MAINTENANCE HANDBOOK ON TRACTION MOTOR TAO - 659

CONTENTS

CHAPTER 1
INTRODUCTION

1.1 Traction Motor is the most important part of a locomotive. This motor is mostly a D.C. Series Commutator Motor, therefore it requires regular maintenance. A large no. of loco-failures are caused due to bad maintenance of Traction-Motors. Therefore it is essential to ensure proper & regular maintenance of Traction Motors. It is observed that, the correct maintenance practices as recommended by manufacturers & RDSO generally remain confined to Manuals and do not percolate upto Artisan's level. The artisan is not taught about the benefits of right maintenance and the repercussions of bad maintenance. Therefore need is felt for developing a comprehensive Training Package, which shall help the Artisans to learn about correct maintenance practices and which shall also serve as a useful guide to the Trainers of the Training Schools. This training package is proposed to comprise of a maintenance handbook, Do's & Don'ts booklet, Lesson plan, Transparencies, Wall posters & Videocassettes. Since majority of traction-motors are of TAO-659 type, this training-package is kept limited to this type of TM only.

1.2 SPECIFICATIONS

The general technical specifications of the motor are:

Make	:	Alsthom/CLW.
Type	:	TAO-659
Insulation	:	Class `H' (Both armature & field)
Suspension	:	Axle hung nose suspended.
Ventilation	:	Air forced.
Weight (complete)	:	2800 Kg.
Temperature rise	:	Armature - 140°C, Field - 160°C.
Coil resistance	:	At 110°C a) Armature - 0.012 Ω b) Main Pole - 0.01117Ω c) Inter Pole- 0.008 Ω
Rating	:	Continuos One Hour

HP	:	770 HP	798 HP
Shaft output	:	575 kW	
Voltage	:	750 V DC	750 V, Max-800/2 V
Current	:	840 Amps.	855 Amps.
Speed	:	1095 RPM	2500 RPM (max)
Air gap	:	Main Pole	Inter pole
		5.5 mm.	6.0 mm
Armature	:		
Weight	:	850 KGs.	
Length	:	390 mm.	
Core OD	:	500 mm.	
Laminations	:	0.5 mm thick, Gr. No. 260	
Net weight of copper	:	67 Kgs.	
Winding	:	Lap - progressive.	
Commutator	:		
Diameter	:	New - 380 mm, Condemning - 364 mm.	
Useful length	:	140 mm.	
Radial wear	:	8 mm (max)	
No.of segments	:	276 Nos.	
Mica thickness	:	1.2 mm (between segments)	
Mica under cutting depth	:	1.8 + 0.2 + 0 + 0	
Brushes	:		
Grade	:	EG 367 or EG 105.	
No.of holders	:	6 Nos.	
Brush/holder	:	3 Nos.	
Size	:	2 x 8x43	
Min. height	:	New - 52 mm., Worn - 27 mm.	
Spring pressure	:	2.2 to 2.4 Kgs.	

Gear Ratio	:	62:15, 58:21
Permanent shunt	:	5 %

Bearing

Type	:	CE -NJ 318, PE -NU 328
Make	:	SKF, NBC, FAG, NORMA
Lubrication	:	Shell Albania EP 2.
Clearance	:	Diametrical - CE 0.30 mm - PE 0.035 mm

1.3 POWER SUPPLY ARRANGEMENT

All the six Nos. of TMs on the locomotive are fed through RSI unit (Rectifier unit). There are three types of arrangements which can be made to supply the power to these motors as shown in figures accordingly the motors can be grouped in three ways i.e. 3s-2p, 2s-3p or 6p

1.3.1 Series-Parallel Combination (3s-2p)

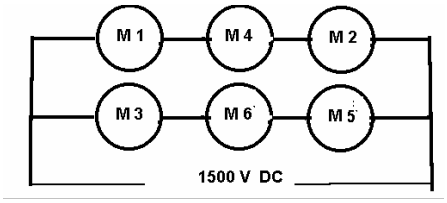


Figure 1.1

Motors on axles 1-4-2 are in series, similarly Motors on axles 3-6-5 are in series. These two series groups are connected in parallel. Though this combination is more economic but in case of failure of any one of the TM, the loco-power drastically reduces by 50% which is the main draw back of this combination. This combination of Tration Motors is therefore being phased out gradually.

1.3.2 Parallel Combination (2s-3p)

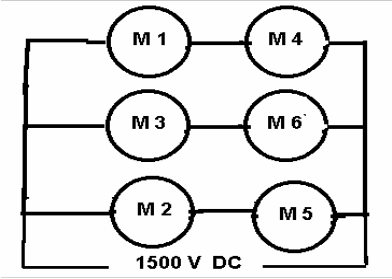


Figure 1.2

This is also called `P' combination. Generally motors on axles 1, 4 are in series, similarly Motors on axles 2,5 and accordingly motors on axles 3&6 are in series. One group has to be isolated in case of any TM problem, which reduces power of the locomotive by 33%.

1.3.3 6 P Combination

In this combination, all six TMs are connected in parallel, and each gets full voltage as shown in figure 1.3. This combination is therefore suitable for low torque & high speeds.

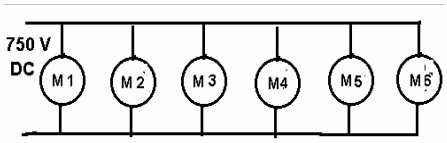


Figure 1.3

1.3.3.1 Advantages

- There is less tendency of wheel slip.
- Suitable to produce high tractive effort.
- Individual TM can be isolated in case of any failure arised on individual TM

1.3.3.2 Disadvantages

- High current rating of transformer is required.
- Two RSI units, two smoothing reactors are provided which increases the number of auxiliaries, and weight of the locomotive.
- Number of contactors and links are increased.

Since advantages outweigh the disadvantages, this combination is preferred.

1.4 Fixing Arrangement

The individual TM is mounted on the wheel set directly by coupling its counter part, axle cap by means of o8 Nos. of bolts, size M 36 x 210 / 150, 4mm pitch. The Traction Motor is suspended in between the wheel set and Bogie Frame lugs by inserting a sandwich mounting block in between bogie lugs and the TM lugs.

A gear case is also fixed on the wheel set, which covers both the TM pinion as well as the gear on the wheel set. The gear case contains a lubricating compound, generally SC- 170 to lubricate the gears.

1.5 CONSTRUCTIONAL FEATURES

The traction motor TAO-659 has the following main parts:

1.5.1 Stator Frame

This is a cast steel magnet frame consisting of main poles and interpoles fixed to it. On the Commutator side, opening has been provided for upper air inlets (from MVMT) and lower inspection cover. The terminal box is situated above the axle side. To the backside of frame, two lugs are extended for suspending the TM in bogie frame by means of inserting a sandwich-mounting block in between the TM lugs & the bogie lugs. For securing the gear case, this frame is also facilitated two eyes on the top & bottom and two inside threaded holes at the pinion end as shown in figure 1.4. The another counter part of the frame is axle cap, which facilitated the axle bearings (half of each PE & CE) oil pumps, wickpads etc. The two oil wicks containers are in communication with each other through an oil passage situated at the upper part of the axle cap. Oil is supplied from an axle driven oil pump in central oil sump; oil delivery being assured in both running directions. Any surplus oil of the containers returns to the pump. Axle cap is also having an arrangement for providing earthing shunts, which allows the return current to rail through the axle & wheel assembly.

