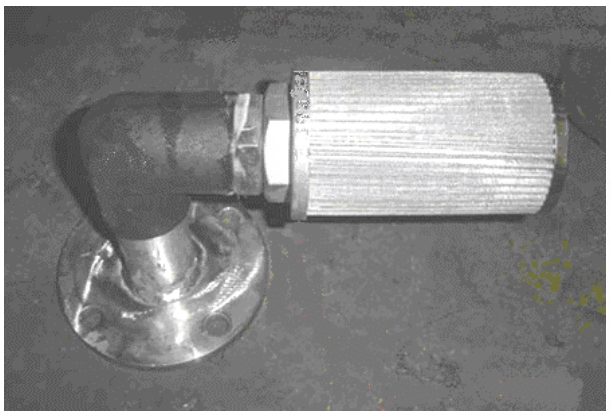
1. Simplify hydraulic circuit.
2. Reduce number of components in the system.

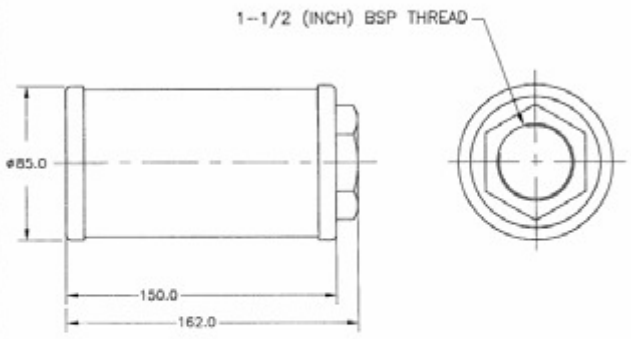


Manifold block is a solid block of steel which houses a several non-return valves (check valves), Pressure relief valves connected to achieve function by internal passages of the block. It facilitates hose connections to various points in the system.

All of them contain cartridge type check valves. Care to be taken for cleanliness of oil because a small dirt or foreign material entrapped in their seating area renders these valves non-functioning.

7.6 Suction Strainer





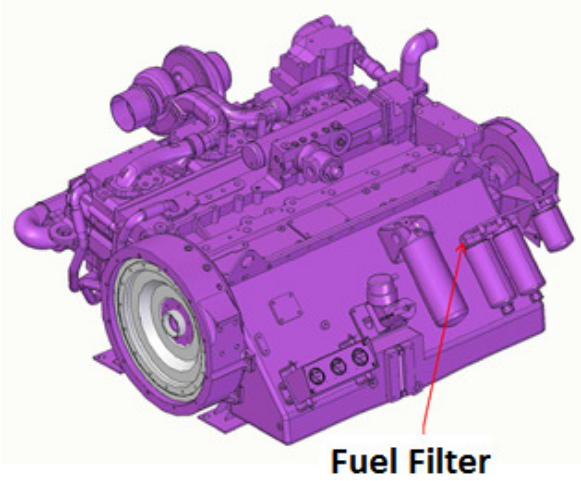
1. Separate Strainers are fitted inside the hydraulic tank one each in the suction line and vent line of pump.
2. Precautions be taken to avoid ingress of dirt particles in the hydraulic tank during initial filling or scheduled maintenance of the hydraulic system.
3. Suction strainer can remove particles up to 150 microns.
4. The strainer protects pump from the entry of harmful solid particles.

7.7 Return line filter

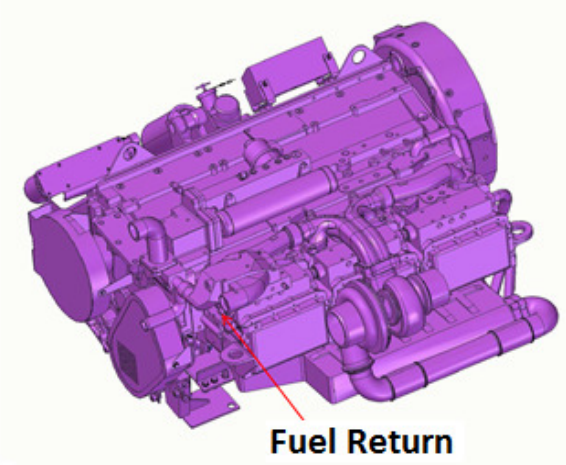
1. Return Line filter is mounted directly on hydraulic tank.
2. It cleans hydraulic oil that may get contaminated due to poor handling or undesirable entry of dust in the system or wear and tear of system components.
3. Return Line filter can filter particles up to 10 microns.
4. There is a container around the filter for the purpose of trapping dirt. When element is removed, this container is drawn out with it, so that any residual dirt is not allowed to flow back into the tank.
5. These filters are fitted with restriction indicator on the top of its head which pops up showing red signal whenever pressure drop across filter element is above 2.5 bar.

8.0 FUEL LINE PIPING ARRANGEMENT

A common under slung fuel tank is provided to cater both the power pack of main traction. Each power pack draws fuel from the fuel tank through an independent piping system. Each line consists of a shut off valve to isolate the supply whenever required for any maintenance. Suspended particles in the fuel settles at the bottom of the tank due to gravity. From shut off valve further piping is done via a strainer, water separator, fuel filter and finally to fuel actuator on the engine. These connections are equipped with flexible hoses. Fuel filter will filter any foreign particles, waste etc. & thus obtained clean fuel is routed by a hose to Fuel pump mounted on the engine.



Excess fuel expelled by the engine is returned back to the fuel tank connected by a hose and metal pipes direct to the common under slung fuel tank. (Fuel return point is positioned at bottom of engine).



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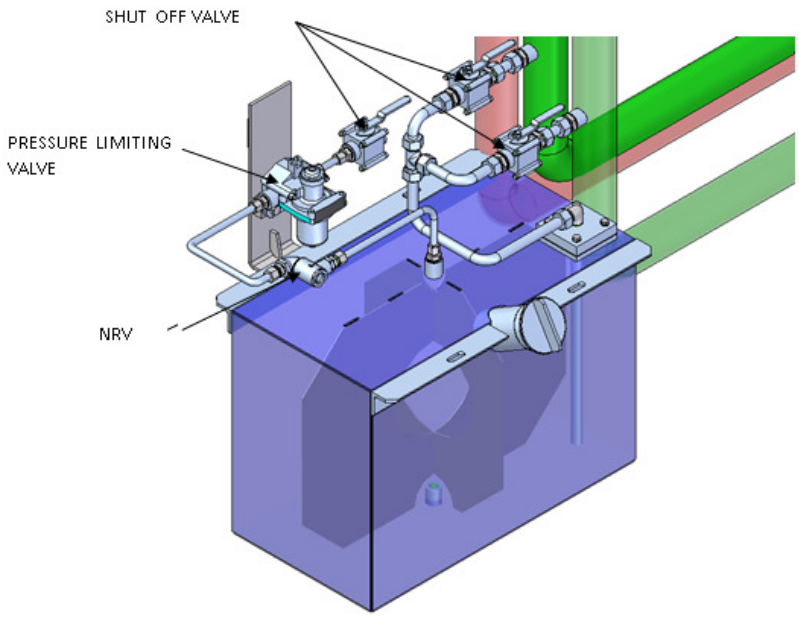
9. WATER RISING APPARATUS

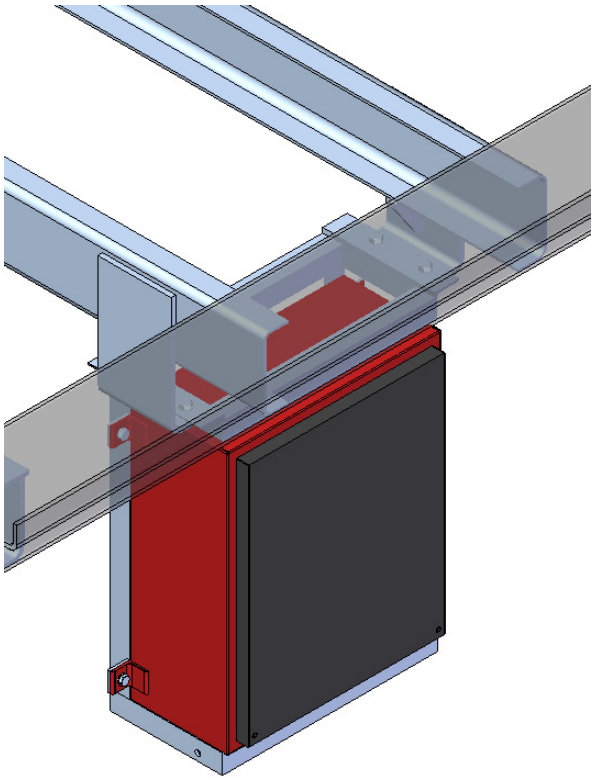
Engine block, radiator unit and connecting piping system needs to be filled with coolant prior to starting the power pack and also may require periodical topping up. The Radiator unit is mounted over the coach roof. Climbing over the roof for periodical topping up of the radiator with coolant is a laborious, time consuming and also poses high voltage power line hazard. A pneumatically operated water rising apparatus (WRA) is mounted under slung to ease out the filling / topping up of coolant. A stainless steel tank comprising a coolant capacity of 100 liters provided.

A pneumatic line with a limiting valve set at 0.5 to 0.8 kg/cm², a non return valve & insolating valve is provided before connecting to tank. When the radiator cooling system required to topping up, the existing pneumatic system's pressured air is allowed inside the tank and in turn this will pressurizes the water to get out of the tank, feeding the cold water line of the radiator through an independent isolating cock and thus tops up the radiator. There are two independent isolating valves are provided in the water lines, these are required to select or open depends on the required engine cooling system to be topped up. The check valve provided in the pneumatic line prevents the reverse entry of coolant water into the pneumatic line. During each top up the shut off valve provided in pneumatic line to be opened first & further isolating valve provided in water like to be opened depends on the required engine to be topped up. **After completing the process both isolating valves to be closed compulsorily**.



10. PANEL RESISTOR BOX MOUNTING ARRANGEMENT

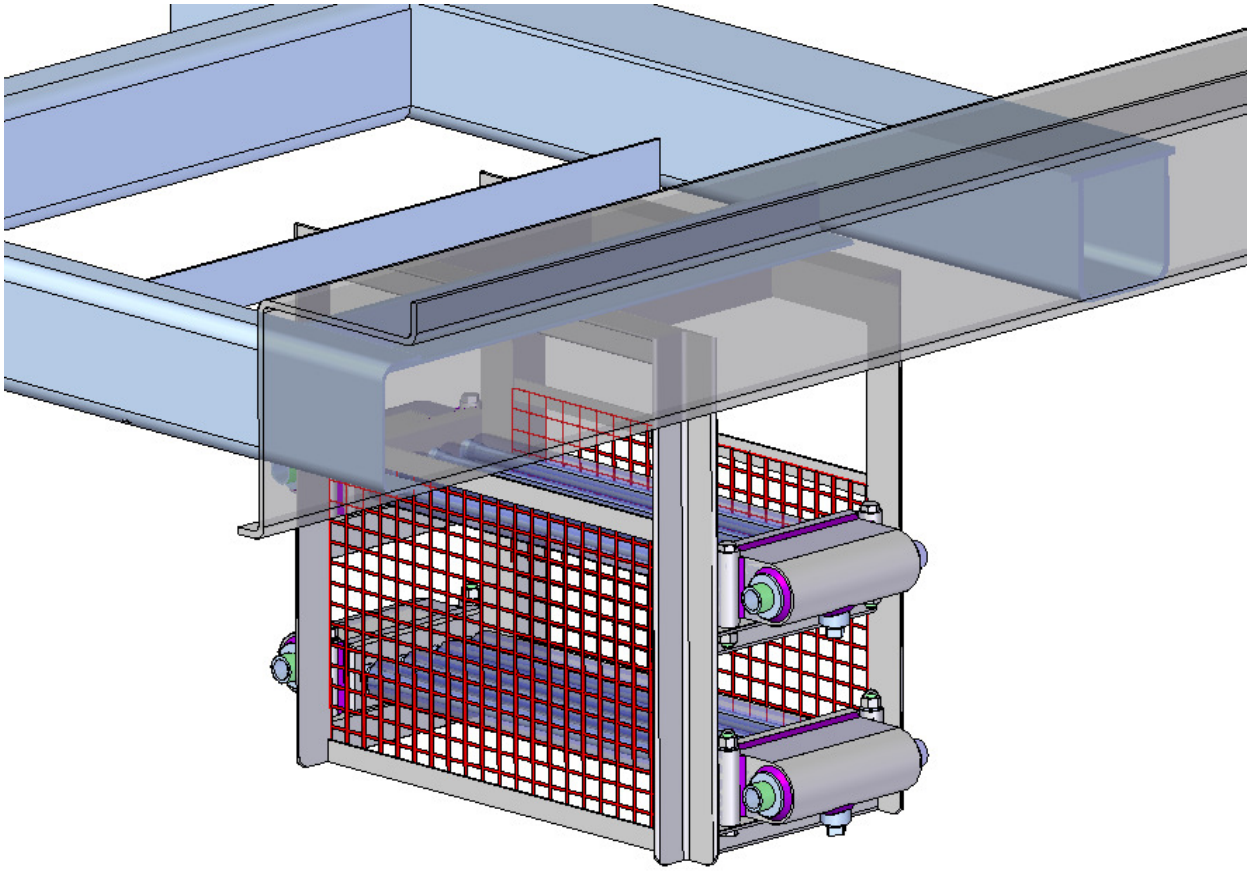
One number of panel resister box houses 6 resistors in a box. This box mounted under slung, supports are taken from the under frame structure as shown in the figure.



The box housed excitation resistor panels for both the alternators. One set of panel consists of 3 resistors each of 36 Ohms, 300 W. Theses 3 resistors are connected in parallel making the equivalent resistance of the circuit 12 ohms.

11. AFTER COOLER MOUNTING ARRANGEMENT

Two numbers of after coolers, Universal make are mounted under slung, supports are taken from the under frame structure as shown in the figure. These after cooler is connected in output of air compressor outlet.



12. MAINTENANCE SCHEDULE FOR DETC POWERPACK

Sl. No.	Parts	Period	Diesel Engine running / stopped	Maintenance Step	Remarks
1.	General Examination	Daily	Stopped	• Check visually all equipment for visible defects, loose bolt & nuts, leakages, missing parts etc. • Check lube oils, fuel, cooling water and air system for leakage and rectify if necessary. • Clean all equipment with lintel cloth. • Clean the vehicle thoroughly with a jet of water and scrub down all dirt and wash again.	Correct if any defects Waste jute should never be used.
2.	Diesel Engine	Daily	Stopped	Refer Diesel engine part.	
3	Cardan Shaft	Daily	Stopped	Check Cardan Shaft for any visual damage.	
4.	Alternators	Daily	Running	Check for any abnormal noise or over heating.	
5.	Diesel Engine	Daily	Running	Refer Diesel engine part.	
6.	Gauges & instrument	Daily	Running	Check the Gauge & instrument operations	
7.	Aux. Alternator	Daily	Running	Check if alternator is charging the battery.	

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NOTES

CHAPTER III

CIRCUIT DESCRIPTION

1. **POWER CIRCUITRY**
2. **AUXILIARY CIRCUITRY**
3. **CONTROL CIRCUITRY**

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CHAPTER III

CIRCUIT DESCRIPTION

1. POWER CIRCUITRY

1.1 SYSTEM DESCRIPTION

A self propelled Diesel Electric Tower Car (DETC) is used for periodical inspection, patrolling and maintenance of traction overhead equipment. It is also used for attending sites of breakdown, restoration of damaged OHE equipment. This can also be used to erect small lengths of catenary and contact wire by way of repairs of damaged OHE.

The power equipment of Diesel Electric Tower Car comprises of two power packs, two separate alternators two power rectifiers & four traction motors to meet all operating conditions of Diesel Electric Tower Car.

The power pack consists of a Diesel Engine of Cummins India make type NTA-855R developing a power of 340 HP @ 1800 RPM continuously and a Brushless CGL make traction alternator type C1009A1, matching rectifier, exciter and rotating diode set capable of developing around 310 HP input to traction (by each power pack).

The Traction Alternator is a single bearing type and compatible for coupling with Cummins Diesel Engine mentioned above. The exciter field current is limited to 6 amps during entire working range of DETC.

The main rectifiers are suitable for over board mounting and are used for rectifying the output of traction alternators. The power rectifier assembly is suitable for operation under one bridge failure condition. It has built-in blower arrangement with fan failure protection.

The traction motors (Type TM2141C) are suitable for mounting on DEMU bogie of Indian Railways. The Traction Motor is self-cooled type and complies with requirements of IEC – 60349-1. The traction motor has moulded inter-pole & main-pole coils bonded with poles. The four traction motors in 4P combination will operate in full field only, utilising full capability of traction alternator. Avoidance of going into a weak field is beneficial from operation point of view, especially utilisation of available adhesion. In addition, such a combination provides following advantages:

- Reduction in control equipment
- Reduction in maintenance cost
- Avoiding transition jerks and loss of power normally encountered in transition

An electronic diesel engine speed governing, alternator exciter excitation and load control module, type LCC107B of GAC make, control the diesel engine speed & excitation of the Traction Alternator. The experience shows that adoption of such a system enables utilisation of maximum diesel engine power on rail, thus optimally utilising the installed power.

The diesel engine speed will be regulated through the 8 pre-selected steps (notches). Driver can operate the DETC at any notch depending upon speed restrictions / desired.

2. AUXILIARY CIRCUITRY

Two 8 kW Auxiliary Brushless Alternator rectifier and regulator system, supply 122±5% Volts DC for Auxiliaries. The alternator is self-cooled and is directly driven from Diesel Engine shaft extension through cardon shaft and flexible coupling. The output of the rectifier regulator is 125V ± 5%. The regulated voltage is available from no load to full load and idle engine RPM to maximum engine RPM.

A 110V DC lead acid battery (Not in CGL Scope of Supply) will float against the auxiliary power and will thus remain in charged condition during normal operation. This battery can supply to fans, lighting and control loads.

PERFORMANCE OF THE SYSTEM

Performance obtainable using two 340 HP diesel engines at 8th notch & 914 mm half worn wheels and 20/91 gear ratio, two traction motors fed from a power pack in Permanent Parallel combination (operating in full field only) is shown on curve No. 50702001.

A maximum speed of 110 Km/h is obtainable with the power equipment proposed by us and meets the following performance requirements as specified in ICF specification no ICF/M/D/SPEC – 300. In addition, use of our equipment gives following performance capability.

1. DETC can carry 12 tons of payload without any additional equipment.

2. Period of continuous running for 4 hours at 100 kph on general tangent track followed by frequent to & fro movement at walking speed for 1.5 hours.
3. Period of continuous running at 40 kph on up or down gradient of 1 in 60 for 4 hours to be followed by frequent to and fro movement at 5 kph for 1.5 hours on the same gradient.
4. When running as a light vehicle, the DETC shall be capable of running at a speed of
   a. 110 kph on level track.
   b. 26 kph on a 1 in 33 up gradient
5. The DETC will be able to start and haul a trailing load of 60 tons on up gradient of 1 in 60.
6. When the DETC hauling a trailing load of 60 tons on 1 in 60 up gradient, the vehicle can reach a maximum speed of 40 kph.

3. CONTROL CIRCUITRY

3.1 110 V DC SUPPLY

110 VDC supply is available in the coach from 110 VDC, 120 A-H battery. This supply is available to control circuit in all positions of Battery Isolating Switch (BIS-110V). During OFF position, we can charge the battery from external source through Battery charging socket. Two Nos. 8 kW Auxiliary Alternators supply 120 ± 5% VDC to the system for control system operation, supply to electromagnetic equipment, electropneumatic equipment, train lighting, Headlight, battery charging, Rectifier Blower Motors, Excitation Control, Governor Supply etc. RCD1, RCD2 and RCD3 are not allowed battery to discharge and allow to charge the battery when both the Auxiliary Alternators / either of the Auxiliary Alternators are in working condition. Supply to both the Rectifier Blowers will be available from Auxiliary Alternators when both of them are in working condition or even when one of the Auxiliary Alternators is working. During normal working condition the 110 VDC Battery isolating switch shall be in “AA-1 & 2 IN CKT” position.

3.2 24 V DC SUPPLY

24 VDC Supply is available in the coach from 24 VDC battery. 20 A Diesel Engine mounted Battery Charging Alternator (BCA) is used for charging the battery, supply to control circuit, electromagnetic equipment, auxiliary equipment etc. This battery is isolated from the circuit when the battery is in OFF position. When Diesel Engines are running, supply shall be available from BCA and corresponding charging

current shall be known from Battery Charging Ammeters provided on the Control Cubicle (Cab-1). 24 VDC Battery supply is used for cranking the Diesel Engines.

3.3 CIRCUIT DESCRIPTION

Preparing Diesel Electric Tower Car/US for operation: -

a. All the MCBs (110 VDC & 24 VDC) are in ON position.
b. Engine Control Switch Mounted on Driver's Desk is in IDLE position while Diesel Engine(s) starting.
c. Motor Cutout switches mounted on control cubicle cabin-1 is in "NORMAL" Position. Depending on the faulty motor, position of the switch is changed to appropriate condition to isolate the faulty Traction Motor.
d. Local/Remote switches mounted on the Control Cubicle-1 are in "Remote" Position when the Diesel Engine is started from driver's desk. It is in "Local" position when the Diesel Engine is started locally from the push button station mounted under the frame.
e. All the by-pass switches are in OFF position.
f. Battery Isolating Switch – BIS (110 Volts DC) is in "AA1&2 in CKT" position and BIS (24 Volts DC) is in ON position.
g. Driver's control switch mounted on Driver's Desk is in "ON" position.
h. Hydraulic oil level switch (HOLS1 [2]) is in close condition, if the oil level is above the specified limit.
i. Diesel Engine mounted water temperature switch (TS11 [12]) is in close condition, if the water temperature is below set position.
j. Diesel Engine mounted lubricating oil pressure switch (PS11 [12]) is in open condition before cranking of Diesel Engine.
k. Diesel Engine mounted overspeed switch (SS11 [12]) is in close condition, if the speed of the Diesel Engine is below overspeed set speed.
l. Cooling water level switch (CWLS1 [2]) is in close condition, if the water level is above set level.
m. Ensure the Master Controller Reverse handle in "OFF" position and Main Handle position is in '0' position.

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3.4 CRANKING OF DIESEL ENGINE

Before starting the Diesel Engine, circuit needs to be reset, which bypass the safety system during starting. The same is accomplished using “Ready to Start” spring loaded switch mounted on the Driver's Desk. During starting Engine Trip Relay FC21 (FC22) is energised and “Engine-1 (2) Trip” & “Engine-1 (2) OFF” indications glow. As soon as the switch is operated, Relays R11 (R12), R21 (R22), R41 (R42), R51 (R52) and R61 (R62) are energised and cut-off supply to Engine Trip Relay FC21 (FC22) & both the indications go off. Now the circuit is set for Diesel Engine cranking. Press “ON” the Diesel Engine-1 ON” spring loaded switch mounted on the Driver's Desk. As soon as the contacts of the “Diesel Engine ON” switch is closed, Engine-1 ON relay S11 (12) get energised though wire no 1654 (1655). Contact of S11 (12) inturn operates Remote ON/OFF Relay R91 (R92) through wire 225 (226). As soon as the R91 (R92) is energised, 24 VDC supply is available to timers TR11 (12) & TR21 (22), Idling solenoid valve & hour meter from 209 (210) through Local / Remote Switch & Diesel Engine ON relay NO Contact. At the same time wire no 213 (214) is energised from 209 (210) through Engine ON relay contact and supply is available to magnetic switch provided on the Diesel Engine (wire no 215/216). As soon as the magnetic switch is energised, supply is fed to starting motor and allows Diesel Engine to start. If the Diesel Engine is not started for set time – say 6 sec (set value of timer TR11 (12]), the circuit will break and disconnect supply to magnetic switch. During the Diesel Engine cranking period, lubricating oil pressure switch is bypassed by Timer 21 (22) contact. The timer is set at approximately 8 sec. (slightly more than the engine cranking time).

3.5 SPEED CONTROL OF DIESEL ENGINE(s)

As Diesel Engine starts running from 0 RPM, speed sensors provided on the Diesel Engine develops frequency signal and give feedback to Speed & Load Control System (LCC-107B) through wire nos. 21A (21B) & 22A (22B). Depending up on the speed setting (Notch), LCC-107B controls the speed of the Diesel Engine. LCC-107B starts pumping current through wire nos. 31A (31B) & 32A (32B) to Actuator provided on the Diesel Engine till its speed reaches its set value. Once its speed is reached to set value, LCC-107B maintains the same actuator current.

Switch ON the “CONTROL” provided on the Driver's Desk. This allows wire no. 1602 to get supply & “CONTROL ON” indication appears. Move the Master Controller Reverse Handle to either Forward or Reverse direction & Main Handle to Notch 1 in depressed deadman condition. There is no change in Diesel Engine(s) speed. Move the Master Controller Main Handle to notch 2. Diesel Engine(s) speed changes to approximately 1000 RPM. Move the Master Controller Main Handle to higher notches. Corresponding

speeds are 1200 RPM at 3rd Notch, 1300 RPM at 4th Notch, 1400 RPM at 5th Notch, 1500 RPM at 6th Notch, 1650 RPM at 7th Notch & 1800 RPM at 8th Notch. Depending upon the speed setting / Notch of the Master Controller, LCC-107B(s) changes the actuator current of Diesel Engine(s).

3.6 TRACTION ALTERNATOR EXCITATION CONTROL

Change the Engine Control Switch to "RUN" position. Ensure that Master Controller Reverse Handle is in either Forward or Reverse direction & Main Handle is in '0' position with pressed deadman condition. Switch ON the "EXC ON" switch provided in the Driver's Control Switch Box. This operation set the control circuit for excitation. Move the Master Controller Main Handle to Notch '1' position with pressed deadman condition. As soon as the Main Handle moves to Notch 1, LCC-107B (s) get 1st notch speed through coded signals. Meanwhile, wire no. 3 get supply through Master Controller, Excitation Control Relay ECR1 (2) get energised and "Excitation-1 (2) - ON" indication appears in LED indication panel. This relay opens the reset voltage 24 VDC between LCC-107B terminals 13 & 14 through wires 203E (203F) & 299A (299B). As soon as the reset voltage is released, the excitation current starts build up from terminals 23 & 24 of LCC-107B(s). Within few seconds it reaches to its maximum to match the Diesel Engine output power (Gross power – Power Consumed by Auxiliaries). Move the Master Controller Main Handle to Notch 2. As soon as the Master Controller Main Handle is moved to 2nd notch, logic signals through wire nos. 4,5,6 & 7 changes the Diesel Engine speed using LCC-107B to 2nd notch speed i.e. 1000 RPM and excitation changes to get the maximum output power to match with Diesel Engine output. Depending upon the V-I characteristics (Load Conditions) of the Traction Alternator, excitation current varies through wire nos. 1901A (1901B) & 2101A (2101B) at fixed notch. External Resistance 12 Ω keeps the Excitation current always below 10 Amps. However, the maximum Excitation current required for Traction Alternator is less than 6 Amps. Same procedure is applicable for higher notches also.

3.7 HEALTHY & FAULT INDICATIONS:

TRACTION CONTROL SUPPLY ON (GREEN): This is a healthy indication of system. When the "Control" Switch provided on the Driver's Control Switch Box of Driver's Desk is in ON position, wire no 1602 gets supply and the indication glows. If this switch is in OFF condition, Diesel Engine speed control & Traction Alternator excitation control are not possible.

ENGINE-1 ON (GREEN): This is a healthy indication of Diesel Engine-1. When the "Diesel Engine-1 ON" spring loaded switch is operated i.e. Diesel Engine-1 cranking operation is performed, Relay S11 energised through wire no.1654 & 1664 and will remain in energised condition. When the relay S11 is in energised position, wire no. 1811 gets supply through its NO contact and hence the indication glows. In case of any protection circuit operates, this relay de-energises and this indication goes off.

ENGINE-2 ON (GREEN): This is a healthy indication of Diesel Engine-2. When the "Diesel Engine-2 ON" spring loaded switch is operated i.e. Diesel Engine-2 cranking operation is performed, Relay S12 energised through wire no.1655 & 1665 and will remain in energised condition. When the relay S12 is in energised position, wire no. 1809 gets supply through its NO contact and hence the indication glows. In case of any protection circuit operates, this relay de-energises and this indication goes off.

ENGINE-1 TRIP (RED): This is a fault indication of Diesel Engine-1. This indication glows in any of the following conditions.

a. Hydraulic Oil Level - LOW

(Normal Hydraulic oil Level is lower than the specified limit)

b. Cooling Water Level - LOW

(Normal Water Level is lower than the specified limit)

c. Lubricating Oil Pressure - LOW

(Normal Lubricating Oil pressure is lower then 10 PSI.

d. Cooling Water Temperature - HIGH

(Normal Cooling Water temperature is more than 95°C)

Hydraulic Oil Level & Water Level of Diesel Engine-1 is monitored by R21 & R61 Relays respectively. Similarly, Cooling Water Temperature & Lubricating Oil Pressure is monitored by R11 & R41 Relays respectively. Any of these operations goes wrong respective relay de-energises and which inturn energises Engine Trip Relay FC21. When FC21 is energised, wire no. 1807 gets supply through one of its contacts and "Engine -1Trip" indication glows.

ENGINE-2 TRIP (RED): This is a fault indication of Diesel Engine-2. This indication glows in any of the following conditions.

a. Hydraulic Oil Level - LOW

(Normal Hydraulic oil Level is lower than the specified limit)

b. Cooling Water Level - LOW

(Normal Water Level is lower than the specified limit)

c. Lubricating Oil Pressure - LOW

(Normal Lubricating Oil pressure is lower then 10 PSI.

d. Cooling Water Temperature - HIGH

(Normal Cooling Water temperature is more than 95°C)

Hydraulic Oil Level & Water Level of Diesel Engine-2 is monitored by R22 & R62 Relays respectively. Similarly, Cooling Water Temperature & Lubricating Oil Pressure is monitored by R12 & R42 Relays respectively. Any of these operations goes wrong respective relay de-energises and which inturn energises Engine Trip Relay FC22. When FC22 is energised, wire no. 1673 gets supply through one of its contacts and "Engine -2Trip" indication glows. Under these circumstances, Diesel Engine shuts down.

MOTOR EARTH FAULT (AMBER): In case power circuit is grounded due to any reason, during operation it causes Ground Fault Relay (GFR) to energise through wire no E. When the GFR is energised, wire no. 1624 gets supply through one of its contacts, leaving an indication "TRACTION MOTOR EARTH FAULT". Once the GFR is energised, it is mechanically latched. Pressing reset button provided with the GFR resets mechanical latching.

PARKING BRAKE APPLIED (RED): When the parking brake is applied, wire no 1677 energised through parking brake governor and "PARKING BRAKE APPLIED" Indication glows.

ALTERNATOR-1 EXCITATION ON (GREEN): This is a healthy indication of system, which shows Traction Alternator-1 excitation is ON. As soon as the Master Controller Main Handle is moved from IDLE to Notch 1, depending upon the Reverse Handle position, either wire no.1 (Forward) or wire no. 2 (Reverse) is energised. These wires inturn feed wire nos. 102A & 109A through reverser interlock, Equipment Governor, Brake Pressure Control Governor and Parking Brake Governors and energise E.P.Contactors LC1 & LC3 mounted inside the Motor Switch Group Cubicle. As soon as these contactors energised, supply is fed

to wire no 1614A and energise Excitation-1 ON Relay ECR1. The moment the Relay ECR1 is energised, indication glows and excitation starts building up from LCC-107B1.

ALTERNATOR-2 EXCITATION ON (GREEN): This is a healthy indication of system, which shows Traction Alternator-2 excitation is ON. As soon as the Master Controller Main Handle is moved from IDLE to Notch 1, depending upon the Reverse Handle position, either wire no.1 (Forward) or wire no. 2 (Reverse) is energised. These wires inturn feed wire nos. 102A & 109B through reverser interlock, Equipment Governor, Brake Pressure Control Governor and Parking Brake Governors and energise E.P.Contactors LC2 & LC4 mounted inside the Motor Switch Group Cubicle. As soon as these contactors energised, supply is fed to wire no 1614B and energise Excitation-2 ON Relay ECR2. The moment the Relay ECR2 is energised, indication glows and excitation starts building up from LCC-107B2.

HIGH COOLING WATER TEMPERATURE (HCWT) – DIESEL ENGINE 1: This is a fault indication of Diesel Engine-1. When the Diesel Engine-1 cooling water temperature goes high (more than the specified limit), the temperature switch provided on the Diesel Engine opens and de-energise the Cooling Water Temperature monitoring Relay R11 through wire no 235. As a result of this, wire no. 4030A gets supply through one of the relay contacts, leaving indication “HCWT ENG-1” on the Indication Panel.

HIGH COOLING WATER TEMPERATURE (HCWT) – DIESEL ENGINE 2: This is a fault indication of Diesel Engine-2. When the Diesel Engine-2 cooling water temperature goes high (more than the specified limit), the temperature switch provided on the Diesel Engine opens and de-energise the Cooling Water Temperature monitoring Relay R12 through wire no 236. As a result of this, wire no. 4030B gets supply through one of the relay contacts, leaving indication “HCWT ENG-2” on the Indication Panel.

AUXILIARY ALTERNATOR-1 FAILURE (RED): Before cranking the Diesel Engine-1, “AUXILIARY ALTERNATOR-1 FAILURE” indication appears on the LED indication panel (through wire no 1683A) provided on the Driver's Desk, as no supply is being generated by Auxiliary Alternator-1. As soon as the Diesel Engine-1 is cranked, Auxiliary Alternator-1 starts generating power and Auxiliary Alternator proving Relay AAPR1 energised through wire no 301 & 303. This relay AAPR1 is always in energised position. When the relay is energised, the indication through its NC contact disappears. When the Auxiliary Alternator – 1 stops generating power on account of a defect in the Auxiliary Alternator – 1 and/or Rectifier and Regulator, the AAPR1 relay de-energises and Auxiliary Alternator – 1 Failure Indication appears in LED indication panel.

AUXILIARY ALTERNATOR-2 FAILURE (RED): Before cranking the Diesel Engine-1, “AUXILIARY ALTERNATOR-2 FAILURE” indication appears on the LED indication panel (through wire no 1683B) provided on the Driver's Desk, as no supply is being generated by Auxiliary Alternator-1. As soon as the Diesel Engine-2 is cranked, Auxiliary Alternator-2 starts generating power and Auxiliary Alternator proving

Relay AAPR2 energised through wire no 302 & 304. This relay AAPR2 is always in energised position. When the relay is energised, the indication through its NC contact disappears. When the Auxiliary Alternator – 2 stops generating power on account of a defect in the Auxiliary Alternator – 2 and/or Rectifier and Regulator, the AAPR2 relay de-energises and Auxiliary Alternator – 2 Failure Indication appears in LED indication panel.

RECTIFIER FUSE FAILURE – 1 (AMBER): In case of any one-fuse failure in Power Rectifier-1, Relay RL1 energises through wire no. 4020. Through one of its contacts, wire no.1612A energised leaving indication "RECT. FUSE FAILURE-1". In case, failure of three different phase-fuses in three different bridges in the same rectifier panel, the same is considered as Single Bridge failure. In this case also "RECT. FUSE FAILURE" indication glows.

RECTIFIER FUSE FAILURE – 2 (AMBER): In case of any one-fuse failure in Power Rectifier-2, Relay RL1 energises through wire no. 4020. Through one of its contacts, wire no.1612B energised leaving indication "RECT. FUSE FAILURE-2". In case, failure of three different phase-fuses in three different bridges in the same rectifier panel, the same is considered as Single Bridge failure. In this case also "RECT. FUSE FAILURE" indication glows.

RECTIFIER –1 COOLING FAN FAILURE (RED): It is a fault indication of Power Rectifier-1. Before the Diesel Engine-1 is not cranked this indication "RECT-1 COOLING FAN FAIL" glows, as there is no supply available to Blower Motor provided inside the Power Rectifier-1. As soon as power is available to cooling fan motor, blower starts working and pressure switch provided inside the cubicle actuates and through wire no.1642A Relay RCFR1 energised. Instantly, the indication goes-off. In case Air pressure switch provided in Rectifier Cubicle-1 fails, Relay RCFR1 will not energise and Rectifier-1 cooling fan failure indication appears in the LED indication panel.

RECTIFIER –2 COOLING FAN FAILURE (RED): It is a fault indication of Power Rectifier-2. Before the Diesel Engine-2 is not cranked this indication "RECT-2 COOLING FAN FAIL" glows, as there is no supply available to Blower Motor provided inside the Power Rectifier-2. As soon as power is available to cooling fan motor, blower starts working and pressure switch provided inside the cubicle actuates and through wire no.1642B Relay RCFR2 energised. Instantly, the indication goes-off. In case Air pressure switch provided in Rectifier Cubicle-2 fails, Relay RCFR2 will not energise and Rectifier-2 cooling fan failure indication appears in the LED indication panel.

GOVERNOR-1 SUPPLY FAILURE (RED): This is a fault indication of the system. During normal working conditions, relay ER1 is energised through wire no 1612 & 1612A and there is no indication "GOV-1 SPLY FAIL" on the indication panel. Either excitation ON/OFF switch is in OFF condition or Engine Control Switch is in IDLE position, the Relay ER1 is De-energised. Once the relay ER1 is de-energised, the

indication glows on the panel. If GOV-1 SPLY FAIL occurs, excitation of Traction Alternator-1 is not possible.

GOVERNOR-2 SUPPLY FAILURE (RED): This is a fault indication of the system. During normal working conditions, relay ER2 is energised through wire no 1612 & 1612B and there is no indication "GOV-2 SPLY FAIL" on the indication panel. Either excitation ON/OFF switch is in OFF condition or Engine Control Switch is in IDLE position, the Relay ER1 is De-energised. Once the relay ER2 is de-energised, the indication glows on the panel. If GOV-2 SPLY FAIL occurs, excitation of Traction Alternator-2 is not possible.

TRACTION MOTOR OVERLOAD (AMBER): Due to any reason any of the Traction Motor overloads i.e. Traction Motor current is more than 600 Amps, corresponding Traction Motor overload relay energised, leaving an indication "TR. MOTOR OVERLOAD" on the indication panel. In case of Traction Motor overload, supply to traction is cut-off by isolating motor contactors on the Motor Switch Group Cubicle. At the same time, excitation of respective Traction Alternator (In case of Traction Motor 1 or 3 overload, Traction Alternator –1 excitation cut-off & in case of Traction Motor 2 or 4 overload, Traction Alternator –2 excitation cut-off) is cut-off. To reset the overloaded traction motor circuit, press the "Traction Motor overload reset" spring loaded switch provided on the Driver's Control Switch Box. This operation is possible only when the Master Controller's Main Handle is in '0' position.

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NOTES

CHAPTER V

TRACTION ALTERNATOR

1. **INTRODUCTION**
2. **SALIENT FEATURES**
3. **ALTERNATOR CONSTRUCTION**
4. **MAINTENANCE SCHEDULE**
5. **ALIGNMENT PROCEDURE WITH DIESEL ENGINE**
6. **PROTECTION OF BALL BEARING**
7. **LONGITUDINAL SECTION**

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CHAPETR V

TRACTION ALTERNATOR

1. INTRODUCTION

This Manual comprises chapters, covering `Description', `Insulation', `operation' and 'maintenance' of alternator. Alternator has been designed and built in accordance with the generally accepted engineering practices of Indian Railways Loco/DEMU Sheds. In case of improper installation or improper operation or improper maintenance, machine gives rise to potential dangers which may cause serious personal injuries or damage.

While designing this Traction alternator, aspects of user-friendly maintenance and easy manufacture were kept in mind. Technical data have been laid down for the machines in accordance with the specifications.

It is assumed that the planning and execution of mechanical/ electrical installation, transportation, erection /commissioning and maintenance will be carried out under the supervision of qualified personnel.

In the case of product maintenance / installation / erection / commissioning, it is advisable to take assistance or services of the competent CG service centres or inform CG works for the assistance.

The direction of rotation is determined from the bearing end of the machine, it is a single bearing machine, directly coupled with Diesel engine on one side and supported on ball bearing on the other side.

1.1 TECHNICAL DATA

C1009A1 AC Alternators is a Salient pole, revolving field, brush-less, self ventilated & single bearing Traction machine. This AC generator is available with SEPARATELY EXCITED SYSTEM (with unique LCC 107B governor of Governors America Corporation).

Description Make & type	CG, C1009A1
Drive-Details of arrangement of bearing and coupling	Direct coupled through flex plates
No. of poles, phases & connections	8 poles, 3 phase, Star
Maximum permissible design speed	2250 rpm
One hour rating	544 A, 450 V, 245 kW at 1800 RPM
Continuous rating	
• High voltage	345 A, 666 V, 230 kW at 1800 RPM
• Low voltage	718 A, 320 V, 230 kW at 1800 RPM
Class and type of insulation	
• Stator	Class H
• Rotor	Class H

Resistance at 20 °C

- Rotor winding 0.74 Ohms
- Stator winding (Per phase) 0.0089 Ohms
- Resistance per phase exciter rotor 44 mill ohms at 20 °C
- Resistance for exciter stator 7.2 ohms at 20 °C.

Details of bearings

Single Ball bearing	SKF - 6317 C/3
Grease-type,	HP LITHON-3
Capacity	250 GMs
Interval for regreasing	6 months
Repack the grease	2 years
grease requirement in new	210 Gm
Shaft bearing seating diameter	85 mm
Min. permissible radial clearance	0.03 to 0.13 mm
Mountings-Details	Directly coupled to engine

Weight

Traction Alternator	1385	kgs
Fan	17	kgs
Rotor	605	kgs
Air Filter Assembly	40	kgs

1.2 IMPORTANT HARDWARES

Bolting place	Size	Quantity	Type
Alternator mounting with main bracket	M24 x 70 lg. P12.9	16 nos.	Socket head
Flexible coupling with rotor shaft	M20 x 50 lg. P10.9	08 nos	Hex. Hd bolt
Alternator mounting with engine adopter	M16 x 70 lg. P12.9	16nos.	Socket head

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1.3 MAINTENANCE SHEET

Sr. No.	Nature of job	Week-ly	Monthly	6 Month	Yearly
01.	Physical inspection	X			
02.	Air outlet cover	X			
03.	Air inlet duct	X			
04.	Terminal box.		X		
05.	Terminal connections		X		
06.	Coupling bolts to engine adoper. & alt. Stator		X		
07.	Alternator fixing bolts to base rail		X		
08.	Topping up of grease in bearing assy.			X	
09.	Insulation resistance of exciter stator, rotor, main stator , ex. St.			X	
10.	Pressure Cleaning				X
11.	Dismantling				Once In 2- year
12.	Fan, flex plate fixing bolts with engine flywheel		X		

2. SALIENT FEATURES OF ALTERNATOR

C1009A1 AC generator is a Salient pole type, revolving field Brush-less type alternator. These AC generators are available in a SEPARATELY EXCITED SYSTEM (with unique LCC107B of GAC, Governors America Corporation).

The insulation system of the stator coils has been improved for higher voltage operation of the high-powered D.E.M.U., D.E.T.C. & shunter. The traction alternator C1009A1 is capable of operation at a top unloading voltage of 750V DC continuously.

This alternator is especially design for Indian Railways by CG. The class 200 Insulation System with Polyesterimide Resin provides best protection against moisture, sand, salt, humidity and corrosive atmosphere ensuring trouble free operations under the most demanding conditions.

Transient voltage dips are lower.

Liberally rated diodes have been used in rotating rectifier assembly to ensure high product reliability specifically for rotating application.

The rotating diodes are protected by a surge suppresser, which has the ability to chop the transients from 1600 volts to less than 450 volts.

For D.E.T.C. /U.S. power requirement is maintained constant at different notches.

Voltage X current = constant

Depending upon the load requirement, Constant & rated powers have been achieved through excitation, which have been controlled with the help governor LCC 107B, which is a special feature of D.E.T.C. /U.S. Depending upon the load requirements of the multiple unit, Governor provides current input to exciter stator, which induces power in exciter armature, which then rectified by diode wheel (rotating rectifier) and is fed into main rotating field, ultimately responsible for the power output of alternator.

The diesel engine in the present case has a gross HP of 340 and input to traction is 310 HP at 38 °C of ambient and at a speed of 1800 RPM. The higher voltage capability of traction alternator enables the locomotive to be operated at full field of traction motors. AC Generator armature winding is housed in Stator and field Winding is placed on Rotor. Brush-less construction of rotating rectifier gives the required amount of excitation to the rotating field.

The excitation circuit is designed to ensure that the excitation current does not exceed by 6 Amps at any operating point.

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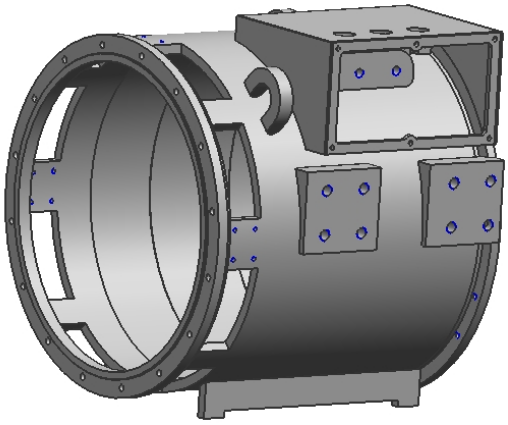
3. ALTERNATOR CONSTRUCTION

3.1 STATOR

Stator consists of stator frame, stator core, armature windings & terminal box.

3.1.1 STATOR FRAME

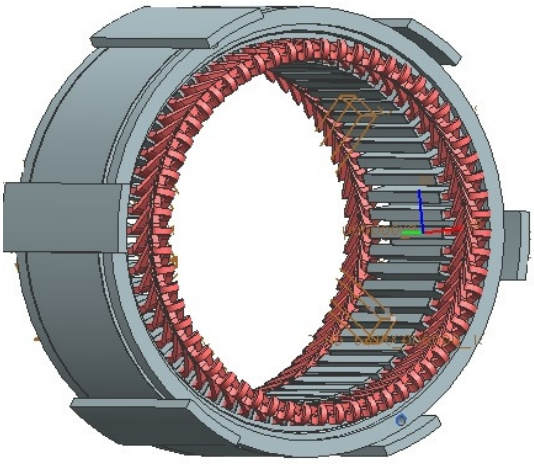
Stator frame along with terminal box is a fabricated structure using mild steel plate. It is designed to ensure correct distribution of airflow over the Stator core and windings.



Stator Frame

3.1.2 STATOR CORE

In stator core, Stampings stack is supported with mild steel end plates at both ends & reinforced with landing bars, which are welded with complete stack & both end plates. Stampings are made of silicon steel with C6 coating for proper welding of stack. These punching are oriented to 90° length one fourth resulting in better magnetic properties.



Stator core with winding

3.1.3 ARAMTURE WINDINGS

Winding is designed for 8 pole, 3 phase, double layer diamond winding star connected, housed in a open slots, single turn (made up of single conductor having no laminations.)

The Connections are made to the phase rings by gas brazing and phase connectors are taken to the terminal box by means of BUS BAR. The phase rings are properly insulated between line to line and live to earth parts.

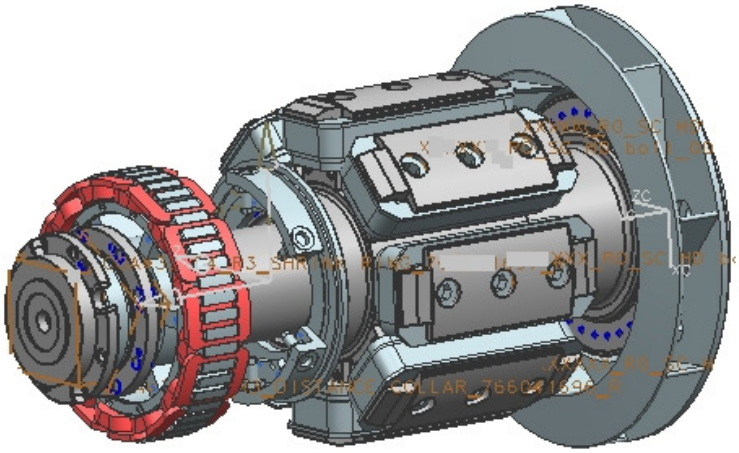
Armature coils are made from polyesterimde enamelled glass lapped Conductor for class 200 suitable for VPI formed on special formers.

Overhang is properly tied up with the help of resiglass tape to the epoxy bracing ring so that the electrical and severe mechanical stress in case of any abnormal event can be resisted by the windings. 5th and 7th harmonics are mitigated by a 60° winding distribution and should not normally be the major target for reduction by pitching.

Stator Coil

3.2 WOUND ROTOR ASSEMBLY

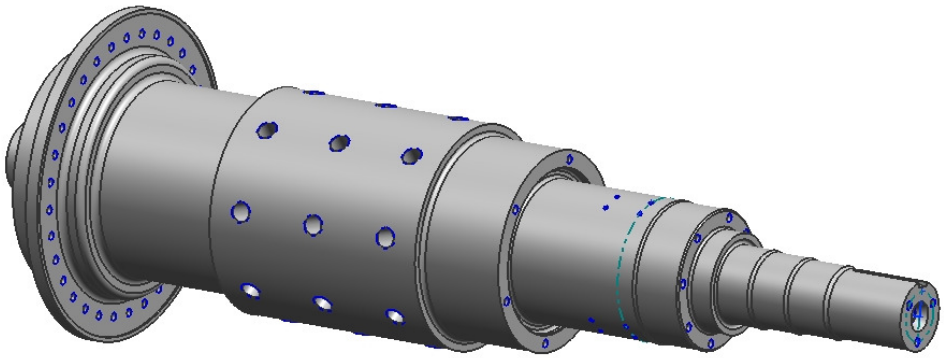
Rotor consists of shaft, 8 rotor field coils (4 north polarity + 4 south polarity), diode assy, exciter armature. The rotor is wet wound for eight poles using epoxy compound and properly interlined to have better resistance to centrifugal force, then locked with support block to have proper locking. The rotor field coils are vacuum pressure impregnated with solventless resin of class 200.



Wound Rotor Assembly

3.2.1 ROTOR HUB:

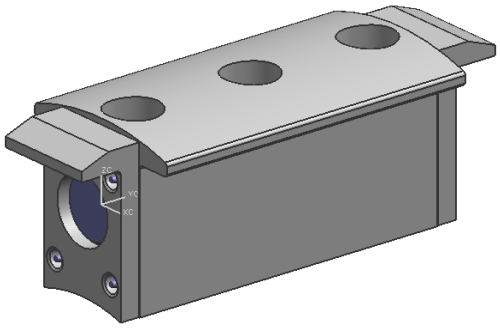
The shaft is made of forged medium-grade carbon steel IS: 2004 CLASS IV. The shaft is liberally designed for overload conditions. The rotor shaft is forged and ultrasonically tested to give greater reliability in performance.



Rotor Hub

3.2.2 ROTOR FIELD COILS

Main field pole is built up of high quality, low silicon, steel sheets, oriented to 180° after every one-fourth length for better grain orientation and better magnetic properties.



Rotor Pole Brick

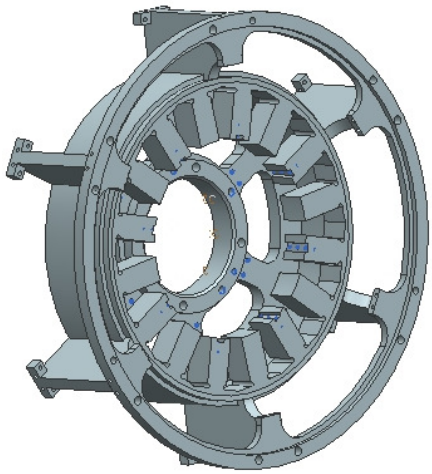
For forming the rotor field coil, main field pole is directly wound with rectangular copper conductor by wet winding process using epoxy compound , which gives better insulation properties and mechanical strength. The coils are formed by winding directly over the pole body to give better rigidity in service and this also minimises the loosening of poles in service. While assembling the wound poles utmost care is taken during the production stage. Field coils are fastened to shaft with high tensile steel bolts with specified torque and locked through tack weld in position.

The coil to coil strap connectors are individually insulated and brazed to the coil leads. The connectors are held and braced to support plate of diode wheel several layers of Resi-glass tape is applied on the connectors (live surface) and cured fully to form a rigid connection.

The fully assembled rotor with field coils and connections is subjected to painting with anti-tracking insulating paint to avoid trapping of moisture and improved electrical properties.

3.3 END FRAME:

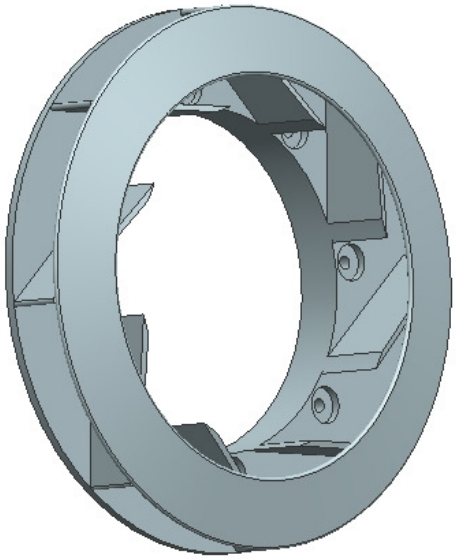
End frame is fabricated from thick steel plate construction, Spigot to the stator frame and is fixed by easily assessable high tensile screws. The end frame supports the exciter winding and bearing assembly. It is so designed to facilitate the easy accessibility of diode wheel for Maintenance.



End Frame

3.4 ROTOR FAN

The rotor fan is manufactured with special Aluminium alloy. Special care is taken to ensure that the fan is free from any sort of casting defects. All the fans undergo thorough dye penetration and radiographic testing for highlighting any surface or sub surface defects.



Rotor Fan

3.5 TERMINAL BOX

This alternator stator is having internally 3 phase star connection, brought to the terminal box bus bars. Phase bus bars are brazed with phase rings, which are supported on the main frame & properly insulated from earth. The phase bus bars coming out of the frame are properly supported on steel cleats with Resi-glass tape to minimise the cable tension. Other end of phase cables is fixed on insulating rod through plated hardware to maintain minimum air gap (creepage) between live to live & live to earth parts. Single holed Lugs are provided for output power cable connection. RTD terminals have been terminated at elex elements supported inside the same terminal box.

3.6 DIODE WHEEL ASSEMBLY

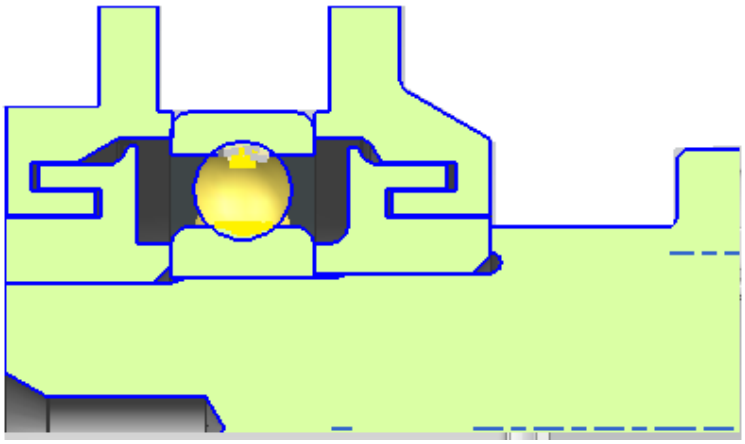
Diode wheel assembly is made up of solid iron plate in which insulation discs are bonded together with resin. Heat sink are specially designed for speed up to 2500rpm. The rotating diodes are protected by a metal oxide varistor against voltage surges arising due to fault conditions on load side. Diodes are suitable upto PIV of 1600 volts, and specially designed for high `g' application, 3 positive and 3 negative diodes of Ruttonsha no. 150LMR is used. Each heat sink is specially designed to accommodate one bridge arm and output is fed into a common copper connector for all the arms to the rotating field.

Details of rotating rectifier

- Mounted on the same rotor shaft of alternator.
- Support plate is made up of mild steel. Its function is clear form the name given to it
- Heat sink is for carrying out the heat generated in the diodes during their operation

3.7 BEARING ARRANGEMENT

The bearing arrangement consists of inner bearing cap, shrink ring, ball bearing, distance collar, outer bearing cap. Assembly stages of these parts are as shown in fig. All these bearing components are made of forged carbon steel as per IS: 2004 class 3 & 4. Self-locating, sealed bearing arrangement has been designed to have better circulation of grease during service. Grease inlet pipe along with grease nipple (1/4 inch BSP) have been provide in outer bearing cover for topping up grease during routine maintenance



Bearing Assembly

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4. MAINTENANCE SCHEDULE

At the outset, it may be emphasised that the routine maintenance of Traction Alternator is much simpler due to the absence of Commutator and its brush-less arrangement.

Routine maintenance of Traction Alternator therefore, mainly includes periodic cleaning and inspection of the machine.

It is recommended that the period of inspection should be more frequent in the initial period of service, and schedule can be subsequently relaxed based on experience. The periodic maintenance schedule chart accompanied with this manual should be filled and should be periodically sent back to the manufacturer.

4.1 CLEANING

Clean all the dust and dirt from the exterior of the Alternator, taking special care at the areas around air opening and inspection covers. Air Inlet cover is removed from the alternator by taking out the M12 hex head screw. Then only the air inlet cover can be removed and it is advisable to take care for withdrawal of small M6 screw while opening the assembly. Air inlet net to be cleaned only with kerosene or and other solvent. Dirt & dust of the alternator is to be cleaned by vaccum cleaner. In absence of vacuum cleaner, dry compressed air is to be used for cleaning. During cleaning it is to be ensured that dust is blown out of alternator or air inlet duct whenever compressed air has been applied for cleaning.

Wipe the dust over the diode and insulation disc and approachable parts of the rotor field coils and connections. Best way of cleaning is to moist a clean lint free cloth with solvent for wiping. Recommended cleaning solvents are given in Table.

While cleaning, look for any defects, hot spots or abnormalities, for taking corrective action consult with manufacturer.

4.2 PERIODIC INSPECTION

Periodic inspection should be carried out after thorough cleaning and following points should be given special attention.

Inspect the diode wheel for any damage of knots of resi-glass and cable holdings. Use glass chord of dia. 1.0 to do the needful as per the perception of operating personal. This is only a temporary solution.

Check machine exciter for any collection of grease leakage from the bearing assy. If the leakage appears to be significant then end frame covers as shown in a figure are to be removed and the leakage should be cleaned.

Check the Main Terminal box and Exciter Terminal Box for dust and use blower.

Check bus bars and connections for cracks or frayed insulation, ensuring complete security, of operating personnel.

Ensure that there are no loose nuts or bolts in the machine and securely close the inspection cover. One should be Very careful while doing the job on the an side (coupling side)

4.2.1 PERIODIC TIGHTENING OF BOLTS

To be done every month for the following assemblies in addition to routine inspection check, carry out with specified torque value. Refer maintenance data for values.

Components	Torque (kgm)
Coupling bolts to engine and fan	8-10
End frame to alternator stator frame	8-10
Cable connections to Alternator	14- 16
Main bracket fixing bolts to AVM	69-83
Air inlet covers.	2-3

Replace any cracked spring/lock washer or any damaged bolt and also check locking of the remaining bolts in rotor if it is taken out for overhauling or for bearing change.

4.2.2 INSULATION CHECK

In every 3 months, check the insulation resistance of the rotor and stator with a 500 Volts Megger and record the IR value. The Alternator can be safely operated with a minimum hot insulation resistance of 1 to 2 Mega ohms. Further fall in IR calls for additional cleaning and re-painting with insulating varnish of stator and rotor. Sometimes the accumulation of moisture in the machine leads to low Insulation Resistance, then the machine needs prolonged drying at low temperature of 100-110 °C till the insulation improves. Specially take care of the deposition of dirt and during the first heavy rains of the season.

WHILE CHECKING WITH 500 VOLTS MEGGER SHORTENS ALL, AC & DC BUSBARS TO AVOID DAMAGE TO THE DIODES. REMOVE THE SHORT AFTER MEGGER CHECK.

4.2.3 RELUBRICATION

50 grams grease (see data for grade) is to be topped up in the end frame bearing assembly only after a year of service or 150000 Kms of run which ever comes first. . This is to be done in addition to all the above checks.

4.2.4 DIODE REPLACEMENT

In the case of damage/failure in diode, diode of same polarity shall be used for replacement. It is recommended that the make of diode be only of Ruttonsha for product reliability. After assembly, the

continuity of replaced diode to be checked with multimeter. Diode to be assembled at specified torque value . For assembly please see the sketches for the detailed assembly.

4.2.5 PERIODIC OVERHAUL

The Alternator is required to be overhauled, even if the same is working satisfactorily. The period of overhaul can be varied between 4 to 5 years depending on the conditions of operation and maintenance.

However the first overhaul is recommended before completion of 2 years as it is the first of its type in India and to have the feed back to the manufacturer.

The routine overhaul mainly consists of

- Dismantling & cleaning
- Inspection & reconditioning
- Replacement & reassembly.

4.3 DISMANTLING & CLEANING OF ALTERNATOR:

Before undertaking dismantling Alternator, examine its OGA & PART drawings submitted to the customer during the approval stage and follow it in presence of experienced personnel or some one from manufacturer side.

It is recommended that, as far as possible, reassemble after overhaul, the same components, which have been dismantled from the machine.

For dismantling refer the figure attached and proceed as follows.

Clean the Traction Alternator externally**.**

After removing the alternator from the Engine, Put the slot wedges provides in the air gap of pole tips in armature portion so that sudden load is not transmitted to the bearings.

Remove bolts of end frame while alternator is kept vertical bearing side up
Use eyebolt of M20 in the taps provided and lift it with the help of wire sling slowly. As soon as the centre is achieved the slot wedges will fall automatically to ground. It is to be replaced while making the alternator horizontal. Use the torque level as specified in the table of technical data.

End frame is a push fit on the frame. There are three tapped holes provided on the 725PCD. Jack with M12 bolts to remove the end frame from main stator frame.

Removing the Outer Bearing cap:

Unlock and remove the bolts for the outer bearing cap and clean with a cotton waste thoroughly.

End frame can be removed from the bearing by keeping the rotor coupling face on the stand and pulling the end frame with the help of sling. First remove from the frame as mentioned above.

Remove end covers and inserts the puller bolts of M20, tapped at both the ends in the inner bearing cap. On the other end put the plate with a hydraulic jack to pull the distance collar, bearing, shrink ring together.

4.3.1 CLEANING

All parts of the disassembled Alternator, including bearing, bearing housing is to be thoroughly cleaned before examination.

Cleaning should be attempted by blowing dry compressed, low-pressure air followed by wiping with clean lintless cloth. Even a stiff Nylon brush or fibre scrapper may be used. In severe cases cloth dampened with solvent can also be used.

CHLORINATED HYDROCARBON TYPE CLEANING SOLVENTS ARE NOT RECOMMENDED FOR USE ON EQUIPMENT BECAUSE OF POSSIBILITY OF INSULATION DAMAGE

CLEANING SOLVENTS MAY BE TOXIC AND/OR INFLAMMABLE. TAKE ADEQUATE PRECAUTIONS AS SPECIFIED BY SOLVENT MANUFACTURES.

Use following cleaners:

a) For insulation: use non-oil quick drying cleaners.

b) For end bearing fits, shafts, metal surfaces use a cleaner which will not leave an oily deposit on the finished surface.

c) For bearings use cleaner which will not completely remove the oil film from finished surfaces. Kerosene, petroleum spirit or petroleum solvents are satisfactory.
Cleaning with steam (alternative method).
d) Heat a washing compound in a steam tank (water and cleaning compound) until the temperature reaches 100 °C.
e) Place the parts to be cleaned in such a position that the steam can be directed from a hose in all directions for cleaning.
f) Allow clean parts to cool and blow compressed air for removing moisture.
g) For electrical components heat them in oven till the moisture is removed.

4.3.2 INSPECTION AND RECONDITIONING:

After the thorough cleaning of all parts, inspect and recondition as follows:

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4.3.2.1 STATOR

After thorough cleaning of stator examine for any loose wedge or damaged insulation or hot spots. If loose wedge is found replace them with new ones giving proper packing beneath them.

If any damaged insulation is noticed on end winding portions, the same can be locally repaired with glass mica tapes and glass tapes.

If a hot spot is noticed on the lead joints, remove insulation and examine the brazed joint. If in doubt re-braze taking adequate protections for surrounding coils by packing wet asbestos putty all around and carry out torch brazing with silphos brazing alloy strip and rod. Re-insulate after re-brazing. Check insulation resistance with a 1000 Volts Megger. IR should be greater than 20 M Ohms. H-V test is to be performed at 1kv for one minute.

If IR is found to be less than the specified limit, when alternator was not in use for a long period of time, for developing the IR, heat the stator in an oven operating at 100 to 110 °C for 6 hours, and check insulation resistance and continue heating till IR is satisfactory.

4.3.2.2 ROTOR

Check the rotor for any damaged or loose coils by tapping the coils using a wooden mallet. Check rotor field coil to coil connections for looseness by tapping.

Rotor insulation resistance to be checked with a 500 Volts Megger. If IR value is more than 20M Ohms no repair is needed to the rotor otherwise it is to be subjected to the following varnish treatment Once again clean the rotor and the rotor coil surface and blow over the shaft barrel.

Heat the rotor in an oven operating at 100 to 110°C for 6 hours.

Check insulation resistance and continue heating till IR is satisfactory. Rotor - 150M ohms, Exciter rotor 50M ohms.

When the rotor is above the room temperature, apply two bricks coats of solvent less resin, all over the rotor pole coils, pole body face and connections ring.
Rotor to be cured at 160□c for 10 hours.

Once again check IR value it should be greater than 40M Ohms.

Apply anti tracking insulating varnish and then rotor is to be cured at 160□C for 6 hours

FIELD CONNECTOR REPLACEMENT:

If any field connector or stator overhang is to be replaced or repaired due to damage or failure, follow the procedure as below:

Cut the Resi-glass binding Tape on the field connector ring at the affected pole coil and remove Resi-glass tape to the extent required. Un braze the coil to coil connector and if the coil to coil connector is damaged, replace it with a fresh one, while replacing ensure the connections are made according to the diagram. See Fig. Stator connection diagram. The bare connector is to be insulated as below:

- One layer half lapped with 0.13mm x 19mm wide kapton mica tape.
- Followed by one layer half lapped 0.038mm x wide P.T.F.E tape.
- Followed by one layer half lapped 0.10mm x 25mm wide Glass tape.
- On the lead to lead insulation between poles use one layer of kapton mica, one layer half lap of glass mica, one layer half lap of glass tape used above.
- Double the above quantity for stator overhang and 3cms on either side of damaged area.

The Resi-glass taping requires curing at 135 °C for 6 to 8 hours and the entire connector ring portion is to be resin treated as mentioned in` rotor reconditioning. During this process remove the diode heat sink as it is not designed for such a high temperature.

RECONDITIONING OF ROTOR FIELD COIL

REPLACEMENT:

If a particular rotor coil is to be dismounted, adopt the following procedure:

a) Mounting of field coil on rotor.

1.0 Place rotor vertically (Bearing end up)

2.0 Open coil to diode wheel connections.

3.0 Unlock and open mounting bolts.

4.0 Remove the coil support by hammering the wedge.

5.0 Isolate the faulty coil leads by removing the insulation and de brazing the joints.

6.0 Remove the tack weld of the mounting bolts.

7.0 Hold pole and coil assembly with a Nylon sling and open pole bolts. Torque required will be around 80 kg-m.

8.0 As pole is directly wound on pole the whole new assembly. Pole is to be replaced in case of faulty pole. Pole is subjected to VPI after forming and consolidation with epoxy resin.

9.0 Check the IR value of the coil it should be more than 150 mega ohms.

MOUNTING OF FIELD COIL

Clean pole body and paint with anti-tracking insulating varnish.

Hold pole assembly vertically up and bring near to shaft barrel. Assemble with pole bolts. Conduct HV test on changed coil at 1.0kV for one minute and then tighten pole bolts with specified torque and tack weld to lock it.

TORQUE IT WITH 80 KG-M
BOLTS M24, CLASS 12.9
LENGTH 140 mm

DO NOT INTER CHANGE ROTOR STRIPS PLACED BELOW THE EACH POLE WITH ONE ANOTHER. AS THIS GOVERNS THE ROTOR DIA VARIATION.

After the field coils are installed, the coils connections are to be completed and the rotor needs to be resin treated in line with the instruction under reconditioning.

Dynamically balance rotor, after the final assembly of diode wheel components. Balance weight can be added on support plate and on coupling face where provision is specially made for this. Balancing should be done at 1100 rpm within 5 GMS of residual unbalance.

4.3.2.3 BEARING COMPONENTS

Examine outer bearing cap, shrink ring, bearing cap for any dents, score marks. If they are of minor nature attend with a oil stone and rinse. If the damage is considerable same are to be replaced with new components.

Examine the followings:

1. Flaking or cracks in the ball path. If found, reject the Bearing.
2. Heavy electrical pitting. If found, reject the bearing.
3. Raised craters around the edges. Stone off (do not file).
4. Mottled distributed pattern of dirt denting. Scrap the Bearing.
5. Evidence of rubbing or turning on the shaft. Look for loose Spacers or interference of the housing parts. If rubbing is Heavy or if there is wear on the shaft, reject the bearing.

Examine the outer race as follows:

Slide the outer ring by hand and if the ball drags, scrap the bearing.

Scrap the bearing if any of the following conditions are discovered on any of the bearing parts.

1. Severe scoring caused by inadequate lubrication.

2. Corrosive pitting caused by moisture or electrolytic action.

3. Break or crack (possibly caused by striking the shafts with a hammer during removal).

4.4 REASSEMBLY OF TRACTION ALTERNATOR

1. Fit the distance collar onto the shaft, if removed, ensuring that it is solidly up to the shaft abutment face.

2. Fit the bearing by heating it to 100 to 110 °C and shrinking onto the shaft (if already removed), when cold. Tap the race to ensure that it is solidly up to shaft abutment face. Put identification marks on both the distance collar and shrink ring.

Rest of the procedure to be followed in reverse as described in clause no 9.1, and of course any other best practices can also be adopted depending on the requirements.

STANDARD REFERENCE CONDITIONS

TEMPERATURE

These alternators are designed for an ambient temperature of 55°C. For marine and other applications where the ambient temperature is greater than 55 °C, the alternators must be derated to ensure that the actual temperature does not exceed the specified maximum, Outputs are normally quoted at 55 ° C. These outputs must be multiplied by the following factors for higher ambient temperatures.

TEMPERATURE (°C)	MULTIPLIER
60	0.95

ALTITUDE

Above 1000m the effectiveness of the air is reduced sufficiently to make derating necessary. For altitudes above 1000m outputs must be multiplied by the following factors.

ALTITUDES	MULTIPLIER
1,500	0.97
2,000	0.94
2,500	0.91
3,000	0.88
3,500	0.85
4,000	0.82

HUMIDITY

Machines are tropicalised and can successfully operate in high humidity levels. Correct choice of the insulating materials and careful assessment of the impregnation varnish system and methods achieve this.

5. ALIGN MENT PROCEDURE OF ALTERNATOR WITH DIESEL ENGINE

1. Rotate the engine freely one or more round complete before alignment.

2. Check the engine crankshaft endplay and note down the end play (x). This should be measured with help of dial bore gauge. Once the measurement is done keep the crankshaft towards vibration damper end.

3. Check the TIR(Total Indicative Reading) of flywheel housing. The check is mandatory if the engine was taken for rebuild and housing was removed.

4. Record dimension “a” by using vernier calliper.

5. Apply little grease on flywheel pilot bore, as the rotor slides in the pilot bore during assembly as a guide.

Preparing the alternator for alignment: -

1. This alternator being a single bearing alternator Never ever attempt to rotate the alternator rotor when it is in uncoupled condition as this may damage the windings of rotor/ stator. Alternator is shipped with rotor locked by shipping bracket.

2. Remove the shipping bracket and mount the flex plates comprising of 8 nos.(1.2 thk) on the rotor by 8 nos hex head bolts M20X55 long and torque them to 100 lb-ft torque. Engage alternator fan with outer diameter of coupling.

3. Place the hand-operated jack properly to lift up the rotor and measure the distance between the rotor and stator frame. This should be considered to be accurate when measurement in all the directions is equal. This exercise should be made with a view to make the rotor shaft horizontal to axis of the alternator/rear bearing.

4. Now measure the endplay of rotor by playing the rotor shaft from rear end, note this play as "y" and finally keep the rotor pushed to the rear end.

5. Measure the dimension "b" with the vernier calliper and note.

Dim "a" stand for distance between alternator stator spigot face & flex plate face, which is fixed on rotor shaft.

Dim "b" stands for distance between engine adopter spigot face & flywheel face.

Shim selection:

1. if a> b then add up the shims between flex plate & Rotor shaft. These shims must have thickness as, 0.1 mm, 0.25 mm, 0.5mm, 1.0mm, and 1.6mm.
2. Thickness of shims to be added :- (a-b) + (x+y)/2
3. Choose the thickness of shims nearest in multiples of 0.1mm so that both rotor and crankshaft are at the centre of the travel in their bearing.
4. Two studs 5/8" unc x 100 mm long are to be fixed diagonally opposite in flex plate mounting hole of engine flywheel.
5. Move/Tilt the alternator to locate studs that are fixed in flywheel, visibly with the holes in flex plate.
6. 16 nos socket head cap screws M16X70mm to be used for holding stator frame of alternator with adopter plate of engine with standard bolt tightening practice (diagonally opposite bolts).
7. Cummins supplied 2 nos out of 8no's hex head bolt 1/2" unc x 3.5 inch to be inserted through alternator fan, flex plate to flywheel. These bolts are to be partly tightened.
8. Both the studs are taken out safely through alternator fan.
9. Remaining all the 10 bolts are to be placed at vacated fixing locations. All the 12 bolts are to be tightened at specified torque value followed by the standard tightening practice.

After assembly of alternator match the load characteristics. If there is an abnormal change in the characteristics, then attention is to be paid on the root cause.

6. PROTECTION OF BALL ROLLER BEARINGS

6.1 GENERAL

The ball bearing incorporated into CG Traction machines is of high quality and adequate capacity as supplied by the leading bearing manufacturers. Every care is taken during assembly to ensure that the correct fitting-tools are employed, and strict cleanliness observed, to achieve long and trouble-free operation of bearings in service.

It is essential that equal care is taken of bearings, which may be subject to removal and replacement during normal overhaul procedures, and of new bearings to be fitted when renewal is necessary.

Bearings seldom break down as a result of normal usage; the most common causes of bearing failure can be traced to mishandling, damage or stress set up during fitting or removal, dirt, corrosion, and over or under lubrication.

ALWAYS CLEAN BEARING COVERS, CAPS AND HOUSINGS BEFORE REMOVING BEARINGS, AND USE CORRECT WITHDRAWAL AND REFITTING TOOLS.

The following information is a general guide to the care and use of roller bearings. More detailed literature is obtainable from the appropriate bearing manufacturers.

6.2 FITTING AND REMOVING BEARINGS

1) The use of a press or extractor is preferable than to a hammer and drift whenever possible. It is also preferable to immerse bearing in oil at a temperature of 100 °C for 25-30 minutes, or place in an oven under the same conditions.

2) If it is necessary to hammer the tool when removing a shaft nut or bearing retaining nut, always firmly support the shaft, to avoid shock-loading the rolling elements or races.

3) Never strike a bearing directly with a hammer; a mild steel or brass drift or tube should be interposed between hammer and bearing. The end of the drift or tube in contact with the bearing should be squared off and free from burrs.

4) Check bearing housings for signs of race creepage.

5) When using presses, extractors or drifts for the fitting/removal of bearings it is essential that no load be transmitted through the rolling elements of the bearing.

6.3 INTERCHANGEABILITY OF BEARING COMPONENTS

Roller bearing components must not be inter changed.

NOTE: Bearing failure can occur as a result of accidental or indiscriminate interchanging of bearing components. The component parts of individual bearings must be kept together at all times and not mixed with other, similar, bearings and bearing components.

6.4 CLEANING AND ANTI-CORROSION TREATMENT

A. General Treatment

Avoid the temptation to spin a bearing after it has been removed from an assembly, and before cleaning; this is to avoid compressing hard particles, which may be present in the lubricant, thereby initiating track defects.

B. Bearings which should not be cleaned

Do not clean bearings, which are to be returned to the manufacturer for defect examination; such bearings should immediately be wrapped in grease-resisting paper and boxed.

C. Cleaning the bearings

The importance of cleanliness when dealing with bearings cannot be too highly emphasised. The parts must be scrupulously clean to enable accurate assessment of serviceability to be made and, if found to be serviceable, it is of equal importance that they be maintained in a clean condition for subsequent build into the assembly.

To minimise the risk or corrosion by handling, it is recommended that, so far as is possible, operators should wear protective gloves during and after the cleaning process.

Bearings or components incorporating bearing surfaces, must in no circumstances be left in a dry condition, or unprotected against corrosion.

Tri-chloro-ethylene, carbon tetrachloride, or paraffin should not to be used for cleaning bearings, as any of these agents can promote corrosion.

D. Cleaning Equipment

Where large numbers of bearings are to be processed it may be advisable to provide separate cleaning, rinsing and inhibiting tanks of a size appropriate to the volume of work. Each tank may be

constructed of mild steel and should be equipped with a drain plug. Wire mesh baskets or platforms should be provided to hold the bearings clear of sediment in the bottom of the tank. The inhibiting oil tank should be heated to 90 ° to 100 °C (194 ° to 212 ° F).

1) Initial cleaning tank

The tank should contain an adequate quantity of white spirit / gasoline and should be drained, cleaned out, and refilled with fresh liquid whenever approximately 100 bearings per gallon of liquid have been processed, or when excessive contamination is suspected.

2) Second-wash tank

Also to contain white spirit / gasoline and to be topped up with fresh, clean liquid to replace drag-out losses.

3) Inhibiting oil tank

The tank to contain inhibiting oil such as shell Ensis 100.

4) Mineral jelly tank

The mineral jelly must be maintained at 80 ° to 90 °C (176 ° to 194°F) and be periodically topped up to replace drag-out losses.

The tank should be cleaned out and refilled with fresh mineral jelly whenever contamination is suspected.

E. Cleaning and temporary inhibiting

To minimise the possibilities of corrosion on the bearing surfaces during cleaning and subsequent inspection, it is recommended that bearings should not remain unwrapped for more than 4 to 5 hours while temporarily inhibited. Bearings should always be immersed in a horizontal position in the cleaning and inhibiting fluids to avoid the retention of air pockets. Rotate the bearings during the cleaning operation.

The following sequence of operations is recommended and should be carried through with the least possible delay between each operation.

1) Wash the bearings in the initial wash tank using a bristle brush to remove all dirt or old lubricant.

2) Remove the bearings from the wash tank and allow draining for 5 minutes.

After the initial wash, carbonised bearings may be soaked in hot mineral oil (90 ° to 100 °C, 194 ° to 212 °F); agitating the bearings slowly, from time to time. Badly carbonised bearings may be cleaned in a strong alkaline solution; see the appropriate manufacturer's instructions.

3) Completely immerse and wash the bearings in the second wash tank.

4) Remove the bearings from the tank and allow draining for 5 minutes.

5) Immerse the bearings in the inhibiting oil tank for temporary protection against corrosion.

6) Remove the bearings from the oil and allow thoroughly draining and cooling in still, dry, dust free air.

At this stage, the bearings should be examined for Defects; however, if some delay between cleaning and examination is unavoidable, the components should be wrapped in grease resisting paper.

F. Treatment of new bearings

New bearings should not be removed from the package until immediately before fitting. It is preferable to remove the preservative from the rolling members and race surfaces by immersion in the inhibiting oil tank as in E5 and 6.

G. Treatment after inspection

After inspection, again wash and inhibit the bearings as described.

If the bearings are not immediately required for fitting they must be wrapped in grease-resisting paper or unsealed polythene envelopes. Bearing may be stored in this condition for up to 14 days.

Bearings to be stored for longer periods should be treated as follows: -

1) Totally immerse the bearings in the mineral jelly tank for approximately 10 minutes.

2) After cooling, dip the bearing a second time into the mineral jelly, remove immediately and wrap the bearing In grease-resisting paper. Store in a dust tight box.

6.5 INSPECTION

After cleaning, bearings should be thoroughly inspected together with associated components, such as seals. The housings and shafts from which the bearings have been removed should also be examined. Thoroughly examine each bearing for visual defects such as rust and discoloration, cracks, wear, indentations and bruising, and track defects. Bearings associated with electrical machines may sometimes be found to contain craters or pits caused by electrical arcing. The craters will have a centre of black, fused, metal. Unless the damage to the rolling element or track is slight, bearings should be rejected.

A. Rust and corrosion

Rust on the rolling elements is not acceptable and the bearing should be rejected. Very light corrosion pitting on the races may be accepted, depending upon the speed and loading of bearings.

B. Discoloration

Slight discoloration of the rolling elements or tracks is acceptable, but if the components turn blue or brown, indicating excessive heat, the bearing must be rejected.

C. Cracks and fractures

In all cases, the bearing must be rejected

D. Flaking

Flaking appears when fragments of material have broken away from the bearing track. Subsequent wear in the bearing due to increasing stresses is accelerated. Then bearing must be rejected.

E. Smearing

Smearing is the result of the balls or rollers sliding rather than rolling in relation to the tracks ocage, causing incipient seizure. The bearing should be rejected.

F. Wear

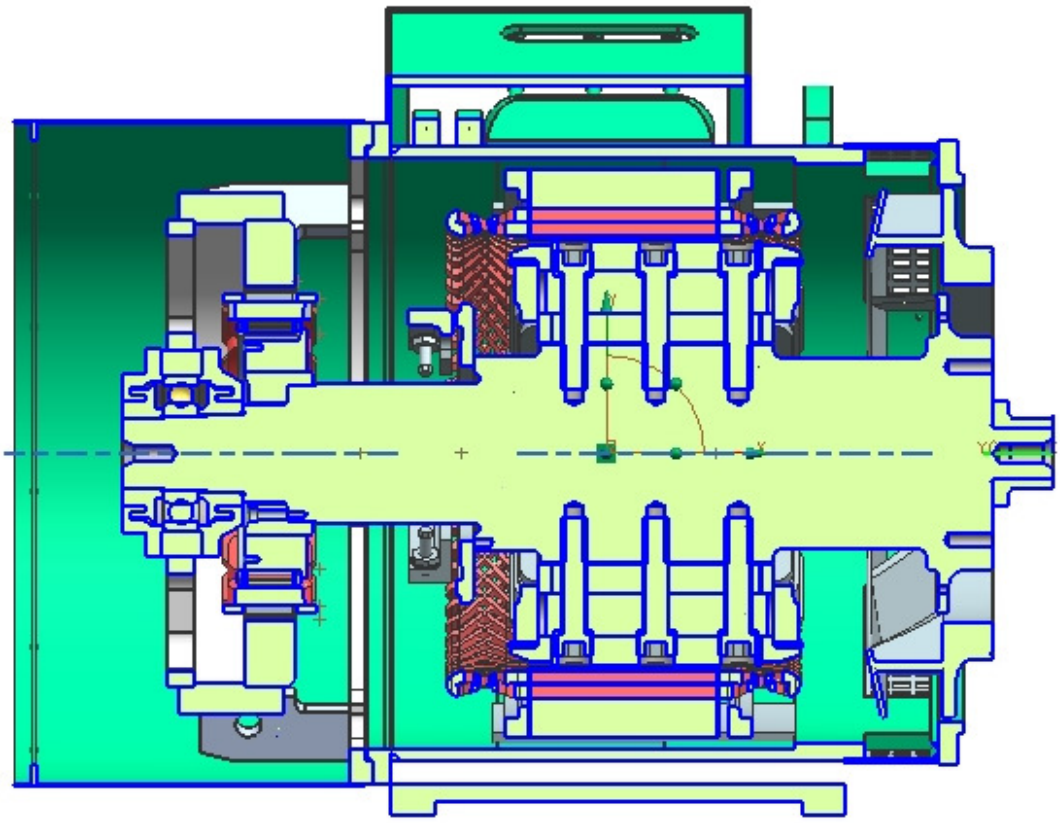
Excessive wear does not occur during normal operation of the bearing. It is generally the result of misuse in fitting, external vibration when the machine is stationary - causing local shock-loading via the rolling elements of the bearing, or the ingress of dirt, inadequate or incorrect lubrication is also a contributory factor.

Non-operating surfaces

(a) Light rust may be removed with fine abrasive cloth, and the bearing thoroughly re-washed as described Shafts and housings The shafts and housing associated with bearings undergoing inspection should be examined for defects. Pick-up or scoring on surfaces, which make contact to the bearing must be rectified by stoning or dressing.

Surfaces, which are worn below the drawing limits, should be built up if possible or the shaft or housing renewed.

7. LONGITUDINAL SECTIONAL VIEW



Longitudinal section of Traction Alternator

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NOTES

CHAPTER VI

POWER RECTIFIER

1. **BRIEF SPECIFICATIONS**
2. **FUNCTION OF THE RECTIFIER UNIT**
3. **DESCRIPTION OF THE RECTIFIER UNIT**
4. **PRE INSTALLTION CHECKS AND COMMISSIONING**
5. **MAINTENANCE**
6. **LIST OF COMPONENTS**

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CHAPTER VI

POWER RECTIFIER

1. BRIEF SPECIFICATIONS

The Rectifier Unit Conforms to Crompton Greaves Specification No. **TE 10002 R0 27.05.2016 and ICF specification ICF/MD/SPEC – 300 R0 DATED 16-04-2016** as per following brief specifications.

1.	Rectifier Type	:	3 Phase Bridge type
2.	No. of Bridge in Parallel	:	Three Nos.
3.	Max. continuous current	:	750 Amps. D.C.
4.	Max. one hour rating	:	1000 Amps. DC
5.	Starting Max. current for 5 Min	:	1200 Amps. D.C.
6.	Max. output voltage	:	900 V.D.C.
7.	Max. Ambient Temp.	:	47°C
8.	Cooling	:	Forced Air
9.	Cooling Blower Supply	:	110 Volts D.C.
10.	Mounting of Rectifier	:	On Board
11.	Dimensions mm. (H x L x W)	:	1695 x 800 x 450 without side panels
12	Weight	:	330 Kgs. Approx

The On-Board mounted Rectifier Unit has been designed to feed the Traction Motor load of the 700 HP DETC. It has been designed to work on 660 Volts max, 3 Phase, 3 Wires AC Input supply derived from underslung alternator. The Rectifier Unit has been designed to withstand shocks and vibrations encountered in service of a rolling stock. It rectifies the three-phase AC voltage into a DC voltage. The equipment meets the requirement of IS: 7788.

2. FUNCTION OF THE RECTIFIER UNIT

The function of the Rectifier is to convert a three-phase supply into DC Voltage, for driving Traction Motors connected in parallel across the Rectifier. Each of the three bridges are protected by Semiconductor grade Fuses at the input. In case of a diode failure, the particular bridge is isolated by its fuses. The other two bridges continue to supply the full load current to the Traction Motors. Hence, n-1 redundancy is built-in. Each of the Main fuses have a smaller fuse called trip-fuse connected across it. When the Main fuse blows the fault current is diverted to these trip fuses. These in turn clear the fault current and in the process operate a plunger, which hits a Micro-switch. This condition stays latched and can be reset only by replacing the Main Fuse and the Trip Fuse. The potential free N/O & N/C contacts of the Micro switches in turn operate a Contactor to give an indication in driver's cabin that a Fuse has blown. In a similar manner failure of a second bridge is indicated by the operation of a second Contactor. In this condition the Control Circuit of the DETC must reduce the maximum load current. A single bridge will no longer be able to carry the full load current of the Traction Motors. **Suitable corrective action must be taken.** The Rectifier is protected at the input and the output by suitable Damping Circuits.

The Rectifier is cooled by forcing air through the fins of the Heat Sink. Force cooling is achieved with the help of a Axial fan arrangement. The Axial Fan operates from 110 VDC Auxiliary Power Supply. The fan, while working, generates a positive pressure inside its casing. This pressure is sensed by a Pressure Switch. In case of

failure of the Axial fan this pressure will drop and is sensed by the Pressure Switch and the information is transmitted to the Control Circuit through its NO & NC potential free contacts.

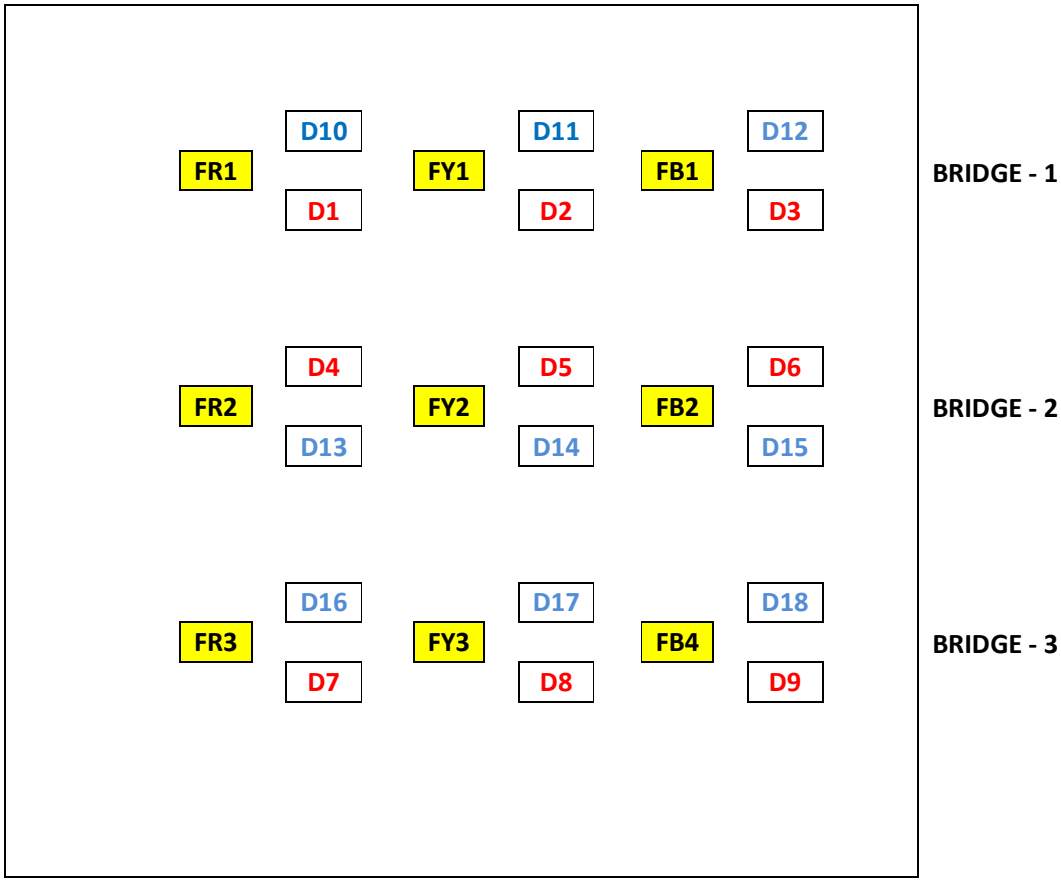
3. DESCRIPTION OF THE RECTIFIER UNIT

The Rectifier has an AC Input and the DC Output terminals are on front bottom side. The Fan draws air from the engine compartment from top and pushes down through the fins of the Heat Sink and is discharged to the atmosphere through bottom floor.

The side panels of the rectifier unit are made of MS with backup of FRP sheet on inner side for creating higher creepage path with live terminals of the unit. These are bolted to main frame.

AC & DC Power Terminals (busbars) are accessible by opening front lower panel and Auxiliary Terminal Board and CT & PT Terminals are accessible by opening rear lower panel.

The Diodes and Fuses are accessible by removing front upper panel. The arrangement is as shown below.



Diodes D1 to D9 – Type OSD 595 N36SQ (With Red cover sleeve)
Diode D10 to D18 – Type OSD 595 P36SQ (With Blue cover sleeve)
FR – Fuses 725 A, 1000 V

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4. PRE INSTALLTION CHECKS AND COMMISSIONING

4.1 RECEIPT INSPECTION

To facilitate transportation, the rectifier unit should be packed thoroughly in wooden crate. On receipt the crate shall be checked for any damage. Any visible sign of damage should be reported to us. After unpacking check the unit internally & externally for any visual damage. Any damage if found, should be reported to us.
.
During the period of unpacking and inspection it must be seen that the unit is not damaged. After unpacking Insulation Resistance and HV Breakdown tests may be performed if necessary.

4.2 INSTALLATION

The Rectifier Unit should be lifted and placed in position using the 4 lifting eyebolts that fitted on top side of the unit. Rectifier Unit should be fixed by the 4 mounting bolts and nuts.

Then connect

a. Input and output cables to the respective terminals
b. 110 VDC supply and Control cables to the control terminal board

4.3 COMMISSIONING

The unit must be subjected to routine checkup including checking of the relevant connections. One has to go through the technical particulars and general feature sections. After checking all the details the Rectifier Unit is ready for use.

Before applying Main AC Power to rectifier, following procedure to be followed.

Axial Fan: The fan speed has been set to give required air flow through rectifier heatsink duct. However it should be checked for air flow from 90 VDC to 125 VDC supply. A potentiometer control has been provided to set fan speed. It can be accessed by opened by removing left side panel.

The fan speed should be set such that at 90 VDC supply it gives minimum 5 mts./sec air velocity through rectifier heatsink duct and should not trip at 125 VDC because of its internal O/L trip mechanism.

Now unit can be energized with 3 Phase AC Supply.

Initially the load may be at half the value for few hours. Check all the components and joints for any abnormal heating or temperature rise or failure. The Load may be gradually increased, in steps till full load is reached. It is suggested to report any abnormal behavior to the manufacturer.

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5. MAINTENANCE

Although due to sufficiently rated quality components and material very low maintenance is required for the unit, but following steps will help in giving trouble free service.

Atleast once a month open the side panels and clean the dust & soots collected on panels and within the unit with dry compressed air or any other suitable means

Check all electrical connections and mechanical assemblies. If found loose, refit it.

Check air speed at outlet of each rectifier duct. It should be minimum 6 mts./ second at outlet.

Check healthiness of rectifier fuses. Failure of fuse will be indicated by ejected plunger of corresponding Trip Indicator Fuse. If found blown, replace both main and trip indicator fuse after rectifying cause of fuse failure.

Clean the Insulators with cloth / brush.

Check conditions of resistors and capacitors. Replace if found damaged.

In case of failure of diode, please follow following removal & refitting procedure.

The fan is brushless type hence it does not need any specific maintenance.

Removal of Diode

Unscrew the lead of diode from busbar.

Remove the diode by removing the Allan bolts using suitable key.

Clean the diode with clean cloth. Check its healthiness. If found defective, use new one to replace it

Mounting of Diode

Clean the base of diode with clean cloth.

Apply a thin layer of silicon oil or good quality contact grease

Clean the surface area of heatsink on which diode is to be placed.

Using same/ same size Allan bolts refit the diode. Initially tighten bolts alternately half to one turn at a time so that diode is clamped with equal force all over. Finally using torque wrench complete tightening of the bolts. The specified torque limit is 1.7 to 2 KN.

Connect the end of lead on busbar.

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6. LIST OF COMPONENTS

S.No.	Item & Type	Manufacturer	Qty./Unit (Nos.)
1	Rectifier Diode Type OSD 595 P 36SQ	RUTTONSHA	09
2	Rectifier Diode Type OSD 595 N 36SQ	RUTTONSHA	09
3	Heatsink Type HT350, 200 mm. long	RUTTONSHA	09
4	Hole Storage Capacitor 0.47 MFD / 2000 V	GE/ ICAR	18
5	Semiconductor Fuse 725A, 1000 V Type 170L 9598	BUSSMANN	09
6	Trip Indicator Fuse Type TI-1200	GE/BUSSMANN	09
7	Microswitch Type : 2K3B033018, 2 C/O	KAYCEE	18
8	Diode Type A3FMR160 for fuse blow supervisory circuit	RUTTONSHA	12
9	D.C. Contactor Type: MN022E - 110V.D.C Coil	L&T/ SIEMENS	02
10	Axial Fan Type A3G 400-BK13-P1 110VDC 0.45 KW	EBM PAPST	01
11	Potentiometer 10K, 1W, 10T (Type 3590) for fan speed Control	BOURNS	01
12	Air Pressure Relay Type : GM-021-00-XB7-5	SWITZER	01
13	Resin Cast Current Transformer 1000 / 5A Type RCT01	GILBERT MAXWELL	01
14	Resin Cast Potential Transformer 1000 / 125V Type RCT01		01
15	Fuse Link 2A , 415VAC Type NSD 2	BUSSMANN	01
16	AC Damping Capacitor 25 MFD / 660 V	ICAR / GE/ YASH	12
17	DC Damping Capacitor 10 MFD / 500 V	ICAR / GE	04
18	Earthing Capacitor 0.1MFD 1200VAC Type FMD 52	El-Ci_Ar	24
19	AC Damping Resistors 5 Ohm / 300 Watts W/W	IRESCO/PEC/ SURE/ KIYOSH	03
20	DC Damping Resistor 2 Ohm / 200 Watts W/W		01
21	DC Damping Resistor 50 KOhm / 50 Watts W/W		01

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CHAPTER VII

TRACTION MOTOR

1. **GENERAL INFORMATION**
2. **TECHNICAL DATA**
3. **CONSTRUCTION**
4. **ERECTION AND COMMISSIONING**
5. **MAINTENANCE AND INSPECTION**
6. **RECONDITIONING AND REPAIRS**
7. **MAINTENANCE SCHEDULE**
8. **TROUBLE PHENOMENON AND REMEDIES**
9. **INSPECTION SCHEDULE**

CHAPTER VII

TRACTION MOTOR

1. GENERAL INFORMATION

The traction motor type TM2141C is a four pole self ventilated machine with a built in fan for DEMU / DETC (Diesel Electric Multiple Unit / Diesel Electric Tower Car) Application. The machine is mounted on the Axle with the help of taper roller suspension bearings. The general information about the traction motor is as illustrated below.

Model	:	TM2141C
Type	:	Self-Ventilated
Field	:	Series Field with Commutating Poles
Field Strength	:	100%
Continuous Rating	:	187 kW (input), 600Volts, 340 Amps, 1520Rpm, (100% Field Strength)
Application Rating (Continuous)	:	111 kW (Input), 327 Volts, 340 Amps, 840 Rpm, 100% Field Strength
Reduction Gear	:	Single Reduction (91/20)
Clearance between Gear case & top of rail with new wheel diameter.	:	140 mm

1.1 FEATURES

- The tractive effort is transmitted from the traction motor to the axle through a single reduction gearing.
- The traction motor is of the Self-ventilation system with the built in Fan sucking air through the Filter Ducting Arrangement.
- The traction motor is of four poles, series wound with commutating poles.
- The Armature and Field windings are of class 200 insulation.
- The tungsten inert gas (TIG) welding is used for connecting Commutator riser to Armature Coil Leads for better reliability.

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2. TECHNICAL DATA

The maintenance of the traction motor should be conducted with respect to the following technical data:

2.1 SPECIFICATIONS

a. Model number	:	TM2141C
b. Type-form	:	Enclosed, Self-ventilated type
		Series excitation with commutating poles
c. Poles	:	4
d. Insulation Class	:	Class-H
e. Continuous Rating	:	187 kW, 600 V , 340 A, 1520 rpm

2.2. RESISTANCE VALUES

		At 20°C	At 115°C
Armature winding	:	0.0114 Ω ± 5%	0.0156 Ω ± 5%
Series field winding	:	0.0128 Ω ± 5%	0.0176 Ω ± 5%
Commutating pole winding	:	0.0084 Ω ± 5%	0.0115 Ω ± 5%

2.3 ARMATURE DETAILS

Core diameter	:	406.4 mm
Core length	:	330 mm
Brg. to Brg. distance	:	795.00 ± 0.20
(Outer face of Distance Collars)		

2.4. ARMATURE BANDING

Material	:	0.33TK x 25 wide (Glass Banding Tape)
Turns on PE winding	:	100 Nos. Approx.
Turns on CE winding	:	100 Nos. Approx

2.5 ARMATURE BEARINGS

		Pinion side	Commutator side
Type of bearings	:	NU324EMC4	NH314EMC4
Manufacturer	:	SKF/FAG or Equivalent	SKF/FAG or Equivalent
Radial clearance of free bearing when new (internal)	:	0.125/0.165mm	0.090/0.125mm

2.6. COMMUTATOR

Diameter when New	:	280 mm
Minimum usable Diameter	:	260 mm
Mica thickness	:	1.0-mm nominal
No. of Commutator Bars	:	200 Nos.
Avg. Voltage between bars	:	12 V.
Reactance Voltage	:	2.3 V at Cont. Rating 3.8 V at Max Speed, Max Voltage Point

2.7. CARBON BRUSHES

Numbers per brush holder	:	2.
Brush grade	:	EG14D
Brush type	:	Split
Brush size	:	20 mm x 40 mm Split x 57 Lg.
Brush spring Pressure	:	Max.3.2kg/brush Min.2.8kg/brush
Brush wear limit	:	Brush rejection length is 32 mm

2.8. BRUSH HOLDERS

Number per motor	:	4
Clearance bottom of brush holder to commutator	:	3 mm Nominal
Sparking tip gap	:	Adjustable, Nominal 12mm

2.9. POLE BORES (AVERAGE)

Main pole	(at center)	:	420.12 mm (Nominal air gap = 6.86mm)
Commutating pole	(at center)	:	412.20 mm (Nominal air gap = 2.90mm)

Tolerance allowed on the Pole Bore Dim is ± 0.2 mm.

2.10. LINER AT BACK OF POLE

Main pole	:	1.0-mm nominal (Magnetic steel)
Commutating pole	:	4.6 mm brass + 2.1 Mag. Steel

2.11. GEAR CASE

Initial charge of Lubrication	:	6.5 Kg Max. 3.5 Kg Min
Type of Gear-case compound	:	HP Gear tak 2. or Bharat Camex Compound .F

2.12. WEIGHT

Motor with pinion	:	1800 kgs.
Armature	:	600 kgs.
Gera Wheel	:	150 kgs.
Gear case	:	90 kgs.

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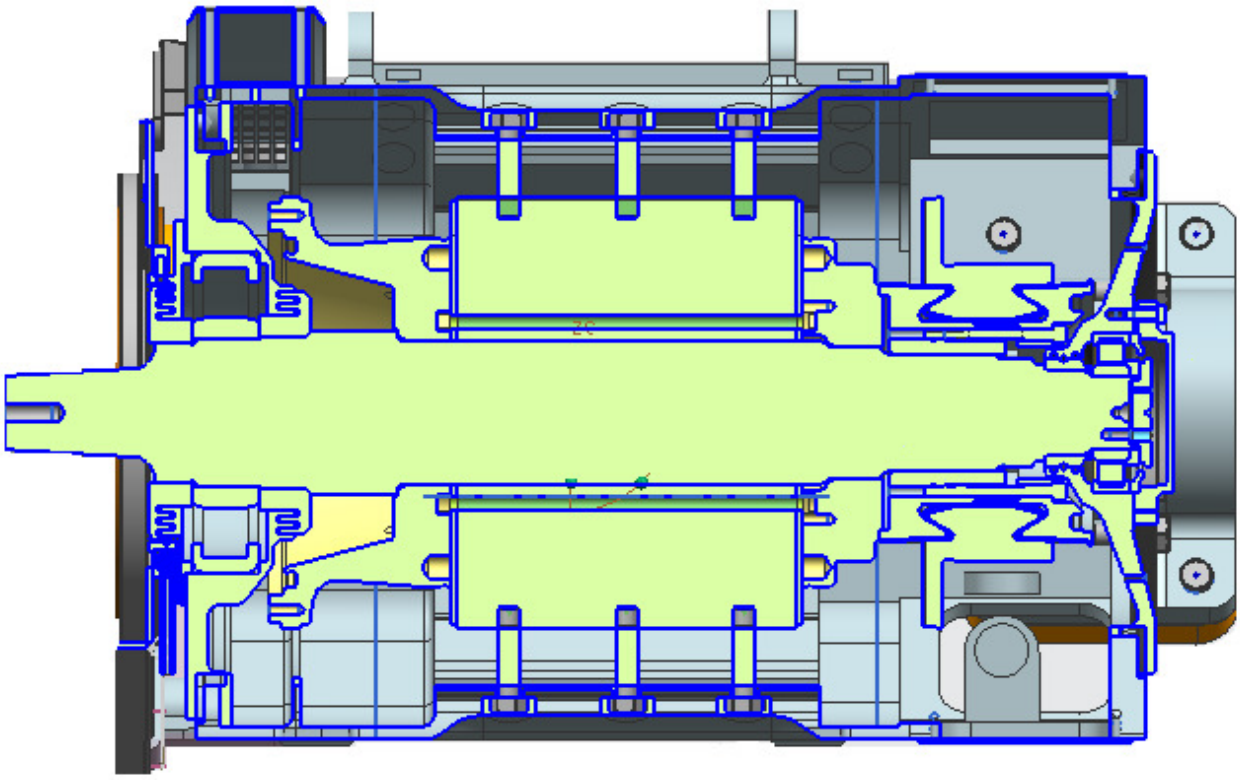
TRACTION MOTOR TYPE TM2141C
LONGITUDINAL SECTION DRAWING



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3. CONSTRUCTION

The basic construction of the traction machine is illustrated in the Longitudinal section drawing indicating the components used. The motor construction can be divided under the following heads.

1) Armature
2) Stator with coils & End-frames
3) Suspension Bearing
4) Gear-case, Gear, Pinion etc

3.1 ARMATURE

ARMATURE SHAFT

The shaft is manufactured & ground from Ni. Cr. Mo. Steel to BS 970 EN-25 "V" Bars forged material, which is ultrasonically tested to avoid any flaws in the raw material for better reliability.

ARMATURE CORE

The Armature core is built up of coated electrical sheet laminations to reduce the eddy current losses.

ARMATURE END-RINGS

The Cast Steel Armature End-ring supporting the Core at pinion end has a mounted lightweight Fan for ventilation. The material of the armature end-ring is forging for withstanding the load. The End-ring on the commutator end is also manufactured from the Forged Material. The fan sucks the air from the commutator end, which travels from the armature core through the End-rings & escapes from the openings provided on the pinion end.

COMMUTATOR

The Commutator is built up with silver bearing copper Commutator bars with the alkyd vinyl bonded mica. Commutator Hub & Commutator End-ring are of forged type. The anti-creepage PTFE Sleeves is fitted on the exposed portion of the Steel Vee-Ring.

ARMATURE WINDING

The armature winding is lap wound type providing four parallel paths. The armature power coil conductors are kapton-covered conductors for better performance. The armature is insulated & wound with class "H" insulation material. The resi-glass banding at both the overhang portions is done with the banding machine under tension. Complete wound Armature is subjected to Vacuum Pressure Impregnation (VPI) in solvent less polyester resin. The Armature Coils are held in the slot portion with the help of slot wedges.

EQUALIZER WINDING

The equalizer winding provides for 50 % Equalization.

ARMATURE BEARINGS

For the armature bearings installed at both commutator and pinion sides, a sealed type cylindrical roller bearing with an additional advantage of intermediate grease refilling systen is employed. At the commutator side, Type NHJ314EMC4 roller bearing is used and at the pinion side, type NU324MC4 is used. These armature bearings can be operated for 3 years duration without dismounting.

ARMATURE BEARING COMPONENTS

The armature bearing-greasing labyrinth consists of forged bearing components accurately machined. The extra firm variety felts are provided in the grooves of the end frames to prevent the lubrication leakage. The distance collars at both the ends are shrink fitted, for the adequate location of the armature roller bearings. The grease thrower at the Pinion end is shrink fitted outside the Bearing Cover P.E for protection against the ingress of dust/Gear Case Compound.

3.2 STATOR

MAGNET FRAME

The magnet Frame is of casted type, with the terminal box provision for the main lead terminations. The frame pole pads are machined accurately to avoid any variations in the pole bores thereby affecting the air gap. The magnet frame is provided with a bracket for vertical mounting of Gear-case which also provides support to the top half of Gear-case.

MAIN POLES

The main pole cores and coils are potted to the core with solvent-less polyester resin for better performance & mechanical endurance. The Main Pole coil is of flat wound type with the frame side coil with 10 turns & armature side coil with 9 turns. The coils are connected by brazing. The two open coils (N-pole) have the terminals integral with them whereas the two crossed coils (S-poles) have terminals brazed with them. The main pole field coils are of construction as illustrated in the fig.

COMMUTATING POLES

The Commutating pole core and coils are also potted with solventless polyester resin. The Compole coil is of 16 turns wound edge-wise. The terminals & connectors are of robust design to avoid the failures under vibrations/impact. The Compole connections are made from the flexible cables.

BRUSH HOLDER AND CARBON BRUSHES

This motor is 4-pole type motor and the brush holders are mounted on the frame pads by bolting arrangements. The brush holders and carbon brushes can be inspected by inspection windows provided. The brush holders are mounted on the frame pads by two insulating rods. The Brush Holders are manufactured from High tensile Brass castings. The Carbon brushes of EG14D are of split type for smooth commutation.

END-FRAMES

The end-frames at both the ends are of Cast steel with the P.E. end-frame having the provision of integral arm with the body for supporting the gear-case.

TERMINAL BOX

The terminal box has been provided in the centre location. The crossover line is fixed to the insulating rod and lead supporter is used at the outlet of lead wires on the fitting-out side. On the reverse of the terminal cover, the packing is stuck to prevent dust from coming into the terminal box. Four Main cables come out in the terminal box which are connected in the sequence of A, AA, FF, F, E when viewed from the front with the Pinion side on the right side & commutator side on the left.

3.3 MOTOR SUSPENSION ARRANGEMENT

The Motor Suspension on axle consists of taper roller bearings and suspension tube. The suspension tube arrangement replaces the traditional use of axle caps & also avoids frequent maintenance. The use of taper-roller bearings in the suspension arrangement allows the motor to run at high speeds.

3.4 GEAR CASE, GEAR WHEEL & PINION

GEAR CASE

The gear compound is filled from the inspection cover installed on the gear case. The Gear case is fabricated type with the assembly in two halves i.e top & bottom half for ease in assembling & dis-assembling. The Top half of gear-case is vertically supported and mounted on frame and end-frame arm PE. The bottom half is horizontally bolted with frame and mounted on end-frame arm on PE side.

EARTHING LEAD ASSEMBLY

The earthing lead assembly is installed on the M8 tapped hole provided on the Magnet Frame.

GEARS & PINIONS

The gear & pinions are manufactured by BS 970 En 354 Case carborised steel conforming to RDSO Spec. MP280009. The gears & pinions are machined in accuracy grade of 6 of BS 235:1987. The gear ratio of 20:91 has been adopted to suit the requirements of the Diesel Electric Multiple Unit application. The Bellow arrangement provides the inlet for the air through the Commutator end, which escapes through the Pinion end.

3.5 EARTH BRUSH AND EARTH BRUSH HOLDER

The earth brush holder is installed in the terminal box of the magnet frame. The earth brush is made of metallic carbon and pressed to the axle by the coil spring.

4. ERECTION AND COMMISSIONING

4.1 COMMISSIONING PRE-CHECKS

Before the motor is mounted on the bogie there are certain checks which need to be performed to assure a reliable service in future. They are mentioned as underneath:-

4.1.1 LIGHT RUN OF MOTOR AT 1000 RPM

Subject the motor to a light run for 30 minutes to check that it runs freely and with quiet bearings. Also record the Bearing temperature at both the ends. The vibration level of the motor should also be within the permissible values of 30 microns.

IT IS NOT ADVISABLE TO RUN BEARINGS AT HIGH SPEED UNDER LIGHT LOAD CONDITIONS FOR LONG PERIODS BECAUSE OF THE POSSIBILITY OF ROLLER SKID, WHICH MAY CAUSE SCUFFING OF THE TRACK AND ROLLER SURFACES.

The motor shall be subjected to a run at no load as per the test schedule & corresponding voltage & current shall be recorded, the readings must be comparable to the values declared in the test results.

4.1.2 MEASUREMENT OF INSULATION RESISTANCE

The Insulation Resistance of the windings of the motor (complete) shall be recorded with 1 kV Megger. In no case the IR Value should be less than 50 Mega-Ohms. In case the value is below the recommended value, the individual windings should be separated & IR value of individual windings should be checked.

4.1.3 MEASUREMENT OF COLD RESISTANCE

The cold resistances of the different windings i.e. Armature, Main Pole and compole windings should be measured with the help of the VI method and the variations in the values shall not be more than 5% of the nominal prescribed values. The Armature winding resistance is measured across the 30 Commutator bars through the inspection window and then the resistance so obtained is to be multiplied by (50/30) = 1.667 to get the complete Armature winding resistance.

4.2 ASSEMBLY AND ERRECTION

As regards the assembly of the various other components on the traction motor i.e. Gear case, Pinion and locking plate, Earthing Brush assembly etc., refer to **Reconditioning and Repairs**. The Earth lead assembly is to be fixed along with the copper washer & M8 bolt on the M8 tapped hole provided on Top of the Magnet frame.

5. MAINTENANCE AND INSPECTION

These checks are to be performed in the condition where the main motor has been installed on the truck.

5.1 BRUSH HOLDERS AND CARBON BRUSHES

The brush holder and carbon brush are important components in particular and have a great effect on commutation. It is therefore necessary to always perform correct maintenance for obtaining normal operation.

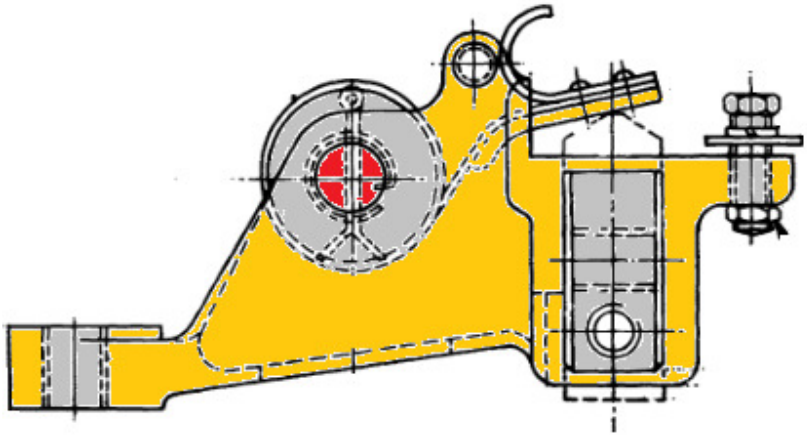
If dust worn powders of carbon brush etc. enter between the holder case pocket and carbon brush and the motor is operated in the sticking state of carbon brush poor contact with the commutator surface is caused and results in poor commutation and/or flash-over from time to time. Therefore, in the check of brush holder, blow out the holder case pocket with air and wipe with a dry cloth carefully.

Contamination of surface of insulating rod may cause a creeping short-circuit. So it should be cleaned by white gasoline-infiltrated rag as frequently as needed.

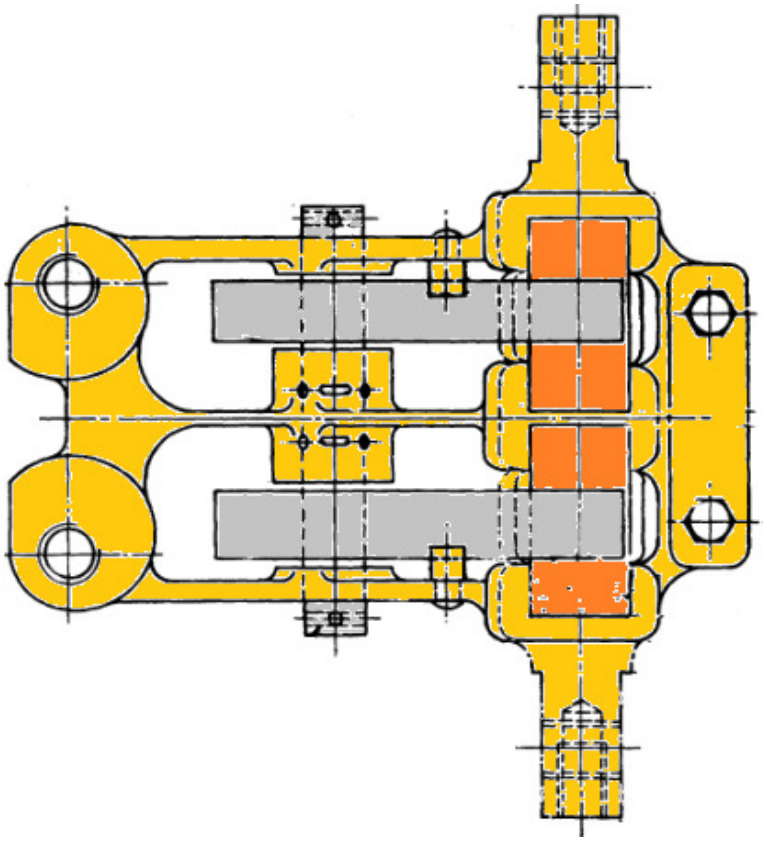
In case that the surface of insulating rod has been roughened by flashover etc. correct with emery paper and clean. If the surface is heavily damaged and cannot be corrected by emery paper and also, crack or seizure is found in the insulating rod, replace with new one.

The carbon brush in the traction motor is tilted, clearance between holder case pocket and carbon brush increases in the revolution. So, check to see as required that the pocket dimension of brush holder case and carbon brush dimension are as specified. If the pocket is found worn beyond the maximum wear limit, replace it with new one.

The quality (material) and shape of carbon brush have a great effect on commutation therefore the specified one must be used without fail. If any carbon brush of different material is used then, it may cause poor commutation, unusual wear, damage of commutator surface etc. So never use any carbon brush made of different material from that in use.



Brush Holder: Side view



Brush Holder: Top view

Check if the carbon brush has such length that it can be used sufficiently till the next check.

Check for Crack in the Carbon brush.

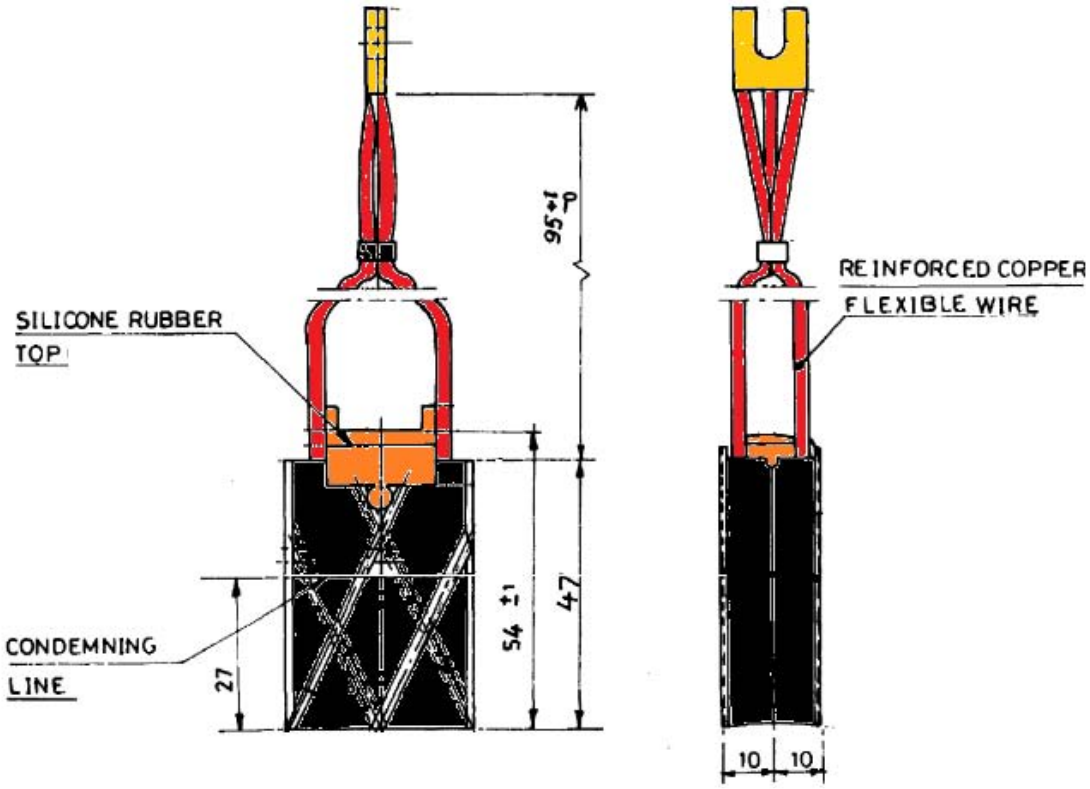
There shouldn't be break of the pigtail (lead wire of carbon brush).

There shouldn't be any looseness, drop-off etc. in the tamped part of pigtail.

The-carbon brush shouldn't be left seized in the holder case pocket.

Contacts of the carbon brush and commutator should be proper in condition.

If the carbon brush can no longer be used till the next check because of wear, replace it with new one. If the dimension is found equal to 37 mm during the check of carbon brush, it may wear down to 32 mm-wear limit, before the next check comes round. All such carbon brush should be replaced.



Carbon Brush

After inserting the carbon brush into the pocket of brush holder try to move the carbon brush up and down and make sure that it moves smoothly.

When setting the brush spring after inserting the carbon brush into the brush holder be careful so that the lead wire (pig tail) of carbon brush is not caught by the spring.

When the worn out carbon brush has been replaced with new one, make slide fitting so that the carbon brush contacts the commutator surface correctly. For making slide fitting of the carbon brush, move emery paper along the commutator surface with the sand side of the emery paper applied to the brush and repeats this procedure a few times.

HANDLE GENTLY IN MAKING SLIDE-FITTING TO AVOID DAMAGE TO THE COMMUTATOR SURFACE.

After completion of the slide-fitting blow away brush powder with compressed air.

Tighten the terminal bolts of carbon brush lead wires securely.

The brush holders are fitted on the Magnet frame Brush gear mounting pads. Carbon brushes can be inspected through the Inspection Cover openings provided on the frame. The latch type inspection covers provides access to the brush holders.

DO NOT RELEASE THE BRUSH SPRING FROM HAND SUDDENLY OR DO NOT DROP THE SPRING OFF THE SPRING SUPPORT. THIS MAY BREAK THE CARBON BRUSH.

5.2 COMMUTATOR

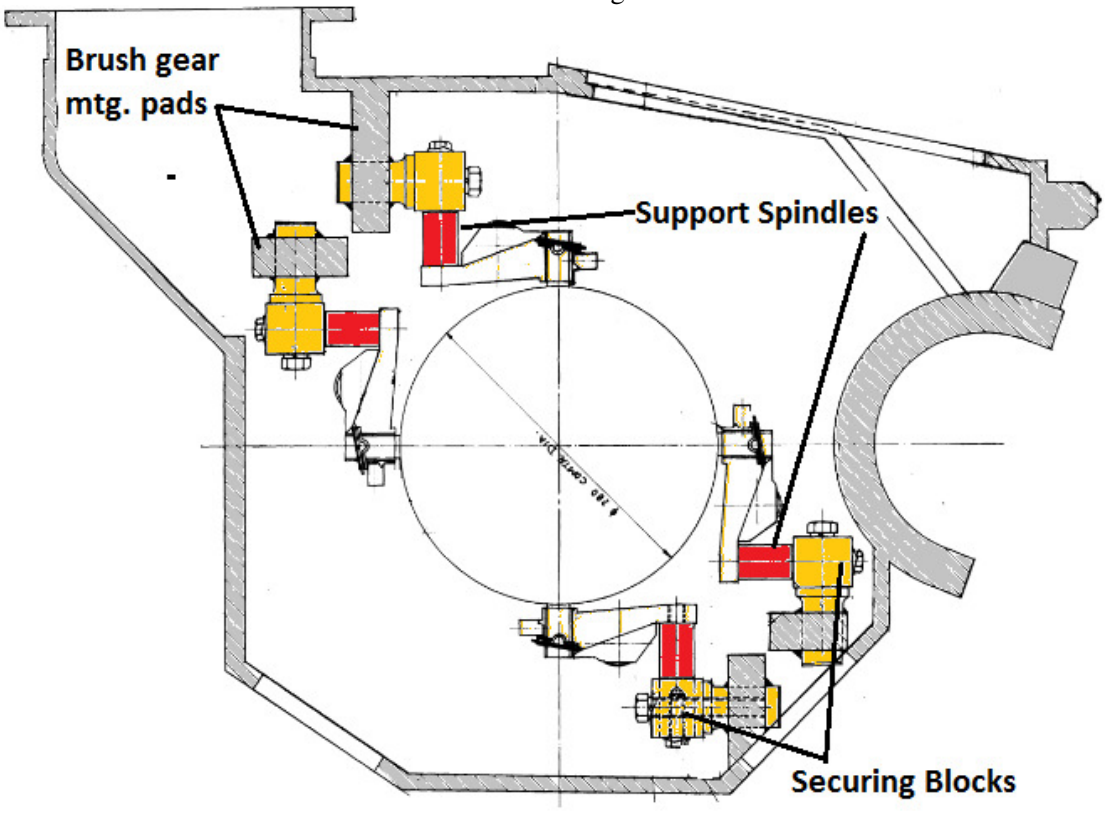
As long as commutator is operated in good condition a film with a certain luster is formed on the commutator surface. However, if a brush made of different material is used or dust gets on the surface, ideal film won't possibly be obtained. Unless otherwise wear of the brush, rough surface of the commutator, stepped wear of the commutator, etc. are caused, there is no need to be concerned about the film on the commutator.

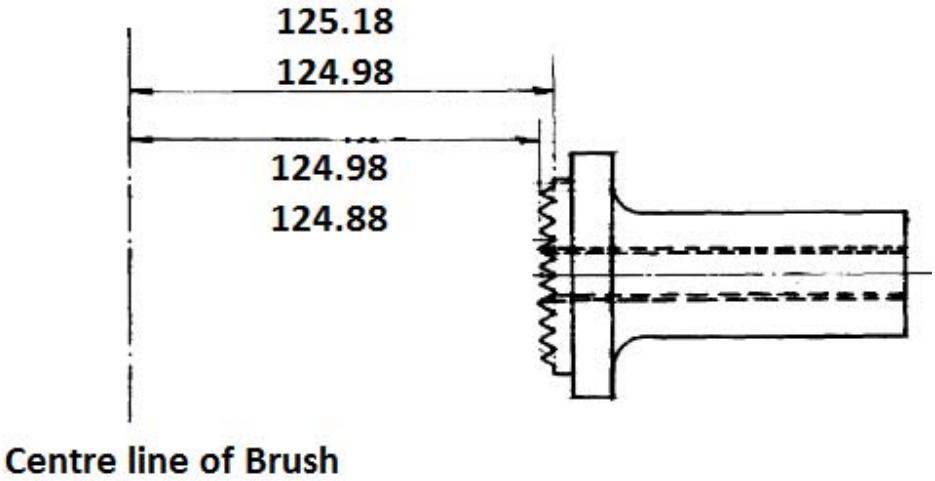
Moreover, if such abnormalities occur, perform the maintenance of commutator. Moreover, after turning the commutator the gap between the commutator and brush holder shall be ensured by shifting the support block for the brush gear assembly towards the commutator side along the oblong hole provided in the support block and then ensuring the torquing of around 12kg-m.

The securing block is welded on the brush gear mounting pads on the traction motor magnet frame which become integral with the magnet frame. Also the securing block and the support block have serrated faces (16 T.P.I) for ensuring proper grip.

The anti-creepage PTFE coated support spindles support the brush holders on the support block. Also the

sparking tip arrangement is provided on the brush holders and end frames with a nominal gap of 12 mm. The dimension of the center line of the carbon brush from the top of the serrations of the securing block is critical and should be maintained as shown in the fig.

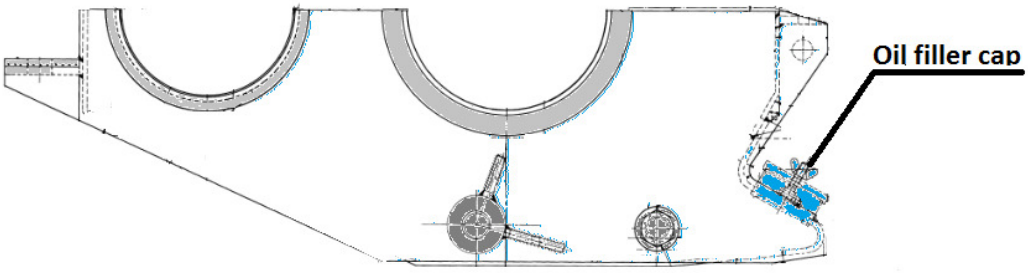




5.3 GEARCASE AND LUBRICATION

The maintenance checks of gear case and gear lubrication oil should be made placing importance on the following aspects:

Open the Oil filler cap & check the Gear compound level.



Gear Case – Bottom half

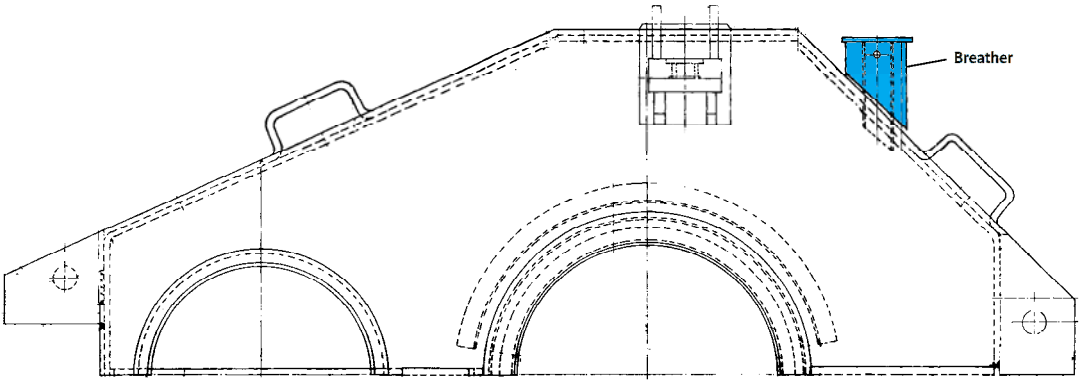
When checking the Gear Compound level, if it is checked immediately after stop of the train, it will be felt as if the gear compound is short. So, check the level after 20 to 30 minutes have elapsed, so that the complete compound collects in the Gear case.

When supplying the compound, heat it to 60 – 80 °C (so that it can flow smoothly)

After the gear oil has been supplied, keep it for 20 to 30 minutes with the motor left in its stationary state, and then check the compound level.

Check to see that there is no leakage of the gear compound. If any leakage of the gear compound is discovered or consumption of the compound is considerably heavy, the felt sealing of gear case might have worn off. So, check for drop - off of the sealing by removing gear case.

Check for obstructions of the breather. If it is discovered clogged with something, blow it out with air.



Gear Case – Top half

Check for looseness of the gear case mounting bolts and for cracks in the gear case.

5.4 GEARCASE CHECKING

During the first few weeks in service, check the level of lubricant every week on several vehicles and look generally for any sign of leakage. All checks should be carried out with the Gear case warm after a run, but after allowing a short period to settle the lubricant. Continue these weekly checks until the lubricant level has fallen to the minimum permissible as indicated by the dipstick, note the time lapse. The shortest time interval on the representative batch of vehicles may be used as a basis for the lubrication schedule, after allowing a safety examination. Thus, if the shortest time interval is two months, specify topping up at monthly intervals.

5.5 ARMATURE BEARINGS

Since the armature bearing is an important mechanical part, it must always be kept in good lubricated state. For this, a regular maintenance is essential. In the routine check, check for unusual sound, oil leak etc. during rotation of the bearing and re-supply grease every year. At the time of overhaul, exchange the whole grease.

SOUND OF BEARINGS

a. In the operation, always pay attention to the working sound of the traction motor and if any unusual sound and/or vibration are observed, stop the operation immediately, dismount the motor and look for the real cause carefully.

b. When the traction motor is removed from the truck be sure to perform the running light test of the motor and check for unusual noise. Check for the noise applying a noise detector bar to the outside

of side cover nearest the bearing at both pinion and commutator sides. In this case even for other few motors check for noise. When comparing the working sound of these motors with each other, it can be judged easily whether the sound is different from the usual one.

5.6 REFILLING OF GREASE

a. The grease to be refilled intermediately should be of the same kind as that used in assembly.

b. The intermediate refilling intervals and the amount of grease refilled should be as described in the **Chapter Reconditioning and repairs.**

5.7 EXAMINATION OF GEARS

Whenever a gear case is removed from a motor, examine the gears carefully. They should be coated uniformly with lubricant, which should show no sign of being contaminated with dirt or water.

If the gears are to re-enter service immediately clean thoroughly using xylol or a similar solvent applied with a brush. Wipe with a cloth afterwards. If the gearwheel is likely to stand for a time, clean only ten to twelve teeth spaced equally round the periphery, leaving lubricant on the reminder of the gearwheel as protection. After examination, if the condition of these cleaned teeth is satisfactory, recoat them with gear compound.

The teeth should be free from cracks and the flanks should have a uniform, unscored polished appearance. The tooth profile should be substantially the same as that of a new gear. If a gearwheel has chipped, broken or badly worn teeth discard it and fit a new gearwheel.

Ensure that, as far as possible, gearwheels are returned to service with the pinions with which they were meshed originally. Do not over fill the gear case, which may flood the PE armature bearing and cause premature bearing failure. Use the opening provided on oil filler unit for measuring the maximum lubricant level.

ENSURE ALSO ON NO ACCOUNT, LUBRICANT LEVEL GOES BELOW THE MINIMUM LEVEL. USE DIPSTICK FOR MAINTAINING MINIMUM LEVEL.

Gear and pinion is to be critically examined before allowing them further for service.

PRECAUTIONS

Whenever a gear or pinion wears significantly there is step created near the root of the tooth where the

tip of the mating tooth runs out of engagement. If the gear center distance is exactly correct, this step will occur at the lowest point of contact between the mating teeth. However the gear center distance cannot be controlled exactly in service due to axle bearing wear. As the gear center distance spreads, the teeth become further out of alignment, this forms step at varying depths.

If the same gearings are used there will be very severe tip loading of the tooth and very poor profile at the root end of the tooth. This can cause severe noise, vibration and premature failure. The step is to be dressed up with the help of small hand grinder. Care should be taken during the grinding operation not to under cut the tooth. Step should be removed before checking the profile of the tooth by profile gauge otherwise faulty readings will occur.

GEAR TOOTH WEAR

Gear tooth wear is measured by scaling the width of the land or tip of the tooth. The gear wheel and pinion should be removed from service when width at tooth tip or maximum wear per flank measures less or more respectively than the following limits:

Gear Wheel		**Pinion**	
Min Tip Width	Max. wear per flank	Min.Tip Width	Max. wear per flank
1.8 mm	1.8 mm	0.8 mm	1.8 mm

PROFILE DEVIATION LIMIT

The maximum profile error on any worn gear wheel when checked by a profile checking gauge should be within 0.2 mm to 0.4 mm Gears/Pinions having more deviation in profile than above should not be used.

Feeler gauges of .05, .1, .15, .2, .25, .3, .4 mm thickness may be required for this purpose. Profile checking gauges can be made as per the instructions given below:

Instructions for Making Gear Tooth profile gauge (using a new gear as a pattern)

1. Be sure that the gear used as a pattern is new. The gauge can only be as accurate as the gear from which it is made. The gear should be thoroughly cleaned before using as a pattern.

2. Make a "partial" mould. The gear itself will complete the mould.

3. Wax all surfaces, which will receive the moulding compound with silicone wax CP mould release. This material is made by the Chemical Development Corporation 53 endicott St. Danvers, Mass U.S.A.

4. Lay the pinion or gear on a flat smooth waxed surface with the bore vertical. If a table is not available make a flat plate and clamp it to the side of the gear or pinion.

5. The pinions are made with tapered teeth that are the tooth is thicker at the outboard (small-bore) end than at the inboard (large bore) end. The pinion should be laid on the flat surface, with the outboard (small-bore) and face down. Thus the gauge will be moulded to fit the thicker end of the tooth.

6. Place the partial mould in position against the tips of the teeth. Make sure that all the surfaces that will contact the moulding compound have been coated with wax as described. The partial mould and the pinion should be clamped in position with "C" clamps to prevent anything from disturbing their position during the hardening process.

7. Mix eleven (11) parts of Ren Die Surface Coat RP-3260-B with one (1) part of Ren die Surface Coat Hardner RP-3260-B by weight. These materials can be obtained from Ren Plastic Inc. P.O. Box. 1256, Lansing 4, Michigan, U.S.A.

8. This is a modified epoxy resin which has a pot life of about 30 minutes at room temperature after the hardener is added.

OBSERVE THE PRECAUTIONS STATED ON THE CAN, ESPECIALLY AVOIDING ANY CONTACT WITH THE SKIN.

9. Pour the thoroughly mixed resin into the mould until full. Allow the mould to set for several hours, preferably 12 hours or more.

10. Remove the parts of the mould the pattern pinion or gear the partial mould and the plate, if one was used. Care should be taken to slide the plastic off the end of the gear teeth so as not to disturb the profile surface of the newly moulded gauge.

6. RECONDITIONING AND REPAIRS

6.1 REMOVAL OF PINION FROM SHAFT

Two methods of pinion removal have been arranged

(1) Injection method
(2) Mechanical

The second method is intended to be used when the injection equipment is not available. When using the injection equipment, it is not necessary to remove the armature from the magnet.

a. REMOVAL OF PINION USING INJECTION EQUIPMENT

This method is recommended for the withdrawal of the Pinion from the shaft, as it is superior to the mechanical method of withdrawal.

Special Tools Required: Injection Equipment.

TO PREVENT PERSONAL INJURY, SOME LOCKING DEVICE/PLATES SHOULD BE USED, TO RETAIN THE PINION AS IT RECOILS DURING THE RELEASE PROCESS.

Couple up the injection equipment. Prime the pump with glycerine and continue pumping until the pinion releases.

Disconnect the injection equipment from the shaft and remove the pinion. Blow out the holes in the shaft and fit the plug for protection.

Glycerine is used by `Brush', but the standard recommended use is oil.

b. REMOVAL OF PINIONS MECHANICAL METHOD

This method is not recommended for the Pinion withdrawal.

Special Tools Required: Withdrawal Tackle, Packing Peg, Hammer etc.

Attach the withdrawal tackle to the pinion, tighten the nuts on the studs and strike the release pawl with a heavy lead hammer, tightening the nuts until the pinion releases.

IT IS NOT ADVISABLE TO STAND IN LINE WITH THE SHAFT DURING WITHDRAWAL OPERATION SINCE THE RECOIL, WHEN THE PINION IS RELEASED MAY CAUSE PERSONAL INJURY.

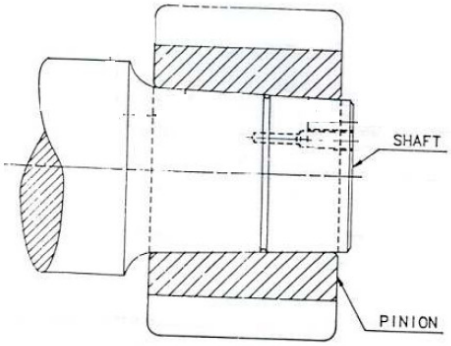
6.2 MOUNTING PINION ON SHAFT

When mounting the traction pinion on the shaft, great care must be taken and the following procedure should be adhered to: -

Ensure that the shaft and bore of the pinion are free from burrs and irregularities; these should be polished out with grinding paste. Remove any sharp edges from the oil distribution channel on the shaft.

Thoroughly clean the injection holes and fitting surfaces with white spirit.

Check the bed of the fitting surfaces using a light smear of Prussian blue paste. A minimum of 85% bed uniformly distributed is required and should be obtained without lapping. Remove the pinion and thoroughly clean the bore and shaft.



Gently "feel on" the pinion ensuring that it is home on the taper.

Using suitable gauges, measure the dimension between the end of the shaft and the face of the pinion. Record this figure for comparison purposes after final pinion fitting. Suspend the pinion in a thermostatically controlled, free circulating oven or use Induction Heater to attain the above temperature on Pinion Bore. Heat the pinion to a temperature of 140 °C to 160 °C above ambient, for at least 6 hours in the Oven.

Remove the pinion from the oven, quickly wipe the bore clean and slam the pinion on the shaft. Allow the shaft and pinion to cool to room temperature. Measure the distance from the end of the shaft to the face of the pinion and subtract this dimension from the one previously recorded. The figure obtained is the advance of the pinion along the taper and must fall between the limits 2.6 mm to 2.9 mm. If the correct advancement is not obtained, remove the pinion and reheat, making the necessary temperature adjustment. Fit the nylon plug in the injection hole.

6.3 WITHDRAWAL OF ARMATURE FROM MOTOR FRAME

Special Tools Required:

- Outer Race Retaining Ring,
- Guide Plug
- End frames Support Tackle

Clean all external parts of the motor before proceeding to dismantle. Lift all the brushes and wrap suitable protection around the commutator face.

At the commutator end remove the bearing cap, using three M12 forcing off screws, the clamping plate, locating ring and grease deflector.

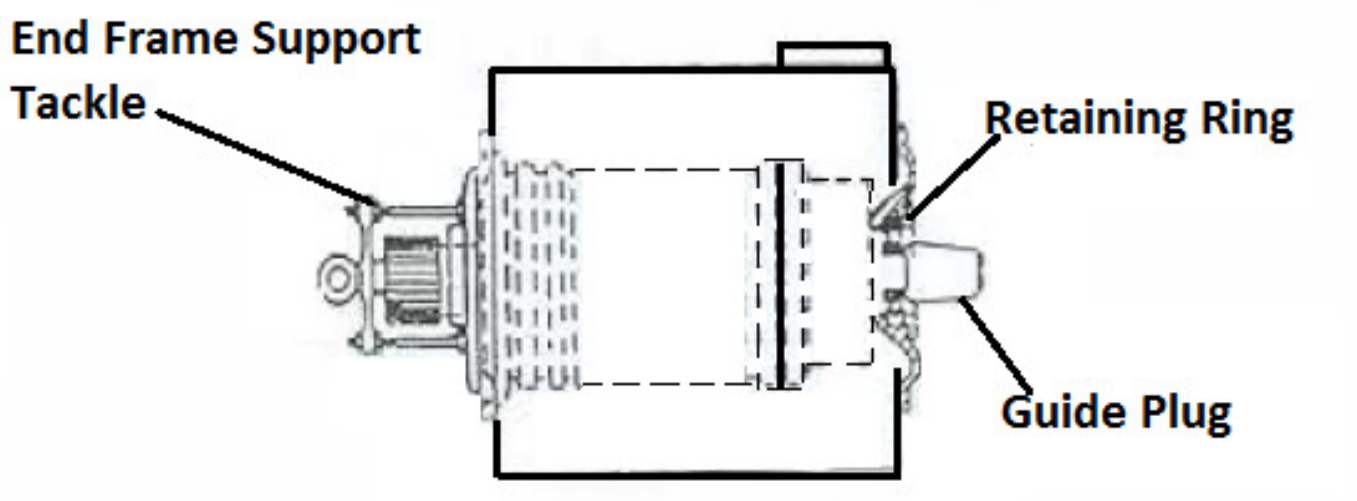
Fit the outer race retaining ring and armature guide plug.

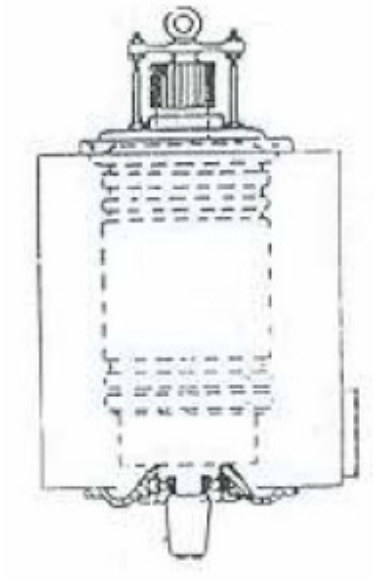
Fit the lifting eye adapter, End frame support tackle and the lifting eye. Turn the motor on end, commutator end downwards, and rest it on suitable packing blocks. Using a spirit level accurately set the motor axis vertically. Attach crane hook to the lifting eye and raise crane sufficiently to take up the strain.

Unlock and remove the six M20 screws and lock washers securing the pinion end to the motor frame.

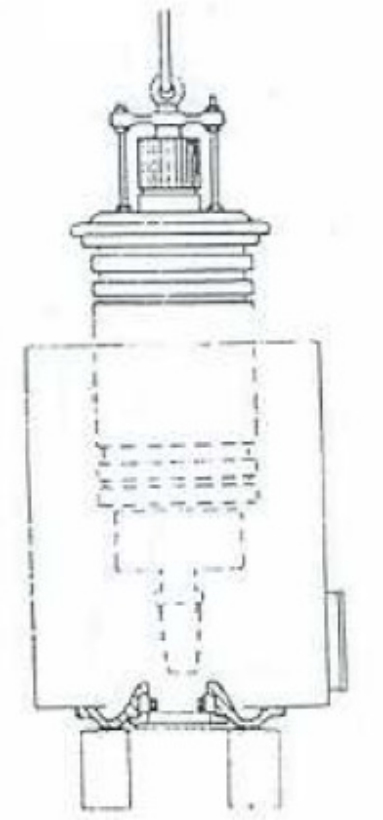
Use three M20 screws to jack the endframe spigot clear at the same time raise the crane to take the weight of the armature.

When the end frame is clear of the motor frame, carefully lift the armature clear and place it horizontally on timber blocks, approx. 350 mm high.





Motor raised in vertical condition



Armature being lifted from Stator

6.4 EXTRACTION OF PINION END ARMATURE BEARING

Special Tools Required:

- Outer Race Bearing Withdrawal Tackle
- Race Bearing Withdrawal Tackle.

Withdraw the armature from the motor frame, using the procedure described in the previous section.

Dismantle the armature lifting tackle, and remove the pinion from the armature shaft, as described in the relevant section.

Remove the bearing cover using two M12 forcing-off screws.

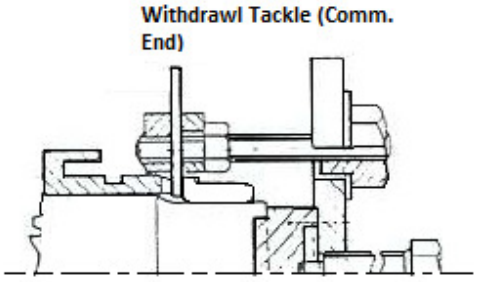
Release the grease thrower from the armature shaft using injection equipment.

Remove the grease deflector.

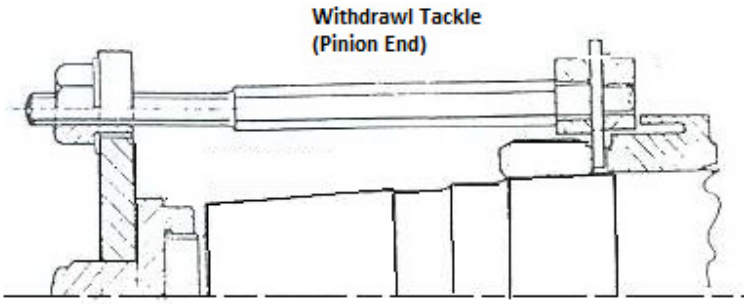
Slide the end frame off the armature shaft. The bearings outer race and roller cage will come away with the housing, leaving the inner race on the shaft.

Fit the outer race withdrawal tackle. Ensure that the claws remain correctly located, while extracting the bearing from the endframe, otherwise the rollers will be damaged.

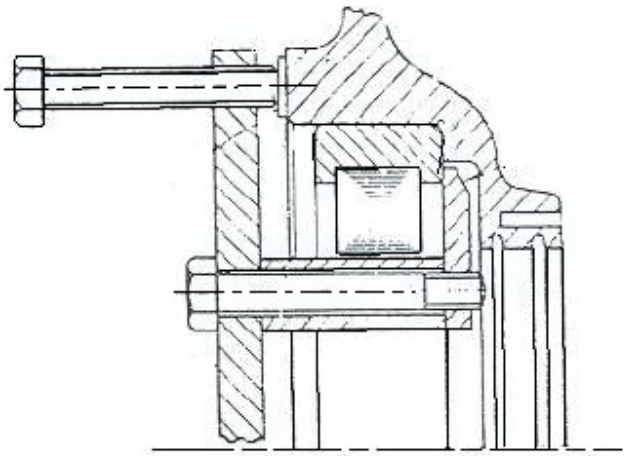
To remove the bearing inner face from the shaft, the withdrawal tackle should be assembled as shown. Ensure that the billets remain securely clamped in their correct positions while the withdrawal nuts are progressively tightened.



Inner race removal (Commutator End)



Inner race removal (Pinion End)



Outer race removal (Pinion and Commutator End)

6.5 ASSEMBLY OF ARMATURE BEARINGS

Ensure that the bearing housing of End frames is perfectly clean and free from caked grease etc. Check the felt grease seals in the outer race pressing ring (PE), and replace if necessary. The felts must be cut accurately and square (6mm x 6mm). When fitting, secure them in the grooves with Anabond binder or some adhesive. Allow some time for the adhesive to set, then lightly oil the felt seals with lubricant.

NOTE: It is essential that the procedures referring to roller bearings be observed.

1. Fill the bearing housing cavity with grease.
2. Thump grease between the rollers and onto the cage at the back of the bearing.
3. Fit the bearing in to the housing with the identification marks facing outwards.
4. Ensure that the outer race is pressed right home to the locating shoulder.
5. To fit the inner race, heat it to 90 - 100 °C by immersion in an oil bath.
6. Ensure that the shaft seating is clean and unblemished and slip the race into position while hot.
7. The race to be fitted with identification marks outwards.
8. Hold the race in position against its distance collar until it has contracted sufficiently to grip the shaft.
9. Using a tabular drift, tap the inner race when at ambient temperature to ensure that it is hard up against the distance collar.
10. The PE and CE distance collar may be machined in the assembled condition on the shaft to maintain the perpendicularity and the bearing to bearing distance (see TECHNICAL DATA) for achieving limited value of bearing run-outs.

RECOMMENDED BEARING GREASE FOR THE ARMATURE BEARINGS

1. TYPE:-SERVOGEM RR3 OF IOC OR HP LITHION 3

   QTY. OF GREASE (FOR INITIAL FILLING)

   PINION END : 0.400 kgs approx.
   COMMUTATOR END : 0.165 kgs approx.

2. REPLENISHING QUANTITY & PERIOD

   PINION END : 0.06 kg approx. (every 4 months)
   COMMUTATOR END : 0.03 kg approx. (every 4 months)

6.6 BEARING ASSEMBLY WITH END FRAME

Special Tool Required: Endframe Support Tackle.

If it was necessary to dismantle the pinion end bearing, fit the Pinion end frame, with outer race and roller cage assembled, on to the armature shaft, and carefully slide the rollers on the inner race. Thump grease between the rollers and onto the cages at the front of the bearing.

Fit the grease deflector and pack the space between bearing and deflector with grease.

Heat the grease thrower to 125 °**C** above ambient and fit it on the shaft to abut against the bearing inner race. Retain the grease thrower in this position until it has cooled. Ensure that the bearing cover is clean and the grease drains clear. Apply 'jointex' sealing compound & packing (Nitrile Rubber) to the joint faces of the endframe and bearing cover and secure the cover with M12 screws and spring washers. Fit the endframe support tackle and lifting eye.

6.7 ARMATURE ASEMBLY INTO MOTOR FRAME.

Special Tools Required:

- Outer Race Retaining Ring
- Guide Plug.

1. Fit the CE endframe spigot, with outer race and roller cage assembled, in to the motor frame.
2. When the end frame is fully – home, secure with M20 screws and bend the locking washers.

3. Fit the outer race-retaining ring to the End frame.

4. Turn the motor frame on end, commutator end downwards, and rest it on suitable packing blocks using a spirit level, accurately set the motor axis vertically. Fit the armature guide plug to the shaft. Attach a crane hook to the lifting eye on the armature and lift the armature to a vertical position.

5. Carefully lower the armature into the motor frame, ensuring that the rollers do not damage the inner race at the commutator end.

6. When the pinion end frame spigot enters the motor frame, pull it fully home by means of the five M20 fixing screws secure the screws by use of locking washers as shown.

7. Carefully turn the motor to the horizontal position, and remove all tools and lifting tackle.

8. At the commutator end, thumb grease between the rollers and into the cage at the front of the bearing. Fit the grease deflector and locating ring, and fil the cavity between this and the grease deflector with grease.

9. Secure the clamp plate to the shaft with the M12 screws and locking plate and turn up the corners of the plate.

10. Fill the outer bearing cap with grease, and apply `Jointex' sealing compound to the joint Surfaces of the bearing cap and End frame.

11. Secure the cap with M12 screws and spring washers.

12. Remove protection from around commutator face lower the brushes and check bedding. Mount the pinion on the shaft, using procedure described.

6.8 REMOVAL OF BRUSH GEAR ASSEMBLY

1. Lift the springs and support them on the cylindrical pins on the Brush Holder body. Now remove the pigtails of the brushes from the Brush holder by loosening the screws then carefully remove the carbon brushes.

2. Remove Screws and washers from the brush holder mountings and detach the cable terminals from the brush gear.

3. Remove Screw and washer and detach the brush gear assembly (excluding the Securing block, which is welded on the frame pads) from the magnet. When the new Brush Gear Assy is mounted on the frame it should be borne in mind that the brush holder pocket centre line exactly coincides with the main pole centre lines.

4. Unlock and remove the Screws and spring washer securing the insulating support spindles with sleeves, to the support block.

5. Remove the insulating support spindles from the brush holder. The support spindles (insulating rods) are fixed in the support block counter bore dia for better grip.

6.9 ASSEMBLY OF BRUSH GEAR

To assemble the brush gear to the magnet frame as per procedure explained above but in reverse order. Ensure that the insulating rods are clean and dry and the set screws are secured.

Remove protection from around commutator face.

Fit and lower the carbon brushes and retains them with the pressure springs. Also screw the pigtails of the Carbon brushes on the provision made on the Brush holder body. Carry out the bedding of the brushes, as per the standard practice followed in the Conventional Motors of Railways.

6.10 REMOVAL OF FIELD POLES FROM MAGNET FRAME

The main pole coils and interpole coils are resin bonded (Potted) onto their respective pole bricks, & if required to be replaced, must be essentially replaced by a wound brick assembly.

DO NOT DISTURB THE POLES AND CABLES UNLESS ABSOLUTELY NECESSARY. BEFORE DISTURBING THE POLES, MEASURE AND RECORD THE MAIN POLE AND INTERPOLE AIR GAPS TO ENSURE THAT THE MOTOR IS REBUILT WITH THE ORIGINAL GAPS.

The air gap is half the difference between the armature and pole face diameters. The tolerance allowed on the air gaps (armature side) is ± 5 % approx. from the nominal value Remove the insulation tape from the coil terminals. Remove the set screws and washers and detach the cable terminals. Remove the set screws and washers and detach the poles.

6.11 ASSSEMBLY OF FIELD POLES FROM MAGNET FRAME

ENSURE THAT THE MAIN POLE ON THE SUSPENSION TUBE SIDE IS MOUNTED WITH SPECIAL REDUCED HEAD BOLT. ONLY.

Also proper recommended torque level should be applied on the Main pole & Compole mounting bolts. Also, proper recommended torque level should be applied on the M.P. and C.P. Mounting bolts. After assembly, mounting bolts shall be locked with the help of the rectangular locking pieces in the counter bore dia. & then the RTV compound should be filled to avoid any dust ingress through the counter bore area.

Secure the main poles and interpoles in their correct positions in the magnet frame, with Mounting Bolts and washers. Measure the armature air gaps and ensures that the dimensions previously recorded are maintained and the pole spacing equalized. When the poles are correctly positioned and secured, tack weld the locking bar in the counter bore to lock the Main Pole & interpole Mounting Bolts.

Secure the cable terminals with Screws and washers (Plated only), and tape the terminals with Silicon rubber Tape - two layer half lap to overlap the cable insulation by 50 mm followed by one layer half lap glass tape. Now shrink the Silicon Rubber tubes on the exposed portions. Apply insulating varnish over the connections and cable. Check the cable insulation with a 1000-volt Megger. This should not be less than 2 Megaohms when cold. Check field system polarities with a compass.

CABLES AND CONNECTIONS MUST BE INSULATED FROM EACH OTHER AND HELD CLEAR OF THE ARMATURE.

6.12 REMOVAL OF GEAR CASE

1. Remove all the old lubricant and dirt from used gear case with a steam lance or a caustic solution.
2. Do not burn gear compound from the Gear case as warping will result.
3. Rinse the Gear case thoroughly in boiling water to remove all traces of caustic solution.
4. Dry and repaint the Gear case.
5. Renew all felt seals.
6. Check that the two halves of the Gear case fit together, that is the groove in the top half fits over the groove of the bottom half and that the semi-circles of each opening are in reasonable alignment.
7. If the two halves do not fit together properly it may be because they were not originally assembled and machined together.
8. Each half of Gearcase is stamped with the same number.
9. Check these numbers (the number will be found at the pinion end of the Gear case on the road wheels side, near the horizontal joint).

6.13 ASSEMBLY OF GEAR CASE

1. Lift the bottom half gear case up around the gearwheel until the felt seals around the motor shaft opening and the axle openings rest on the bearing cap and gearwheel hub respectively.

2. Insert one M36 mounting bolt, fitted with new lock washers, and screw down to support the gear case, but do not tighten.

3. Heat about 3.5 kg of gear lubricant to about 85 °C and pour it over the pinion and gearwheel or alternatively paint this lubricant onto the teeth.

4. Lower the top half Gear case over the gears until the felt seal rests on the bearing cap and insert and screw down the M30, M36 mounting bolt. Do not tighten bolt.

5. Fit two M30 joint bolts and nuts, using new lock-washers and tighten with torque value at 35 kg-m.

6. Tighten the two M36 mounting bolts at specified torque of 65 kgm.

7. Top up Gear case with lubricant-use dipstick.

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7. MAINTENANCE SCHEDULE

Maintenance scheduling is very important and critical for the efficient performance of the electrical machines. During periodical inspections, incipient faults or defects can be located and rectified. Such attention definitely reduces the cost of repair and lengthens the life of the equipment. The most suitable intervals between service maintenance occasions can only be determined by actual service experience. Initially, the intervals should be as specified until it becomes possible to change them as experience is gained. In the case of lubricants, the quantities and frequency of lubrications specified should similarly be treated as guide only. The actual interval between lubrication and quantity of lubricant should be determined from experience and individual duties of each machine.

A complete history of each machine, detailing the maintenance effected, lubricant consumption, list of renewals, replacement etc. is therefore of the utmost importance and is thus advised to maintain such records.

7.1 PUTTING INTO SERVICE

After putting new or reconditioned machines into service for the first time, the following checks should be carried out, during or at the end of first week of operation:

Check that after the motor has been mounted backlash exists between pinion and gearwheel. New gears are manufactured to have a nominal backlash of 0.2 to 0.7mm, as measured on the outer i.e. non-relieved end of the gears.

Check tightness of all bolts, particularly axle caps, gear case and brush gear bolts. Examine commutator and brush gear and check that skin on the commutator is being formed and carbon brushes are bedded correctly.

Check that after a load run, temperatures of axle Suspension Taper Roller Bearings are not excessive.

Check for leaks of gear lubricant. Measure and record gearcase compound.

7.2 ROUTINE MAINTENANCE

a. **Monthly**

1. Before removing the commutator covers, brush off loose dust or dirt.
2. Examine the commutator and clean the outer, have a well-polished surface and free from bar marking or bar edge burning.
3. Remove any copper beads from the commutator surface with fine carborundum cloth. Deposits from dirty or greasy hands should be removed by a solvent.
4. Examine the brush gear and clean the insulating rods.
5. Checks that the brush springs sit correctly on the brushes and that the springs are in good condition.
6. Check carbon brushes for wear.
7. Fit new brushes in place if any brush is unlikely to last until the next inspection.
8. See the **Technical Data** for minimum length and brush grade.
9. Bed all new brushes to the curvature of the commutator.

10. Check the brushes for mechanical damage, breakage of flexible, etc. Fit new brushes if necessary.
11. Check that the flexibles are firmly secured to the brush holder.
12. Check brushes for freedom in the brush-holder and if stick ring cleans both the brush and
13. the brush-way in the holder.
14. Do not soak the brush, as the solvent will eventually ooze out, affecting the commutator and causing the brush to jam in the holder.
15. If the brush appears to be excessively slack in the brush-holder, check the brush size and discard the brush or the holder as the case may be.
16. If brush holders have to be removed from the machine, slip thin; clean press board between each brush-holder and the commutator to avoid damaging the commutator surface.
17. On replacing brush-holders check the clearance between the underside of the brush-holder and the commutator. See **Technical Data.**
18. Look carefully for any signs of flash over, overheating, loose connections or damaged insulation.
19. Top up Gear case to the level of gear oil filler unit. See **Technical Data** for Grade of lubricant.
20. Top up axle Suspension bearing Grease - See **Technical Data** & **Suspension unit arrangement Assembly & Disassembly** for grade of grease.

b. Three monthly

1. Monthly service plus blow out machines using clean dry compressed air.
2. Take particular care to direct air under the commutator in order to remove dirt lodged in the armature core ducts.
3. Check tightness of all brush gear bolts.
4. Check tightness of bolts securing Suspension Tube and gear case.
5. Check air inlet bellows for cracking tearing or collapsing. Renew if necessary.
6. Check for leakage from the Gear case and Axle caps. Top up the bearings with the recommended quantity of bearing grease. Top the roller suspension bearing with grease.
7. Top the armature bearing with grease. Refer to the recommended quantity of the bearing grease.

c. Six Monthly

Three monthly services plus: -

Clean outlet provided on PE End Shield in bottoms.

d. Annually

Six monthly services plus:-

1. When motors are removed from bogies for wheel turning etc. clean pinion and gearwheel and check for tooth wear.
2. Before fitting the gear cases, clean out old lubricant to avoid the possibility of gears running subsequently in contaminated lubricant.

e. Overhaul-Three yearly

1. Remove traction motors from the bogies for overhaul and run on no load at about 1000 rpm and check for noisy bearing rough commutator, vibration and brush chatter.
2. Dismantle the motor and clean the armature and field system. Dry out to remove any detrimental

moisture.

3. After drying out, check the hot insulation resistance of the traction motor & if found more than 1 Mega ohm applies a high voltage test at 1.5 kV.
4. Check the armature for open and short circuits by a commutator bar-to-bar test at 600 V.
5. Remove the brush holder from the machine. Clean and inspect for brush clearance in the holder-spring pressure and damage Recondition as necessary.
6. If the field coils and connections are in good condition then dry paint the interior of machine with insulating varnish such as E-233 red of Dr. Beck or equivalent. If the field coils require repair, remove and recondition individually. Check the armature bearing details for damage & renew as necessary.
7. Inspect the shaft for damages to pinion and bearing seating and ensure that it is straight.
8. Inspect the armature for loose bands, solder throwing etc. Recondition as required. If the commutator is worn or damaged, skim the commutator and undercut the mica. It should be ensured that the Commutator is turned only upto the safe wearing depth diameter i.e. 260 mm
9. Varnish impregnates the repaired or reconditioned armature with the polyester VPI Resin FT2005 of Dr. Beck.
10. Inspect the axle bearings for wear, distortion and cracks. Also ensure the intactness of the suspension tube bolts.
11. At the end, dynamically balance the armature ensuring that the maximum unbalance does not exceed 3gm-mm, reassemble the machine and paint the exterior of the machine.
12. Run the machine on no load at about 1000-RPM for 120 minutes to ensure correct operation of the bearings. When installing the motor in the bogie ensure that all bolts are tightened to the specified torque values. Fill the Gear case with the correct lubricant to the maximum specified level.
13. After assembly with the bogie, run the motorized bogies for 240 minutes to ensure proper alignment of the gears and proper seating of gear case felts over axle.

    Initially, it is expected that the temperature of the areas near to the felts will go upto 100°C but, after excess felt has been worn off, the temperatures of these areas will return back to normal temperature zone of 50-60° C.

8. TROUBLE PHENOMENON AND REMEDIES

TROUBLE PHENOMENA	TROUBLE PART	POSSIBLE CAUSE	INSPECTION AND REMEDY
Commutation Trouble	1. Carbon brushes	a. Grade or Form	Examine if different grade is used and inspect the actual brush spring pressure, if some abnormality is found adjust as designated.
		b.Excessive wear	Check for spring pressure, should be within specified limits
		c. Chattering vibration	Remove oxygenated film of commutator surface or change grade of brush
		d.Brush Sticking	Clean the brush holder pocket, check for any deformation in the pocket, use a new carbon brush
		e. Copper picking/ spotting	Machine is running over loaded for periods more than the specified limits
		f. Sticking of oil film	Unequal oxygenated film causes excessive wear, replace with a new one.
		g. Unbalance of brush current	Looseness of pig tail, insufficient contact of brushes with commutator. Replace carbon brushes.
		h. Brush wear	Lift up of carbon brushes causes spark and damage. Replace with a new one.
	2. Commutator	a. High-bar, low-bar, deformation, ovality	Color change, unequal oxygenated film, abnormal wear of brush may cause the flashover. Polish commutator surface with lathe.
		b. Joggle wear and roughening of surface	Wear of brush. Polish commutator surface with lathe
		c. Bad chamfering or bad undercutting	Reform
		d. Shorting of bar by dust and foreign material between grooves	Inspect and clean
		e. Abnormal temp. rise	Color would change at abnormally high temperatures. Examine ventilation and load.
		f. Black bar	Adjust commutation
		g. Vibration	Examine radial and lateral clearance of bearings. Vibration of truck and unbalance of armature. Abnormality shall be adjusted according to the maintenance data

	3. Brush Holder	a. Wear of inside of carbon way	Big gap to brush worsens sliding performance. Measure dimension, replace with new one.
		b. Improper attaching	Crookedness pitch, gap should be examined and adjusted.
		c. Improper spring pressure	Check pressure and adjust pressure as designated.
	4. Other parts	a. Inadequate condition of riser, shorting of armature coil	Color of commutator surface may be changed (ex. Black)
		b. Invasion of dust, rain	Roughening of commutator surface. Machine commutator. Prevent invasion of water.
		c. Wheel slip, skid	Change current limit
		d. Over current, Over voltage	Examine safety relay
Over Heating	1. Bearing	a. Bruise, scratch, rust	Replace with new one
		b. Improper quantity of grease	Replenish with new grease. Apply proper grease
		c. Improper attaching, fitting or clearance of bearings	Check attaching and adjust it. Check clearance and replace it with good one.
	2. Coils	a. Layer short, insulation breakdown	Find trouble part and replace it.
Other Trouble	1. Insulation breakdown	a.Insulation breakdown of coil, commutator. Lead wire.Inner connection, brush holder	Abnormality in megger DC component shall be systematically examined so as to find troubled part Repair the damaged parts according to insulation.
Oil Leakage	1. Armature bearing grease	a. Improper grease quantity	Check the quantity of grease. Refer recommended quantity of grease
	2. Gear case	a. Excess charge of gear compound	Check the compound
		b. Bad packing and compound sealing	Replace with new packing and oil sealing.

9. INSPECTION SCHEDULE

INSPECTION ITEMS AND STANDARD	REPAIR LIMIT OR OPERATION RANGE	INSPECTION INTERVAL					
		TRIP	MONTHLY	THREE MONTHLY	SIX MONTHLY	YEARLY	TWO YEARLY
1. TRACTION MOTOR IN GENERAL							
a. Appearance in general		0	0	0	0	0	0
b. Attaching of Inspection cover		0	0	0	0	0	0
c. Loosening of bolts, damage of lockwashers		0			0	0	0
d. Invasion of dust and water					0	0	0
e. Condition of lead wire, and cleat, contact of terminals.				0	0	0	0
f. Oil leakage of bearing				0	0	0	0
g. Grease adding to armature bearing					0	0	0
h. Grease adding to motor suspension bearing							
2. ARMATURE							
2.1 Commutator							
a. Diameter : 280 mm	a. 260 mm						0
b. Eccentricity	b. 0.03 mm						0
c. Inequality in diameter	c. 0.05 mm						0
d. High or low bar	d. 0.03 mm						0
e. Under cutting depth : 0.9 to 1.5							0

INSPECTION ITEMS AND STANDARD	REPAIR LIMIT OR OPERATION RANGE	INSPECTION INTERVAL					
		TRIP	MONTHLY	THREE MONTHLY	SIX MONTHLY	YEARLY	TWO YEARLY
f. Chamfering sharp edge cutting : 0.3 mm						0	0
g. Width of riser : 20 mm (excluding TIG welding)							0
h. Difference of voltage drop between bars within 5%							0
i. Dielectric test newly manufactured : 2,500 V/ 1 min Repaired : 1,500 V/1 min							
2.2 Armature Coil							0
a. Cleaning							0
b. Interturn insulation test							
2.3 Shaft, bearing and Pinion							
a. Diameter of shaft bearing on pinion side : 120 mm	a. 120 + 0.05 + 0.03						0
b. Diameter of shaft bearing on commutator side : 70 mm	b. 70 + 0.04 + 0.02						0
c. Wrap of shaft (deflection of shaft end)	c. less than 0.03 mm						0
d. Taking off, cleaning, inspection and oiling of bearing							0
e. Interference fit shall be applied to inlay of inner ring of roller bearing and shaft of pinion side. Temperature of heating : 110 – 120º C							0
f. Interference fit shall be applied to inlay of inner ring of roller bearing and shaft of commutator side Temperature of heating : 110 – 120º C							0
g. Radial clearance of the roller bearing on pinion side							0

INSPECTION ITEMS AND STANDARD	REPAIR LIMIT OR OPERATION RANGE	INSPECTION INTERVAL					
		TRIP	MONTHLY	THREE MONTHLY	SIX MONTHLY	YEARLY	TWO YEARLY
h. Interference fit shall be applied to inlay of pinion. Interference Heating temperature : 140 – 160º C above ambient							0
i. Contact degree of armature shaft and taper of pinion shall be more than 90 %	80 % minimum for used						0
j. Ultra sonic and magnetic particle testing shall be carried out about shaft.							0
3. STATOR							
3.1 Magnet frame							0
a. Dimensions of mounting parts (as shown in drawing) b. Lead wire with damaged covering or damaged terminal shall be replaced. c. Damage of core of lead wire and connector may be used	Less than 10 %						
3.3 Brush holder and Carbon Brush a. Cleaning and check				0	0	0	0
b. Spring pressure (at assembly) at At Brush height 57 mm : 3.20 kgf /brush At Brush height 32 mm : 2.80 kgf/ brush	2.50 to 3.30 kgf/brush				0	0	0
c. Dimensions of brush holder pocket Thickness : 20.00 mm Width : 40.00 mm	20.3 mm 40.3 mm					0	0

INSPECTION ITEMS AND STANDARD	REPAIR LIMIT OR OPERATION RANGE	INSPECTION INTERVAL					
		TRIP	MONTHLY	THREE MONTHLY	SIX MONTHLY	YEARLY	TWO YEARLY
d. Clearance between Brush holder Face and commutator surface Gap : 2 – 3 mm nominal						0	0
Distance between brush end face and commutator end face : more than 4 mm			0	0	0	0	0
e. Length of carbon brush	Service length : 25 mm Exchange						
f. Chipping of carbon brush	limit : 32 mm	0		0	0	0	0
g. Pigtail breaking of brush	less than 10 %	0		0	0	0	0
3.4 Gear Case							0
a. Check the gear compound level		0		0	0	0	
b. Check the packing of gear case. Worn packing should be replaced.							0
c. Gear compound leakage		0		0	0	0	0
4. ASSEMBLY TEST AND OTHERS							
a. Bedding of carbon brush				0	0	0	0
b. Dielectric test							
New : 2.5 kV, 50 hz for 1 min	1.5 KV/1min						
Repaired : 1.5 kV, 50 hz for 1 min	(Repaired)						0
c. Insulation Resistance test							
d. No – load test							
Examine abnormal vibration or abnormal noise	More than 1.0 MΩ					0	0
i. 1000 rpm for 1 hour in both directions.							0
ii. 2000 rpm for 15 min in both directions.							

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CHAPTER VIII

AUXILIARY ALTERNATOR

1. **INTRODUCTION**
2. **DESCRIPTION**
3. **PRINCIPLE OF OPERATION**
4. **WORKING OF REGULATOR**
5. **ROUTINE MAINTENANCE**
6. **PERIODICAL OVERHAULING**
7. **REMOVAL OF ROTOR & BEARINGS**
8. **ASSEMBLY**
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CHAPTER VIII

AUXILIARY ALTERNATOR

1. INTRODUCTION

KEL Alternators type KELA 121125 FM are designed to be driven with a cardan shaft coupled directly to the diesel engine through flexible coupling. The alternator with associated regulator rectifier unit delivers 8 KW power at a constant voltage of 120 ± 5% from no load to 74 A load at all notch positions of the engine.

The system consists of a Brushless inductor type alternator and a completely static regulator rectifier unit. The alternator is completely devoid of any type of moving coils or sliding contacts and this ensures a trouble free operation without practically any maintenance.

The regulator - rectifier unit makes use of silicone diodes, and "Magnetic Amplifiers". All the components used in the rectifier - regulator unit are unlike transistors and thyristors-tailor made to the requirements of the hazardous application to which they are put in Rolling stock. As such the reliability of KEL generating system is high.

2. DESCRIPTION:

The statodyne type KELA 12125 FM is a totally enclosed machine developing a constant voltage of 120V (±5%) at a maximum load current of 74 Amps DC.

The machines are used for :

I. Charging of 110 Volts battery provided on the car.

II. Light and fan loads of the coach

III. Control system (20 Amps)

IV. Head light of 750 watts at 32 volts, the voltage being dropped through a resistor from 135 volts DC.

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2.1 Generator data

Rated Capacity	:	8 KW
Type	:	KELA 12125 FM
Mounting	:	Foot Mounting
Enclosure	:	Totally Enclosed IP 55
Cooling	:	Self cooled
Minimum speed for full output	:	700 rpm for 70A at 120 Volts.
Maximum speed	:	2000 rpm
Weight of Alternator	:	302 Kg
Class of insulation :		
a) Stator	:	Class H
b) Field	:	Class H
Type of Bearing :		
a) Drive End	:	NU311
b) Non drive End	:	6311
Resistance between two phase	:	0.198 Ohms ± 5%
Field Resistance	:	12.98 Ohms ± 5%

2.2 Rectifier-Regulator Unit :

Type	:	KEL C 12125 FM
Full load	:	64 A
Voltage setting	:	125 V at 32 A at 1500 rpm
Max load	:	74 A
Class of insulation	:	F
Weight of Regulator	:	52 Kg

The rectifier regulator also is a totally enclosed unit. It consists of:

i. A power rectifier comprising of :-

a. One full wave, three phase bridge connected rectifier, using six silicone diodes.

b. Capacitors to protect the rectifier diodes from surges and to filter the DC output.

ii. A regulator rack consisting of :-

a. One field transformer (FT)

b. One magnetic amplifier (MA)
c. One Field rectifier unit (D3, D4)
d. Two voltage detectors (DT1 & DT2)
e. One free wheeling diode (D5)
f. One burden resistance (RBI)
g. Two blocking diodes (D1, D2)

iii. Three current transformers connected in star for sensing the load current (CT1, CT2 & CT3)

The phase and field fuses are provided on the rectifier board of the regulator.

The labels provided for terminals on the terminating portion of the regulator as follows.

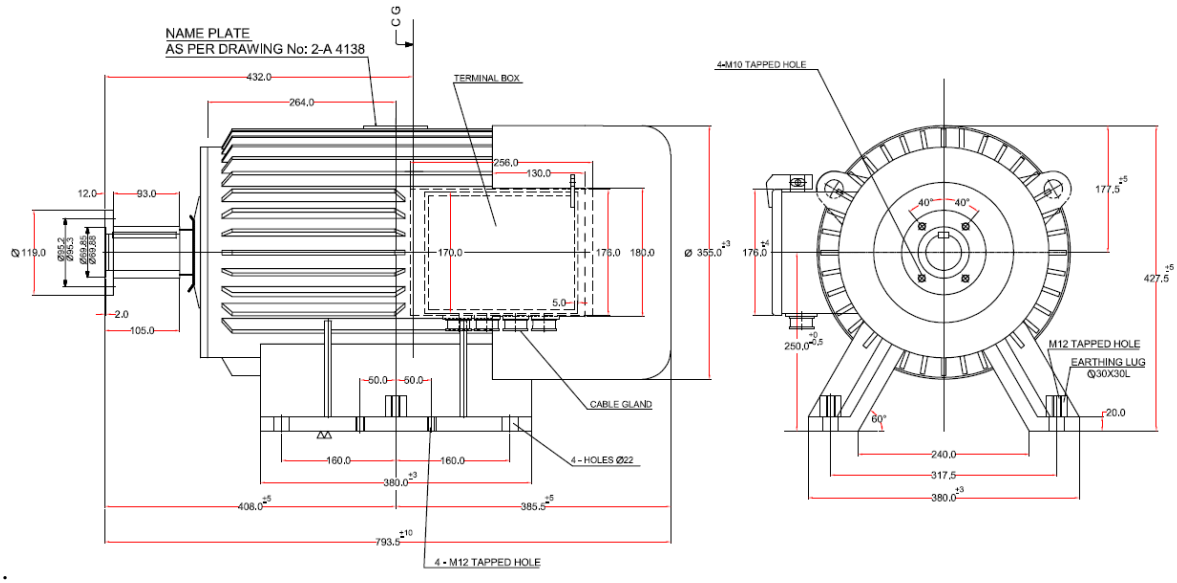
U, V, W	-	AC input to Regulator from Alternator.
+DC, -DC	-	DC output from regulator

Output field terminals from regulator to alternator field coil terminals.

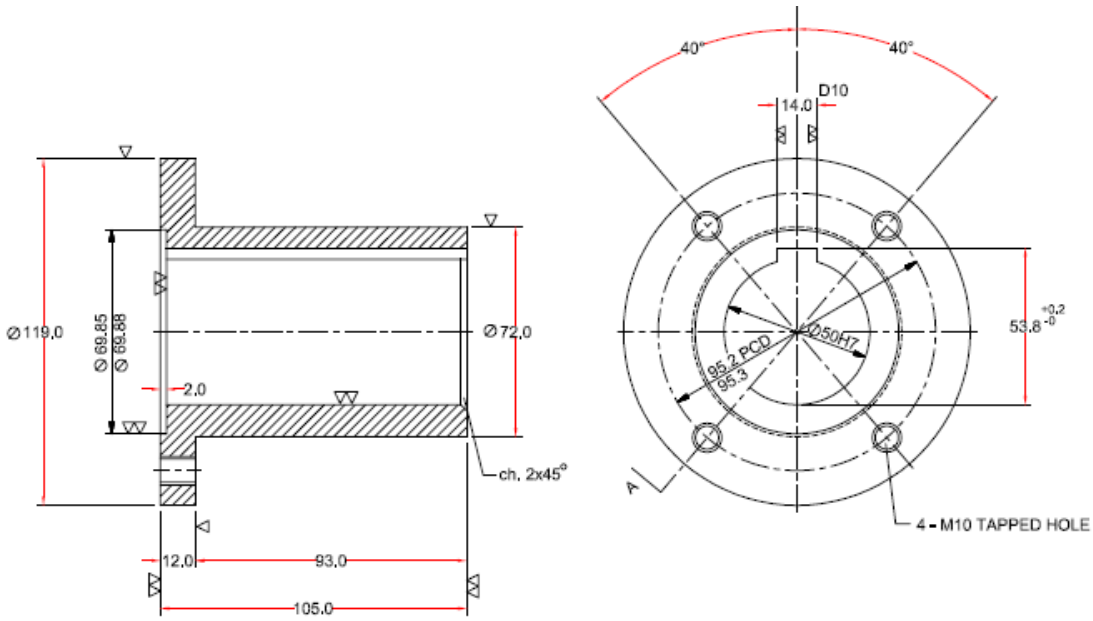
3. PRINCIPLE OF OPERATION

3.1 Generator

As mentioned above the statodyne generator is a three phase, homopolar, inductor type alternator without any rotating, commutator or sliprings. The field windings and AC windings are located in the stator. The field coils are concentrated in two slots. Each field coil shares half the total number of stator slots.



Outline drawing of 8 kW Auxiliary alternator



Details of Coupling Flange

The rotor is made up of silicon steel laminations and resembles a cogged wheel. The teeth and slots are uniformly distributed on the rotor surface.

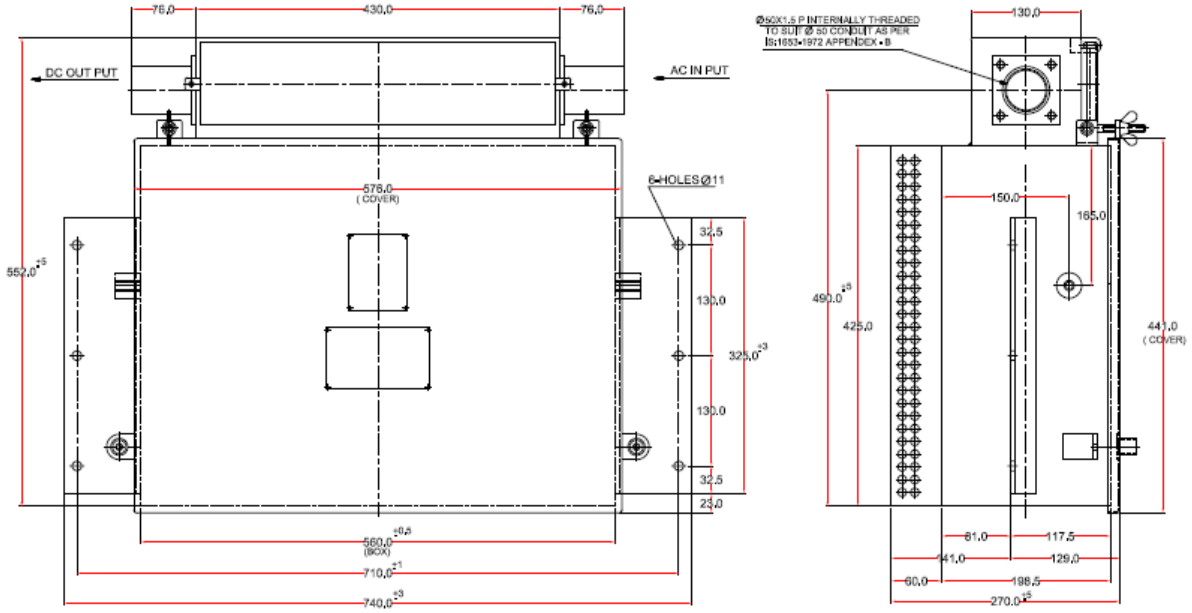
The core of the stator, completely embraced by the field coils will retain a small residual magnetism if excited by a battery. The flux produced by the field coil finds its path through the rotor and when the rotor is rotated the passage of rotor teeth and slots under the field offers a varying reluctance path for the flux produced by the field coils. This flux varying periodically also links the AC coils and induces an alternating voltage in the AC coils. The frequency of the voltage depends on the speed of revolution of rotor and the magnitude is decided upon the speed as well as strength of field.

The field is strengthened by a positive feedback system in the regulator. Thus when the rotor is rotated the residual magnetism will cause an induced e.m.f. in the AC coils, which is strengthened further by the positive feedback to the field. The voltage rises till it is a controlled by the regulator.

The AC coils are connected in star and six output leads are brought to the terminal board on the alternator.

3.2 Power - Rectifier

This consists of six silicon diodes connected in three phase full wave bridge. The three phase output of the alternator is rectified by these diodes to give a DC output at terminals + DC and -DC.



Outline drawing of Rectifier Regulator Unit

Each diode is protected against transient surges voltage by capacitor C1. The whole bridge is protected against high frequency surges by capacitor C3. The DC output is filtered by capacitor C2.

3.3 Current Transformer

The current transformers are used to sense the load current for the current limit. When the primary winding of each current transformer carries load current, the secondary winding feeds a three phases voltage to the rectifier RT2 in the regulator rack.

3.4 The regulator rack

The regulator rack consists of the following parts.

3.4.1 Excitation Transformer

This is a one winding transformer with tappings for input and output. The transformer steps down the voltage for the field coils. The output of the transformer is taken in the field through the magnetic amplifier before being rectified by field rectifier diodes.

The transformer has five set of terminals.

Terminals 14 & 15, input from phase 14 & 15 of alternator. Centre tapping, terminal 19, goes to the -ve terminal for field supply.

Terminals 18 & 161 are the output terminals and go to the respective terminals on the magnetic amplifier.

3.4.2 Magnetic Amplifier

The magnetic amplifier forms the nucleus of the regulator circuit; It works on the principle of saturation of magnetic core. The equipment has six sets of windings:

Two load windings: 18 - 162 & 17 – 161

Four control windings: 10 – 11, 26 – 27, 29 - 30 & 20 – 40

(Of these only 10-11 and 20-40 are used in the circuit. 10-11 for voltage and current control & 20-40 for gain control).

The field current passes through the load windings of the magnetic amplifier. Subject to the command from the voltage and current sensing circuits, manifested through the control winding 10-11, the load winding offers variable impedance of the field circuit.

3.4.3 Field rectifier unit

The two silicon diodes D3, D4 acts as a full wave rectifier for the field supply. These diodes conduct alternately. The rectified current from the diodes is taken through the feedback winding 20-40 of the magnetic amplifier. Terminals 20 & 19 form the +ve & -ve terminals form the field assembly.

3.4.4 Free - Wheeling Diode

In the normal circumstances this diode D5 has no function. But should there be any reason for a surge from the field circuit which will have a polarity opposite to that of excitation, this diode will conduct avoiding creepage of the surge voltage to more important components like Magnetic Amplifier.

3.4.5 Rectifier Bridge

Each bridge RT1 & RT2 is made up of six silicon diodes, connected for three phase full wave rectification, RT1 supplies the rectified voltage for voltage detector DT1 which is also the voltage developed by the alternator, RT2 rectifies the three phase voltage developed at C.T secondary side and supplies to the voltage detector DT2.

3.4.6 Voltage Detector DT1, DT2

These voltage detectors serve the function of providing necessary “error signal” for voltage regulation & current limiting.

It consists of a network of zener diode, potential divider & rheostat. The voltage drop across resistance can be adjusted by varying the resistances Rh1 & Rh2.

In the case of DT1 when the output voltage exceeds the voltage of the alternator the voltage drop across R1 will be sufficient to cause zener break down and this will send a current through the control winding 10-11 of the magnetic amplifier.

Similarly, in the case of DT2, when the current reaches preset value the voltage induced in the secondary of the current transformer after rectification by RT2 will be sufficient to cause conduction of the zener diode and to produce the necessary error signal to magnetic amplifier for current control.

Zener diode has a characteristic that the diode starts conducting only at a designated voltage (zener voltage). The voltage across the zener will be maintained even if the voltage input to the circuit is increased. Thus it serves as base for comparison.

3.4.7 Blocking diodes

Diodes D1 & D2 are used to block the current from one zener to the other. Diode DI prevents creepage of current from DT2 to DT1 and D2 prevents current from DT1 to DT2. This is achieved by the unidirectional property of diodes.

3.4.8 Regulator failure relay

One number over voltage under voltage relay is provided to indicate the failure of the regulator. When output terminal voltage of the regulator drop below the pre-set value the relay trips and indication lamp will glow. And same in the case of over voltage.

3.4.9 Regulator failure indication lamp

One number indication lamp is provided to show the failure of the regulator. This is connected in series with the battery and the contacts of the regulator failure relay.

4. WORKING OF REGULATOR

The three phase output from the alternator is rectified by the bridge connected silicon diodes. The DC excitation to the field is obtained by full wave rectification of alternating current provided through the load windings of the magnetic amplifier.

The voltage induced in the alternator winding depends on the speed of revolution of rotor and on the excitation current. In the absence of voltage detector and magnetic amplifier, the voltage of the alternator will rise indefinitely due to the positive feed back limited only by saturation of stator. But as soon as the preset voltage is reached the zener diode in detector DT1 conducts and sends a control current through the magnetic amplifier winding 10-11. The flux produced by the control current is in such a way that it opposes the flux produced by the load windings, there by increasing the impedance of the field circuit. This increase in field impedance reduces the field current and feed back the output voltage to the normal value required.

The current limiting is also achieved in a similar manner. When the pre-determined load current is delivered

by the alternator, the secondary voltage of the CT after rectification by bridge RT2 will provide the necessary "error signal" for the magnetic amplifier. In this case also the voltage drop across the resistance will be sufficient to cause the zener diode in DT2 to conduct. The control current from this also passes through the same control winding 10-11. The effect of this control current is to retain the current at the limited value and to reduce the voltage. For a sustained overload, the generator voltage will fall to the battery voltage & relieve the alternator immediately, thereby reducing the chances of damage due to the load.

5. ROUTINE MAINTENANCE

5.1 Alternator :

- Check the suspension and securing nut after every round trip.
- Inspect the terminal box for water tightness.

5.2 Regulator box

See that all securing fasteners are held properly

Keep the cover tightly closed.

Ingress of water and dust in the regulator box will damage the equipment beyond repair.

6. PERIODICAL OVERHAULING

6.1 Alternator

- Clean and regrease the bearing after removing the bearing from the bearing housing. The bearing is designed for regreasing in workshops at long intervals of 5000 hours in operation. However, it is recommended that during POH, the bearing should be regreased.
- Before using new grease the bearing should be thoroughly cleaned with white spirit. 24 gms. Of lithon 2 should be used for refilling.
- The bearings should be changed, if it is found defective during inspection.
- Clean the mating surface of the end shield, before assembly the surface should be coated evenly with gasket shellac.
- While removing and placing the rotor, care should be taken to see that the rotor does not rub over the field coils.
- If any grease has crept into the stator surface clean it before assembly.
- If stator & rotor parts are found rusty, clean and slightly coat with Dr. Beck make E1mo65E/R insulating

varnish.

6.2 Regulator box

If no failure or defect has been observed, clean & tighten all components and ensure that all joints and connections are properly tight.

7. REMOVAL OF ROTOR & BEARINGS

The following procedures should be adopted for dismantling alternator.

a. Remove the fan cover from one end after removing the M10 screws.

b. Using a box spanner of size 13 unscrew the two screws securing the screw locking washer.

If these screws have been locked by steel wires or by tack welding, proceed only after removing the locking arrangement.

c. Remove flange from the shaft.

d. Bend back the SKF lock washer M8 12 from DE side

e. Remove lock nut SKF KM 12 from DE side.

f. Remove all the end shield fixing screws from NDE side.

g. Locate the two tapped holes on the endshield on NDE side along with the rotor and bearing on NDE side and screw in two M I0 screws. The two screws should be turned in equally, as the screwing progress the endshield comes out gradually along with the rotor bearings on NDE side. The endshield and bearing on DE side remain and in its place.

h. Gently pull out the rotor from the stator. Care should be taken to see that the rotor does not pull over the stator coils.

i. After removing the endshield fixing screws from NDE side, remove the end shield by screwing into M10 screws in the tapped holes on the endshield.

j. The endshield on NDE side now lies along with the rotor. Bend back the lock washer M8 12 & remove the locknut KM 12. Remove the bearing covers. Remove the spacer, pull out the end shield from the shaft. The end shield comes out along with the bearing. (The inner race remains on the shaft).

k. The bearing can be removed from the end shield by gently pressing out, in a hydraulic press. The pressure should be applied gradually.

l. The inner race can be removed by slightly heating the inner race by using an induction heater. The ring comes out of the shaft on slight knocking.

8. ASSEMBLY

Assembly of the alternator can be proceeded on the reverse way with special care on the following points:

a. The inner race of the bearing should be heated in an oil bath at about 80 deg. C to 90 deg. C before insertion on to the shaft.
b. The end shield should be heated in an electric oven to about 120 deg.C before locating the bearing in it.
c. In order to seat the bearing properly internal bearing cover should be fixed on to the end shield before heating the end shield.
d. Before inserting the bearing to the shaft, the internal bearing cover should be placed in its position.
e. If this is not done it is impossible to assemble the machine
f. Gasket shellac (Addison) should be applied evenly on all the mating surfaces of bearing cover and end shield.
g. Take special care to see that the bearing comes on the terminal box side.
h. While removing and fixing the SKF lock nuts use a hook spanner. Never use any tools for this purpose
i. The cooled bearing put in back to back arrangement is placed inside the heated endshield and outside bearing cover assembly. The whole thing is then inserted into the shaft, which will mate with inside bearing cover.

9. DO's AND DON'Ts FOR THE EQUIPMENT

A. ALTERNATOR

a. Open up the terminal box once in two weeks and clean up the dust if any accumulated in it.
b. Check up the tightness of connection once in two weeks.
c. Keep the terminal box tightly closed
d. Regreasing should be made after thoroughly cleaning the bearings with while spirit. It is preferable to regrease the bearing only during POH.
e. Don't overgrease the bearings.
f. The field connection on the alternator terminal box should not be reversed.
g. Use the cable sockets and cable glands for connections.
h. Never give separate excitation to the field. It will damage the regulator components.

B. REGULATOR

a. Don’t disturb the setting on the voltage and current potentiometer. Best results are obtained with the settings made by the manufacturer.
b. Don’t open the regulator box unless a defect is observed.
c. Don’t use a megger to test the components. Use a multimeter.
d. If earth resistance is to be measured, disconnect the leads from alternator and load.
e. Short circuit all the seven terminals, before using a meggar.
f. Don’t reverse the field terminal connections.
g. If a diode is to be replaced its base should be evenly coated with silicon grease.
h. In no circumstances the burden resistance setting should be disturbed.
i. Use only HRC fuses in phase and field circuits

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CHAPTER IX

CONTROL GEAR EQUIPMENT

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CHAPTER IX
CONTROL GEAR ITEMS

Master Controller

Master Controller is used to select various speed of Diesel Engine as well as to change the direction of vehicle. It has two handles, which function is explained below:

i) Accelerating Handle:

This handle has nine notch positions i.e. 0-1-2-3-4-5-6-7 & 8. The vehicle will accelerate as the driver moves the handle from a lower notch to a higher notch.

ii) Reversing Handle:

It has three positions i.e. REVERSE - OFF - FORWARD. The position of this handle decides the direction of movement of train.

A locking key is also provided. Reverse Handle can not be operated unless the locking key is inserted in the keyhole & rotated by 90^{o} clockwise.

Mechanical interlocking is provided to prevent unauthorised operation of either accelerating or reversing handle. It has following features:

I) Reverse handle can be moved to either "Forward" or "Reverse" position only when the key is inserted inside the keyhole & rotated by 90^{o} clockwise.

ii) Accelerating handle can be moved only when reverse handle is either at "Forward" or "Reverse" position i.e accelerating handle cannot move when reverse handle is at "0" position.

iii) Reverse handle can be moved only when the accelerating handle is at "0" position.

iv) A deadman's mechanism is provided with the accelerating handle. When the accelerating handle is depressed deadman contact closes & when the handle is released, it opens to cut off the traction control supply & thus the power to Traction Motors. The mechanism is so designed such that it trips only when the "Reverse Handle" is either at forward or reverse position.

v) Key can be removed only after the accelerating handle is brought to "off " position and reverse handle is brought to "0" position.

Make & Type No	:	Inder Engg., 9MC-MU-018
Operating Voltage	:	110V DC
Current Rating	:	10 Amps (Thermal)

Motor Overload Relays

It is used for protection of Traction Motor from current overloading.

The relay has two coils -

a) Operating Coil: It is single turn coil, which passes through the yoke of relay.

b) Resetting Coil: This coil is provided for resetting the overloaded relay to resume normal operation. This coil is suitable for remote resetting operation.

The relay has six auxiliary contacts (3NO+3NC) for use in control & indication circuits. When the motor current exceeds the value at which the relay is set to trip, the yoke gets magnetised, which pulls down the armature of main coil. At the same time armature of reset coil is released and position of auxiliary contacts is changed.

Thus the supply to E.P.Contactor coil, through auxiliary contacts of overload relay is cut off, which in turn breaks the power circuit thus preventing the motor from overloading.

Make & Type No	:	Inder Engg
Current Rating	:	900 Amps
Reset Coil	:	DC 110V, 1 Minute
Reset Coil Resistance	:	160 Ω
Calibration range	:	600A, 700A, 800A and 900A
Trip Coil Setting	:	650A.
Capacity of contact (Auxiliary)		
i) Thermal	:	3A
ii) Rupturing	:	0.5A, 110 V.
Min. operating voltage (Hot)	:	< 66V

E.P. Reverser

E.P.Reverser is used to change the direction of field current of Traction Motor, thus changing the direction of the coach. It is a 4-Pole off load switch, which carries rated current during its operation. It has two sets of Magnet valves, one each for forward and reverse operation. It has 4 power contacts and 4 auxiliary contacts (change over type). When forward coil is energised, all 4 power contacts and 4 auxiliary contacts operate & make connection in forward direction. Similarly reverse connection is made when reverse coil is energised.

Make	:	Inder Engg.
Rating of main contacts	:	600 Amps (Thermal)
No. of main poles	:	4 Nos. (change over type)
Rated Operating Air Pressure	:	5 Kg/cm^2
Rated coil Voltage	:	110 V DC
Rating of Auxiliary Contacts	:	10 Amps (Thermal)
Min. operating voltage	:	68 Volts
Min. Operating Pressure	:	4 Kg/cm^2

Electro-pneumatic Contactor

EP Contactors are required to connect / isolate the Traction Motors to / from the power circuit. These contactors are On-Load Switches and are required to isolate the motors on load from the power circuit.

These EP Contactors are fitted with a cylinder and piston, which operate main contacts of copper with silver / silver cadmium oxide tips. These silver tips are protected from damage due to arcing. A blow-out coil is fitted to extinguish the Arc when the main contacts are open (on-load) and this is assisted by an arc chute.

When the magnet valve is energised, air is admitted to the cylinder. This causes the piston to rise and main contacts close.

One set of auxiliary contacts are provided, when the magnet valve is energised the auxiliary contact arm shall move upwards and shall cause the auxiliary contacts to close.

When the magnet valve is de-energised, air exhausts from the cylinder and the piston moves downwards to open the main contacts and at the same time the auxiliary contact arm also moves downwards and open the auxiliary contacts.

Make & type	:	Inder Engg., 9-24PC2-15
Operating Voltage	:	110 VDC
Operating pneumatic pressure	:	4.5 Kg/Cm^2
Main Contacts Rating	:	1500 Volts, 1390 Amps
Auxiliary Contacts Rating	:	3Amps @ 110 VDC

Load Ammeter Shunt

Two separate load ammeter shunts are provided one for motor no. 1 and other for motor no. 2 to measure the motor current.

Rating	:	1000A / 75mV
Make	:	AE, Mumbai

Ground Fault Relay

Ground fault relay operates in the event of ground fault in power circuit. It is a current operated relay. Once the ground fault has occurred, the relay gets latched & it can be reset manually with the help of reset knob provided on the relay. A cutout switch is provided in series with the relay coil to isolate the relay from power circuit.

Trip Coil Setting	:	180-280 mA
Rating of Auxiliary Contacts	:	5 Amps (Thermal)
Resistance of Coil	:	630Ω at 20° C.

General Purpose Relay - 1

It consists of General Purpose Relays for sequencing, interlocking & protection.

Make & Type No	:	Schneider
Coil Voltage	:	120V DC
Contact Arrangement	:	4 NO
Add on Block	:	4 Amps; 2NO+2NC or 4NC

General Purpose Relay - 2

Make & Type No	:	Schneider
Coil Voltage	:	24V DC
Contact Arrangement	:	4 NO
Add on Block	:	4 Amps; 2NO+2NC or 4NC

Resistor Panel

Resistor panel provides external resistance to the exciter stator coils of Traction Alternator for limiting the excitation current to a safe value in the event of failure of excitation control function.

Make & Type No	:	PEC; PPR 300
Rating	:	12 Ω , 300 watts

Bypass switches:

Bypass switches are used to bypass a protection circuit when the corresponding protection circuit is not working properly or intended to bypass under strict vigilance. The circuits/relays, which can be bypassed, are listed below with their operating pressure range:

Make & Type No	:	RGK; 1510.4430
SPST	:	15 Amps, 250V AC/DC

Driver's Control Switch Box:

Driver's control switch box contain switches for various control operations. It has spring-loaded switches as well as change over type switches.

All the switches in the top row are mechanically interlocked with Driver's Control Switch removable handle. The switches can be unlocked by pressing the handle down by 10mm and turning it clockwise by 45 degrees. The handle can be inserted/removed in OFF position only. Moreover, the top row switches are automatically reset to normal position when the handle is removed.

10 Auxiliary switches are also provided, which operate when the Key is inserted and kept in ON position.

Make	:	Inder Engg.
Thermal Current rating of contacts	:	10 Amps
Breaking Capacity of Contacts	:	2Amps inductive Load at 110V DC
Main Switches	:	2NO + 1NC
Driver's Control Switch	:	8NO + 2NC
Lamp rating	:	125V, 10W
Wire wound Resistor	:	250 Ω ± 3%, 3W

Engine Control Switch

Engine control switch has two positions namely 'IDLE' & 'RUN'. The switch put-off the excitation of Traction Alternator there by preventing Power to Traction Motors unless it is switched to 'RUN' position & Master Controller is taken to notch 1 or higher notches.

Make	:	JSL
Brand Name	:	JMP
Rating (Thermal)	:	25 Amps, 500V AC
Contact Arrangement	:	3NO + 3NC

Load Ammeter and Ammeter selection switch

Ammeter and Selector Switch is provided for indication/measurement of load current. Using selector switch load current of Traction Motors 1 & 2 can be selected. Motor current of rest of the motor currents cannot be measured with the selector switch & Load ammeter. Load Ammeter has a basic rating of 75 mV and is shown in 1000 Amps DC range.

Load Ammeter

Make & Type No	:	AE; SM144
Rating	:	0-75mV/0-1000 A
Dimension	:	144 x 144 mm

Ammeter Selection Switch

Make & Type No	:	KAYCEE ; RP125B
Rating	:	16 Amps AC/DC, 2 way with off

Motor cutout switch

2 Nos. switches are provided in Control Cubicle to isolate either a single motor or a pair of motors in the event of fault on Traction Motors. The operational sequence of switches is listed below.

1) MCS-1: ALL in /Motor 1 out / Motor 3 Out / Motor 1 & 3 Out

2) MCS-2: All in /Motor 2 Out / Motor 4 Out / Motor 2 & 4 out

"Off" position indicates normal/healthy operation.

Make	:	KAYCEE (programme Switch)
Rating	:	16 Amps, 250V AC/DC
No of Poles & Positions	:	4 Pole & 4 Way

Voltmeter and voltmeter switch

One no. Voltmeter and one no. Voltmeter switch is provided in Control Cubicle, for measurement of system control voltages 110 V DC & 24 VDC. Voltmeter switch is connected in series with the voltmeters. The indication on voltmeter is available only when the switch is turned on.

Voltmeter

Make & Type No	:	AE; SQ96
Rating	:	0-150V DC
Dimension	:	96 x 96 mm

Voltmeter switch

Make & Type No	:	RGK; 1510.4430
Rating	:	15 Amps, 250V AC/DC

Battery (110V) Cut out switch

This switch is provided to isolate entire control and auxiliary circuit from 110 V battery. 32 Amps & 63 Amps in-built fuses are also provided in the switch.

Make & Type No	:	Salzer

Contact Rating : 300 Amps

Reverse Current Diode

Reverse current Diode is provided for protection of batteries against discharging, when the 18.5 kW Auxiliary Alternator supply is not available.

Make	:	Ruttonsha
Average Forward Current	:	150 Amps
PIV at rated junction temperature	:	1000 V

Battery (24V) Isolating Switch

Make & type	:	Inder Engg.
Rating	:	250 Amps, 415V, 50 Hz

Timers

Make & type	:	ETR650, Siemens
No. of Changeover Contacts	:	4 Nos.

Local/Remote Switch

Type & Make	:	Kaycee (Program Switch)
Rating	:	16 Amp, 2-pole, 3-way

Instrument Lamp

Type & Make	:	Siemens, 3SB0420-2A
Rating	:	110 VDC
Lamp	:	110 VDC, 2W

Auxiliary Fuse Panel

Type & Make	:	Siemens, 3NH3 030

Rating	:	125 Amps
Fuse Rating	:	32Amps, 3NA1001
Fuse Rating	:	63 Amps, 3NA1015

Hand Lamp socket

Ratings	:	10 Amps, 3-pin

Miniature Circuit Breaker (MCB)

MCB's are used to protect electric circuits against overloading caused by excessive currents due to sustained overloads or short circuits. MCBs are used in CAB-1 and CAB-2.

Make	:	Schneider
Specification	:	SPEC/E-12/1/04 & SKEL-3700
Ratings	:	5A, 10A, 15A & 30 Amps

LED Indication Panel

36 LED Module indication panel is mounted on the Driver's Desk-DPC. The LED indications are provided to identify various fault & healthy features of the vehicle.

Make & Type	:	Inder Engg & 36 LED
Voltage of operation	:	110 VDC

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NOTES

CHAPETR X

MAINTENANCE INSTRUCTIONS

CONTROL GEAR EQUIPMENT

Maintenance Manual

DIESEL ELECTRIC TOWER CAR | UNDER SLUNG TRANSMISSION

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CHAPTER X

MAINTENANCE INSTRUCTIONS
CONTROL GEAR EQUIPMENT

1. INTRODUCTION

ELECTRIC TRACTION EQUIPMENT must be reliable in order to avoid failures, traffic delays and loss of revenue due to lack of public confidence. The equipment must also operate cheaply for economical operation in service.

These requirements can only be fulfilled if preventive measures are taken, in the form of periodical Service Maintenance and Overhaul, which must be thoroughly organised and meticulously and conscientiously carried out at the times recommended in this Maintenance manual.

The intervals, at which Service Maintenance and Overhaul are carried out, are calculated on the basis of either time or distance travelled and will depend upon the type of equipment, the nature of service, and climatic conditions. In the case of diesel-electric equipment, the intervals may depend upon the number of hours the engine runs.

If the weekly mileage is regular and approximately constant, a time-period basis of maintenance is probably more satisfactory; but if the weekly, monthly or seasonal mileage is subject to wide variations, the use of the time period basis would introduce differences in the distance travelled, in which case the distance basis of maintenance would be preferable.

1.1 Service Maintenance

This is carried out on a regular basis in order to maintain the equipment in sound condition and to prevent service failures. If maintenance is carried out efficiently at the established periods, the equipment will operate reliably between overhauls.

Maintenance is usually carried out in the running shed and comprises examination, cleaning, lubrication, any necessary adjustments for wear, and changing worn consumable parts such as carbon brushes, contacts, arc chutes etc. fitting new or re-conditioned parts.

Consumable part must not be allowed to wear beyond the specified minimum dimensions. If it is estimated that a part will become fully worn before the next maintenance occasion, it must be replaced by a new or reconditioned part. In addition, a sufficient margin for wear should be allowed in case a normal maintenance occasion is missed, due to the hazards of severe weather or other unusual traffic conditions.

The intervals at which the various maintenance operations are carried out can only be determined by observation and experience. At first, the intervals should be about one week or 3200 km, and they should be lengthened gradually as experience is gained without, of course, endangering the reliability of the equipment. Eventually, when the maximum intervals have been established, they should, if possible, be arranged to fit the occasions when the vehicle visits the running shed for maintenance of the mechanical parts of the vehicle.

1.2 Overhaul

This is carried out in the workshop, and comprises repairing and reconditioning the equipment; that is, dismantling, replacing worn or defective parts by new or reconditioned components, re-assembling the equipment and testing it for correct operation.

The periods between overhauls are best determined by withdrawing the equipment for service after a period of two years or 160,000 km, and subjecting it to a detailed examination, which will also necessitate a certain amount of dismantling. If it is found that the equipment has not reached the Overhaul state, it should then be returned to service.

In general, periods between overhaul should not be less than three years. These periods are, however, capable of being extended to five years or more provided.

a) Modern high-grade lubricants are used.
b) Maintenance is efficiently carried out.
c) Thorough attention is given to cleanliness.

Experience on many railways, in different parts of the world, has shown that more frequent maintenance and overhaul are necessary for the mechanical parts of the vehicle than for the electrical equipment. As the program for the electrical work must be built up gradually, and the periods extended as experience is gained, every endeavour should be made to fit the electrical program into the mechanical program, in order to minimise the time that the vehicle is out of service.

1.3 Records

Accurate records should be kept of the maintenance and overhaul work carried out in order to determine the amount by which the Maintenance and Overhaul periods may be extended. "Cardex" is a suitable system for this purpose, and it would contain card for each of the items on which records are to be kept, for example, armatures, machine stators, gears, pinions pantograph wearing-strips (if fitted), cleaning filters and radiators, etc.

2. CLEANLINESS

Cleanliness is essential to good maintenance and trouble-free service, and the work of cleaning must be thoroughly carried out at the established intervals.

Metallic dust from the wheels and brake shoes is detrimental to equipment and, if the dust is allowed to lie on insulation surfaces or to penetrate coils, it can cause electrical failure.

This dust, when dry, is usually easy to remove, but if it becomes bound with water or oil, its removal is more difficult. Operators must, therefore, avoid leaving deposits, which have this binding action.

The degree of cleanliness, which can be maintained, depends to a large extent on the location of the equipment and whether it is totally enclosed, ventilated, or outside-mounted.

When no ventilation is required because the production of heat is low, apparatus is enclosed in dust-proof cases, compartments or cupboards; ensure that the rubber or felt jointing of the covers or doors is maintained in good condition.

Ensure that the devices for keeping covers and doors closed are also well maintained and lubricated when necessary.

Compartments, which cannot be seated easily, for example when they are provided with sliding doors, are sometimes pressurised with filtered air. When this is the case, it is important to ensure that any failure of air supply is restored without delay, and the filter is cleaned regularly, or changed when necessary. Although the frequency of cleaning totally enclosed apparatus is much less than that required for ventilated or roof-mounted apparatus, it must not be neglected if failure is to be avoided.

Apparatus such as resistors and rectifiers, etc., which have to dissipate heat to avoid excessive temperature, are either free-ventilated or force-ventilated with unfiltered air and require frequent cleaning, as they readily become contaminated with dirt and brake shoe dust.

On electric vehicles on which roof-mounted apparatus is fitted, there are large porcelain insulators, which may collect much falling dirt and therefore must be kept clean. Rubber hose for the pantograph air supply must also be cleaned and kept free of oil and grease. Examine all roof equipment and check for mechanical damage; remove any debris that may have lodged on the roof.

3. LUBRICATION

In general, lubricants should be used sparingly to avoid contaminating insulation and other parts of apparatus. Clean the electrical sliding contacts of knife switches, drum switches and reversing switches etc., periodically, then lightly smear them with 4 x grease (supplied by Dow Corning, USA)

Pivots for contactors and hinged contact fingers, etc., are lubricated during assembly, chiefly as rust inhibitor prior to being placed in service. Do not add lubricant at periodical maintenance because the pivots have an extremely long life, even when operating dry, and if lubricants were added it would tend to contaminate other parts of the apparatus, thus forming a dirt-collecting surface. Lubricate pivots only at overhaul with grade SAE 30 oil.

Lubricate cylinders, piston, rods, sliding parts and solid (no oil-impregnated) rollers, etc., periodically with grade SAE 30 oil.

Do not add grease to ball bearing between overhauls, unless otherwise specified in this manual; clean and re-pack them at overhaul with Shell Alvania 3 or other approved grease. Also use this grease for smearing the teeth of racks and pinions, and for lubricating sleeve-bearings.

Lubricate oil-impregnated rollers and bearing bushes with grade SAE 30 oil only an overhaul.

Lubricate the hinges on pantograph current-collectors with no-water-soluble grease or oil.

The foregoing information is given as a guide, and it is recommended that operators discuss with an oil company's local representative, the lubricants best suited to the particular climatic conditions under which the equipment will operate.

4. TIGHTNESS OF BOLTS SCREWS AND NUTS

It is essential that all bolts, screws and nuts are kept tight, because any loosening can cause failure of the vehicle as well as damage to adjacent or associated apparatus. There is also the possibility of fire being caused by arcing at loose terminals.

Suitable locking devices are provided in the form of high grade spring locking-washers, locking plates, grub screws or prick-punching etc., and when dismantling take place these locking devices must be replaced by devices of the same grade of material and in the same form as originally supplied.

Contactor contacts, which are subjected to repeated impacts, connections, which are subjected to severe heating cycles such as those, associated with resistors, and the smaller sizes of cable terminals, are items which are most liable to loosen.

Before the equipment enters service, carefully check every electrical connection and contact. Repeat this check after a week and then every three months for the first twelve month's operation. If at the end of twelve months, no further loosening is detected, it can be assumed that all connections will maintain their tightness for an indefinite period and the checking may be discontinued.

The reason why certain contacts and connections become loose is due to the copper deforming slightly when under pressure, and the repeated tightening causes it to become compacted and work hardened.

5. ELECTRICAL INSULATION

Insulation can fail either by puncture through the body to the material, or by surface breakdown.

Puncture depends upon the quality and thickness of the material and the voltage across it. It follows, therefore, that if insulating material has suffered damage, it must only be replaced by material of the original thickness and quality.

Surface breakdown depends upon the quality of the surface of the material, its cleanliness and freedom from moisture, the surface length, and the voltage across it.

If the surface is contaminated by dirt and/or moisture it becomes slightly conducting and a minute current will flow along a very narrow track. This current will produce heat along the track, which may cause the dirt and/or the surface of the insulation to carbonise and the "tracking" current to increase. The action then becomes cumulative and if the surface is not cleaned, a flashover of power current will occur sooner or later.

The insulation surface between two points at different voltage level is known as the "creepage distance" while "tracking" is the term applied to the visible evidence of the passage of minute currents along irregular tracks on the insulation surface.

The top surface of horizontal insulation is, of course, mere prone to contamination by dirt and moisture and requires more frequent cleaning than vertical surfaces.

When an insulation surface becomes damaged by tracking or has deteriorated with age, it can be reconditioned by painting it with good anti-tracking enamel. Such as grey insulating enamel which can be supplied by brush and which is air-drying.

When apparatus is being overhauled, take the opportunity to recondition the insulation surface, if this appears to be necessary. If porcelain insulation suffers surface damage, fit new porcelain; however, the surface of Mycalex insulation or resin-bonded asbestos can be reconditioned by cleaning it with fine glass paper.

Porcelain insulators which are exposed to the weather may become encrusted with a hard surface of carbon, copper and brake-shoe dust, etc., which is difficult to remove. By coating the surface with Metroarc-17 or Silicone-110 grease, the contaminants may be removed easily at suitable grease intervals; re-grease the porcelain insulators after cleaning. First, apply the grease thinly on the hands, then run the hands lightly over the porcelain surface.

6. ARC CHUTES

The arc-chute walls, especially the area adjacent to the contact tips, will exhibit charring and soot from the arc, and splatter from the contacts dependent on the severity and duration of the arc. Maintenance work is rarely necessary but it is important to examine the arc chute interior for unusual charring or an unusual extent or copper splatter on the arc horns or splatters which would indicate a fault on the Contactor or its associated equipment.

If an arc chute is removed for inspection, always refit it in its original position so that the pattern of its characteristic wear can continue. To achieve this, mark each arc chute to correspond with its Contactor.

When an arc chute has reached its safe limit to working life on a heavy-duty Contactor it may be economic to extend its life by interchanging it with the chute from a lightly loaded Contactor.

Record any such interchanges so that the equipment inspectors understand the reason for wear on the lightly loaded Contactor, the arc chute of which may normally remain almost as new.

After fitting an arc chute and during any inspection of arc chutes, ensure that the chute is securely in position and, PROVIDED THAT THE CONTACTOR IS NOT LIVE, manually operate the Contactor and observe that the moving contact does not foul the chute.

Ensure that spare arc chutes are always available in the running sheds, safely stacked and kept clean and dry, to enable any damaged or badly-eroded chute to be changed quickly.

Overhaul

Asbestos develops a skin, which would not be disturbed by rough filing. Use a fine file or glass paper to remove loose dirt and any copper globules, which may foul the moving contact.

Since un-weathered asbestos is hygroscopic, new or freshly repaired arc chutes should be kept warm and dry. Wet arc chutes can cause low readings of insulation resistance on the power circuits.

Mycalex is not hygroscopic and the surface can be reconditioned by rough filing, if necessary.

Examine the arc chute mounting arrangement. Recondition Starting threads on mounting blocks and screws.

Examine the arc-chute interior for signs of rubbing or transferred paint due to fouling by the piston insulator or the blow cut coil.

Erosion in the form of creators in the side plates, and gutters in the top and bottom spreaders can often be repaired with an arc-resisting cement provided that the erosion has not penetrated too deeply. Clean thoroughly with glass paper the part to be cemented. The cement can then be applied with a knife and the repair dried in an oven or air dried before the chute is used again.

Scrape any soot from the joints between side plates, splitters and spreaders and look for penetration by the arc in to the joint. Fill any such penetration with arc-resisting cement. Use this cement to coat the joints during re-assembly of any arc chute components, which are prone to severe penetration.

Ensure that any copper inserts in the arc-chute body are securely fixed.

Ensure that incorrect re-assembly does not allow the arc to strike any fixings, especially which pass through the arc chute.

7. ARCING HORNS

Contactors with un-swept top arcing horns depend upon a good fit between the horn and the chute to produce a gas proof joint for the protection of the blow-out coil; this close fit must be preserved when a new arc chute or horn is fitted. This fit should be equivalent to a clearance not greater than 0.25 mm between horn and chute.

When arcing horns become badly eroded at their tips and become appreciably shortened, fit new horns.
When unswept top arcing-horns become eroded to half their original thickness, fit new horns.

8. CONTACTS

Copper and silver are in general use as contact materials. Although the resistance values are similar, silver is an inferior arcing material due to its rapid erosion and is used only for low-voltage control-circuits with light arcing duty and for heavy-current contacts with no arcing duty.
Silver forms on its surface a low-resistance sulphide, which is brown to black in colour, and need not be disturbed.

Copper forms an oxide, dark in colour, which has a high resistance. This would cause overheating if it were left on a contact face.
For Contactors (which interrupt current frequently as distinct from a switch or an isolator) copper is used. Each contact is formed in the shape of a foot with a distinct heel and toe and the moving contact is spring-mounted on a pivot. As the Contactor closes, initial contact is made at the toes of the contacts and, as closure proceeds, the moving contact rolls and slides over the fixed contact until final contact is made at the heels. The action is reversed when the Contactor opens; the area of contact travels to the toes where the contacts separate, so that the arcing when current is broken has its roots at the toes of the contacts. By this means, the transfer of current can take place across well-mated surfaces free from arcing. The action of the moving contact is termed KNUCKLING and is a combined rolling-and-sliding motion.
Copper contacts for light-duty contactors and for switches do not always have a distinct toe and heel with a knuckling action, but they are always given a sliding action or WIPE, which promotes a self cleaning action of any copper oxide that may have formed.
In general, silver contacts close with a simple butting action and such contacts are termed BUTT contacts.
The term OVER-TRAVEL is used for both wiped and butt contacts with reference to some particular point on the moving contact or its carrier and denotes the distance that this point would travel after making

initial contact if the fixed contact were then removed. It is therefore an indication of the amount the contacts can wear before effective contact fails.

In some applications, a Contactor may combine the properties of copper and silver by having a pair of copper contacts with silver inserts at the current-carrying areas. On other contactors, separate pairs of contacts in parallel are used, one pair of copper and one pair of silver, with the silver, contacts closed only in the fully-closed position of the contractor and the copper contacts making and breaking the current.

DO NOT USE EMERY OR GLASS PAPER to clean contacts, as particles of these materials, which might adhere to the surfaces, would cause faulty contacts.

DO NOT USE WIRE WOOL to clean contacts or any other electrical apparatus.

When contact tips are being fitted, tighten them lightly, and then finally tighten them with the Contactor energised or firmly held in its closed position. This will give the best possible bedding of the contacts.

Some contact carriers have a ledge on which the contact locates, so that no movement can take place during the repeated closing of the Contactor and such contacts must be seated fully with the fixing screw and tightened before finally tightening with the Contactor fully closed.

On a rebuilt Contactor, the fixed-contact holder may be askew, thus preventing good bedding of the contacts. Correct the contact holder by slackening its fixings, then tightening with the Contactor closed.

If the contact tips are discoloured by overheating, examine them for dirt or a coating of copper oxide on both the front and rear conducting surfaces; check also the tightness and bedding of the contacts with each other and with their holders. Overheating may also be caused by low contact-pressure due to worn contacts, lack of overtravel, or a weak knuckling-spring.

Examine knuckling or contact springs periodically to ensure that no stiffness has developed in the hinge, and that the spring has not weakened. An experienced inspector will quickly discover any abnormality of the hinge or the spring pressure by manipulating the device.

Fit new contacts in place, if any, which have worn to half their original thickness of copper or silver. Always fit new contacts in pairs since it is not practical to bed a new contact with a worn one. Except on small contactors and auxiliary contacts hand filing of badly worn contacts to produce a true surface capable of being correctly mated, is a highly-skilled operation and is rarely successful. If it is attempted, the filing should be carried out with the contacts in a vice so that pivots or pistons are not stressed, and no metal particles fall on the apparatus.

Transference of metal from one contact to the other occasionally occurs in inductive circuits. When this occurs, file the contacts to their normal contour in a vice, or if the transference is appreciable, fit new contacts.

Restrict filing in position to a fine file to remove copper oxide and small high spots on current-carrying surfaces, also to remove copper beads from contact edges and arc-rupturing areas, since these may foul the arc chute or may eventually drop into the moving parts of the contactor.

Copper contacts

After a few weeks in service, the appearance of the contacts will indicate where the interruption is taking place by a rough copper surface and where current carrying takes place by bright copper areas. A dull surface indicates where the contacts are not mating; such a surface on the heel of a contact would indicate that the knuckling action is incomplete or that the contacts are misaligned.

A regular inspector will appreciate the condition to be expected from the contacts. Since each pair will develop contact wear and copper splatter on the arc horns and arc chutes characteristic of its position in the circuit. As a guide to the amount of wear to expect, the inspector should at first learn whether each pair of contacts breaks or makes current or both or is simply used for isolation. Note that the contact wear on some contactors with light duty or infrequent heavy duty under fault conditions, may be largely due to mechanical hammering and knuckling. The inspector should be able to recognise unusual wear, which may indicate a fault on the contactor or on its associated equipment.

Current-carrying areas which have a bright appearance, but which have become rough and pitted, indicate good contact and need not be disturbed.

Silver Contacts

In normal operation only a visual inspection is necessary between overhauls.

On control circuits with inductance, arcing will cause a transfer of metal, but the resulting pip and trough will not normally warrant attention until the overhaul stage. When appreciable erosion has occurred, smooth the surfaces with a fine file and readjust the contact gap and overtravel.

The contact pressure of control and auxiliary contacts are not critical, but it is necessary to ensure that they have adequate overtravel, so that they will be effective even after some wear has taken place.

On power circuits, there will be no arcing unless there is fault condition.

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9. PNEUMATIC PISTONS AND CYLINDERS

9.1 Lubrication

Lubricate the cylinders and piston rods of E.P. Contactors periodically with grade SAE 30 oil, otherwise their operation will become sluggish, and this will be detrimental to the general operation of the equipment, particularly to rupture the arc. Lack of lubricant will also cause rapid wear of the cylinder wall, piston rod and guide.

In order to lubricate the piston rod of an E.P. Contactor, raise the piston in its cylinder (by pressing the magnet valve button) and add a small quantity of oil to the countersink which surrounds the rod at the top of the cylinder to lubricate the cylinder, inject a small quantity of oil through the special oil-hole in the cylinder wall.

E.P.Contactors with horizontally disposed cylinders do not require the piston rod to be lubricated, because the rod passes through a clearance hole in the end of the cylinder.

Lubricate the cylinders of reversing switches and change over switches with grade SAE 30 oil, through nipples provided in the cylinder walls. Before adding the lubricant , ensure that the piston is coincident with its nipple. When one piston has been lubricated, move the piston assembly to the other end of its stroke (by pressing the relevant magnet-valve button).

Before refitting a piston in to its cylinder, smear the cylinder wall thoroughly with oil.

Lubricate the rack, pinions and levers of reversing switches and changeover switches with Shell Alvania 3 or 4x grease.

9.2 Dismantling and assembling

Cylinder walls have a very fine and smooth finish to avoid wearing out the rubber piston seal. Great care must be taken, therefore, to ensure that the surface is not damaged.

When dismantling the pistons of pneumatic contactors, it should be borne in mind that the return spring is under compression. When the nut holding the piston to the rod is released, it will tend to fly out of the cylinder and might be damaged or cause damage to neighbouring apparatus or injury to personnel.

Carefully examine rubber seals at over haul; fit new seals if appreciable wear is evident. Seals are slightly elastic and must be stretched and forced over the lip on the piston in to the groove.

When fitting a piston rod, anneal the copper washer seal in order to ensure an airtight joint, when refitting a cylinder cover, use a new jointing gasket because the existing gasket is invariably damaged during the removal of the cover, and pieces of the old gasket adhere to the cylinder and cover. Ensure that all traces of the old gasket are removed before fitting the new gasket.

Pneumatic cylinders for contactors are sometimes provided with a loose tube on the piston rod which acts as a piston stop to protect the return spring against over-compression. During re-assembly work, this tube must not be omitted.

10. RESISTORS

- The following types of resistor are most commonly used on traction equipment
- Expanded metal or metal strip wound on edge
- Wire wound, mica insulated metal tubes
- Vitreous enamelled, wire wound, porcelain tubes
- Flat, wire or metal tape wound mica elements

Maintenance

- Check that all nuts, bolts and screws are tight.
- Ensure that all connections, tapping and terminals are secure and in good condition.
- Inspect resistors for damage and overheating; if necessary fit new units.
- Examine insulators and supports, remove cracked or chipped insulators and fit new ones.
- Wipe insulators with clean, dry cloth-Blow-out resistor banks with dry compressed air.

Overhaul

- Repeat maintenance.

- Re-varnish insulation surfaces, other than porcelain.
- Clean metal support frames and covers, repaint if necessary
- Check resistance values to figures given "Data for Control Apparatus".

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NOTES

CHAPTER XI

DRIVING INSTRUCTION

CHAPTER XI

DRIVING INSTRUCTIONS

1. OPERATING INSTRUCTIONS FOR DRIVER

1) **Preparation of Vehicle for Service**

The driver should be provided with a master controller key and driver's control key. Before taking a train into service, the driver must check the following points.

1.1 Check that all sealed switches are in OFF position.

1.2 Insert driver's control switch (DCS) key in Driver's Control Switch box (BL box) and turn in ON & OFF.

1.3 Insert the master controller key and operate FORWARD & REVERSE and keep it in the OFF position.

1.4 Switch on 24-Volt DC Battery isolating switch in the engine room.

1.5 Switch on 110 Volt DC battery isolating fuse switch behind driver's seat.

1.6 Switch on both battery voltmeter switches and check for

i) Starting battery voltage reads 24V

ii) Control battery voltage reads above 88V

1.7 Switch on all MCBs (control and auxiliary) except rectifier blower motor MCB

i) Switch on 110 V MCB and 24 V MCB in the engine control panel

ii) Throw the local/remote selector switch in the engine control panel to remote side.

1.8 Insert DCS key in the BL box & turn it ON.

1.9 Switch ON control switch in the BL box.

Control ON indication will come on LED indication panel.

1.10 Press lamp test switch and see that all LED indications are glowing.

1.11 Keep Engine Control Switch (ECS) in "IDLE" position.

1.12 Press "Engine ON" switch.
"Engine ON" indication will come and "Engine TRIP" indication will go OFF.

1.13 Once Engine is ON, auxiliary alternator rectifier set will generate supply and auxiliary alternator failure indication will go off.

1.14 Switch ON rectifier blower motor MCB. Rectifier blower motor will start functioning now. Rectifier cooling fan failure indication will go off.

1.15 Keep the test sequence switch in OFF condition and ECS continue to be in "IDLE" position.

1.16 Allow the engine to run in IDLE position till feed pipe pressure reaches 7 Kg/cm sq. For fast build up of the pressure engine can be notched up accordingly.

Note: Alternator Excitation ON switch on BL box should necessarily be in OFF condition.

2. Instructions for driving

2.1 Ensure that parking brake is released. If not, release the parking brake switch.

2.2 If feed pipe pressure is built up to 7 Kg/cm sq. and guard's key is inserted, driver's interlock relay (DIR) will operate thereby drive function released indication will come. It is now possible to take traction.

2.3 Put ECS switch in "RUN" position

2.4 Switch on Excitation ON switch in BL box. Alternator Excitation ON indication will come.

2.5 Ensure that brake pipe pressure is 5 Kg/cm sq.

2.6 Move the master controller key in clockwise direction by 90° & set the reverse handle of master controller to the FORWARD position.

2.7 Depress deadman's handle and move it in the Notch-1 position.

2.8 Now, the master controller can be moved to next notch.

3. Instructions for shutting off the vehicle

3.1 Bring the master controller handle to OFF position & release the deadman's knob.

3.2 Switch OFF the excitation.

3.3 Apply parking brake

3.4 Put ECS switch in "IDLE" position. Switch off engine by pressing Engine OFF switches.

3.5 Switch off the Control Switch in BL box.

3.6 Bring DCS key in off position and remove it from DCS box.

3.7 Switch off control battery and starting battery-isolating switches.

3.8 Close all the doors and windows of the driving cab.

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CHAPTER XII

DETC DRAWINGS

1. **Power Pack and accessories**
2. **Wiring Schematics**
3. **General Arrangement Drawings**

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CHAPTER XII

DETC DRAWINGS

A. Power Pack and accessories

S. No.	Description	Drawing No.
1	Power Pack Arrangement	45812450
2	Power pack Assembly	45812440
3	Air Cleaner Arrangement	45831110 S1,S2
4	Exhaust Pipe Mounting Arrangement	45820420
5	Radiator Mounting Arrangement	45820470
6	Radiator Water Piping Arrangement	45820510 S1,S2
7	Schematic Diagram of Hydraulic Circuit	45825260
8	Fuel Line Piping Arrangement	45825270

B. Wiring Schematics

S. No.	Description	Drawing No.
1	Power Schematic	30104007
2	Control Schematic Cab - 1	30104005
3	Control Schematic Cab - 2	30104006
4	Auxiliary Schematic	30104008
5	Power pack schematic 1 & 2	30104009

C. General Arrangement Drawings

S. No.	Description	Drawing No.
1	Traction Alternator	CGA/101004
2	Traction Motor	11290003
3	Power Rectifier - OGA	1216-02-1807
4	Power Rectifier - IGA	1216-03-1807
5	Auxiliary Alternator	19A 3086
6	Rectifier Regulator Unit	4A 3089
7	Driver's Desk	31610140
8	Control Cubicle Cab 1 - OGA	31610142
9	Control Cubicle Cab 1 - IGA	31610143
10	Control Cubicle Cab 2	31610138
11	Motor Switch Group Cubicle - OGA	31610144
12	Motor Switch Group Cubicle - IGA	31610145
13	Resistor Panel	31610139

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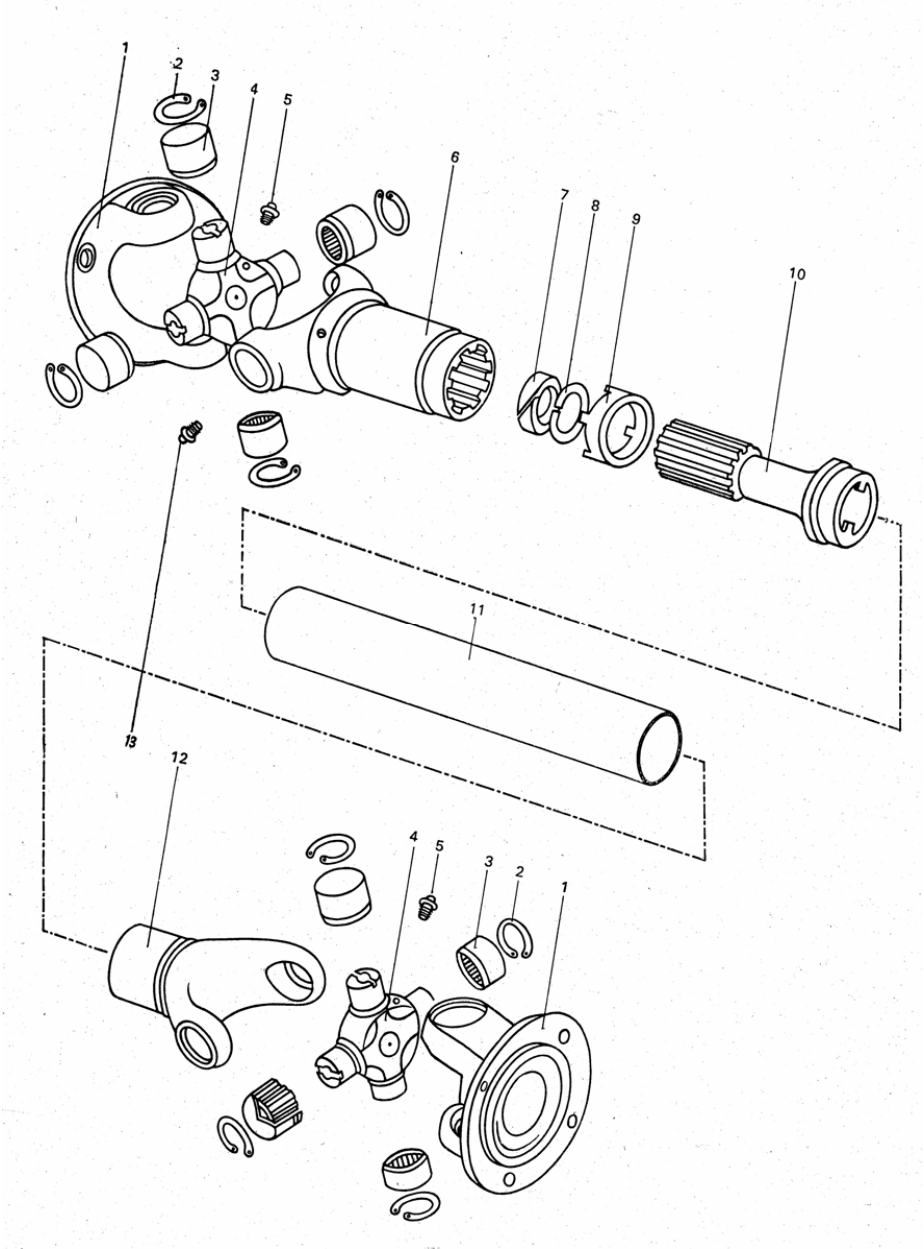
Annexure 1

Cardan Shaft

A1.1 Introduction

1. Exploded view
2. Specifications
3. Installation, Maintenance and servicing



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A1.2 Key to typical exploded view:

1. Flange yoke
2. snap ring
3. Bearing cups
4. Journal
5. Lubricator

(1–5: U.J. kit)

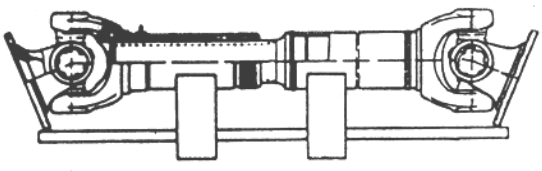
6. Sleeve yoke with sleeve yoke plug
7. Cork washer
8. Steel washer
9. Dust cap
10. Slip stub shaft
11. Tube
12. Stud ball yoke
13. Lubricator

A1.3 Installation, Maintenance and Servicing

A1.3.1 Transport and storage

Care should be taken on the following points:

1. The shafts should be transported in horizontal position. For vertical transportation an additional protection must be provided in order to avoid the shaft coming apart. The sleeve yoke plug and the dust cap of the spline seal must not be loaded by the weight of the propeller shaft.
2. Shocks and bumps must be avoided during transport.
3. The shafts should be stored side by side on wooden frames and the flange yokes should be supported loosely, as shown



4. Balance weight strips wherever fitted on the shaft tube should not be removed. Removal will create unbalance which will cause uneven running and premature wear of the propeller shaft joints and the bearings of the connected units.

A1.3.2 Installation

For satisfactory operation, the driving shaft and the driven shaft should be coplanar and the propeller shaft should be installed either as per arrangement 1 or 2 shown below:

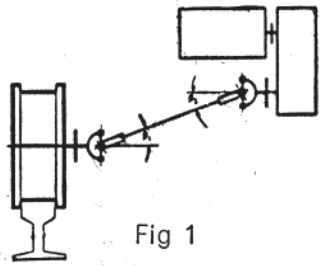


Fig 1

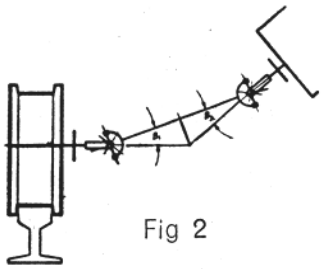


Fig 2

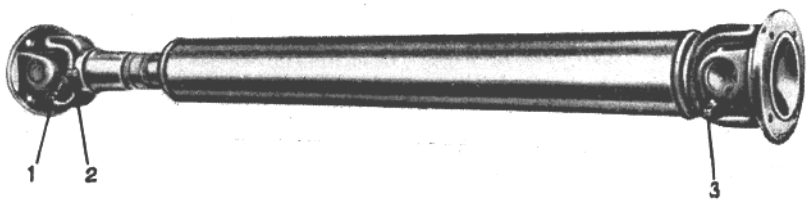
The flanges of the propeller shaft and that of companion flange (propeller shaft mating part fitted on the driving/driven shaft) should be free of dirt, grease, paint, anti-rust compound, burrs, etc., This is important as torque is transmitted through friction between flanges. For the same reason only the bolts and nuts recommended, same to be torque tightened.

The spigot bore/dia of companion flange should be concentric with driving/driven shaft on which it is fitted and its flange face should be square to driving/driven shaft to ensure true running of propeller shaft.

The mounting bold should be steadily tightened with a torque wrench in a crosswise pattern to torque values indicated.

While using fixed length propeller shaft and universal joint (types J & L) at least one of the units to be connected should be capable of axial movement and subsequent bolting down as the propeller shaft/universal joint has to be fitted over the flange spigot dia/bore.

Important: The propeller shaft/universal joint is to be is to be greased at points 1,2 and 3 before installation.



A1.3.3 Maintenance

Maintenance should be carried out at regular intervals and it is advisable to do-ordinate this with the maintenance work of the other items of machinery/installation. The maintenance intervals mentioned herein are only for guidance. The actual frequency will depend on working conditions.

1. **Noise testing:** continuously, any deviation from normal working noise should be located and corrected immediately.
2. **Checking of Flange bolts:** periodically the bolts should be checked for tightness and tightened whenever necessary.
3. **Lubrication:** propeller shafts should be periodically greased with lithium based grease only. This should be acid and soap free, as the former causes corrosion and the latter clogs the passages. Recommended grease are given in separate table. The propeller shaft should be greased at three points, where the grease nipples are provided. Greasing of joints to be done till the grease comes out through the seals, and for sleeve yoke till the grease flows out through the vent holes on the sleeve yoke plug.

Application	**Joints**	**Sliding splines**
Earth moving equipment	5000 kms	2500 kms
Trucks, Lorries, Busses	10000 kms	5000 kms
Locomotives, Railcars, Rolling mills Cranes,	30 days/500 hrs.	30 days/500 hrs.

Marine applications & general machinery		

A1.3.4 Servicing

A1.3.4.1 Dis-assembly of propeller shaft

Remove the dust cap, pull back the cork washer & steel washer and pull off the sliding joint from the shaft. (Flange yoke to sleeve yoke)

Disassembly of the universal joint

(Snap ring type : 0400 to 1510 series)

1. Clean enamel / paint from snap rings and top of bearing cups. Remove snap rings by pinching their ears together with a pair of pliers and rising with a screw driver. If ring does not snap out of the groove readily, tap end of bearing race lightly to relieve the pressure against the ring. Support sleeve yoke lug on a wooden block and tap yoke ears with a soft hammer.

1. Now the bearing cup should begin to emerge. Turn the joint and finally remove the bearing cup with fingers. Care should be taken to avoid any of needle rollers being dropped.
2. Similarly remove the opposite bearing cup also. If necessary tap bearing cup from inside with a small dia bar, taking care not to damage the bearing cups / journal.
3. Now the sleeve yoke can be removed, rest the two exposed trunnions on wooden blocks to avoid damage. By tapping the yoke ears lightly with a soft hammer and following the above procedure, remove the other two bearing cups.
4. On the same lines dis-assemble the fixed joint (stub ball yoke side) also.

A1.3.4.1.1 Examination and check for wear

The parts most likely to show signs of wear after long usage are bearing cups and journals. Should looseness in the fit of these parts, load markings or distortion be observed they should be renewed complete as a unit, because worn needle bearings used with a new journal, or new needle bearings used with a worn journal, will wear more rapidly, making another replacement necessary in a short time.

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It is essential that bearing cups are a light drive fit in the yoke trunion

In the rare event of wear having taken place in the yoke cross holes, the holes will most certainly be oval and the yokes must be replaced.

In the case of wear of the cross holes in stub ball yoke, which is welded onto tube, only in cases of emergency should this stub ball yoke be replaced. Normally stub ball yoke along with tube and slip stub shaft should be replaced as one unit.

The other parts likely to show signs of wear are the splined sleeve yoke, or slip stub shaft. a total of 0.004" (0.1mm) circumferential movement, measure on the outside diameter of the spline, should not be exceeded. Should the slip stub shaft require renewing, this must be dealt with in the same way as the stub ball yoke.

A1.3.4.2 Re-assembly

1. Assemble needle rollers in the bearing cups. Should any difficulty be encountered while assembling needle rollers in the bearing cup, smear the wall of the cup with grease. It is advisable to install new gaskets and gasket retainers on the journal or spider assembly. It is also useful to have snap rings available as replacements in the even of damaging a ring whilst dis-assembling the joint.
2. See that all drilled holes in journals are cleaned out and filled with grease, with the rollers in position fill the races about one-third full with grease.
3. Insert journal in yoke holes and using a soft round drift with flat face about 1/32" (0.8mm) smaller in diameter than the hole in the yoke, tap the bearing cup into position. Repeat this operation for the other three bearing cups. Fit snap rings or bearing caps, bearing cap screws, locking plate etc., with the bearing cap type make sure that bearing cups are placed with the slot in the top of the cup in line with bearing cap screw holes, so that they are prevented from rotating by the key in the bearing cap. If joint appears to bind, tap lightly with a wooden mallet, which will relieve any pressure of the bearings on the end of the journal. When refitting a sliding joint on shaft, be sure that trunnions in sliding and fixed yoke are in line. Observing that arrows marked on splined sleeve yoke and slip stub/tube are in line can check this.

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Annexure 2

Trouble shooting – Power pack

Sl. No.	IN CASE OF	CAUSE	REMEDY
1	Engine does not crank	Drained battery	Check & charge battery
		Incorrect /loosen battery connections	Check the battery connections and rectify
2	Engine cranks but doesn't starts	No fuel in tank	Add sufficient fuel
		Fuel filter clogged	Clean the fuel filter
		Improper Fuel connections at pump	Identify any loose connections and rectify
		Restriction in air inlet / exhaust	Check piping and rectify if any restriction exists
3	Starts but does not throttle	Air entering in the fuel system	Check all the fuel connections, tighten if found loose
		Fuel suction line restricted	Inspect fuel line for any blockage
		Fuel contaminated	Inspect fuel sample / verify by connecting a temporary fuel tank
4	Excessive exhaust smoke	Air inlet filter clogged	Remove and clean the filter element
		Contaminated fuel	Check the fuel sample & replenish with new fuel
5	Low engine out put power	Restriction in air inlet / exhaust	Check piping and rectify if any restriction exists
		Excessive lubricating oil	Check the lube oil level in sump with dipstick provided and reduce if it is high

		Improper / leakage in fuel flow to fuel pump	Check any leakage / restriction at connections, rectify if any
		Malfunction of throttle solenoid valves	Check and rectify if any
6	Low engine speed at full throttle	Malfunction of tachometer	Test and rectify
		Fuel line restricted	Check and rectify
		Excessive traction load on the power pack	Reduce the vehicle load
7	Vehicle does not moves when engine throttled	Vehicle brakes applied	Release the brake on desk and bring brake handle to 'Release & running'
		Controls not engaged in Forward / Reverse	Check & select master controller direction selector to required position, if not selected
		Parking brakes applied	Release the parking brake with operating switch provided on desk
8	No water outlet from water rising apparatus	System Pressure not developed	Check and open the isolating cock at air inlet side and Check for proper functioning of Limiting valve and non return valve
		Insufficient suction head / inlet restricted	Check water availability at pipe outlet / inspect for any block in the pipe
		Isolating valve at outlet is closed	Check and open the valve
		Hose / pipe joints leaking or disconnected	Check for proper connections / routing with respect to drawing

Annexure 3

TIGHTENING TORQUE IN N-m FOR THREADED COMPONENTS.

	MATERIAL PROPERTY CLASS AS PER IS:1367			
	8.8		10.9	
MIN.YIELDSTRESS N/mm2	640		900	
SIZE	SCREW	BOLT	SCREW	BOLT
M4	2.5	1.5	3	2
M5	6	3	8	4
M6	10	7	15	11
M8	24	18	34	26
M8x1.0	29	23	41	32
M10	46	38	64	53
M10X1.0	53	41	75	57
M12	76	63	107	89
M12X1.5	93	70	130	99
M14	117	90	165	126
M14X1.5	137	121	193	170
M16	176	139	248	195
M16X1.5	196	156	275	220
M18	245	186	344	261

M18X1.5	264	220	372	310
M20	328	264	461	372
M20X1.5	343	294	482	413
M20X2.0	333	284	468	399
M22	421	343	592	482
M22X1.5	441	392	620	551
M22X2.0	431	362	606	510
M24	549	411	772	579
M24X1.5	578	441	813	620
M24X2.0	568	431	799	606
M27	921	539	1296	758
M27X1.5	1078	637	1516	896
M27X2.0	1029	607	1447	854
M30	1264	725	1778	1020
M30X1.5	1539	921	2164	1296
M30X2.0	1470	882	2068	1241
M33	1735		2440	
M33X1.5	2059		2895	
M33X2.0	1980		2785	
M36	2216		3116	

M36X1.5	2706		3805	
M36X2.0	2608		3668	
M36X3.0	2402		3378	

The above values apply to bolts of lengths in excess of 5 times the thread diameter. For smaller lengths the valves are to be reduced by 10%.

To get lb-ft multiply the above values by 0.737

To get lb-inch multiply the above values by 8.85

To get kg-m multiply the above values by 0.102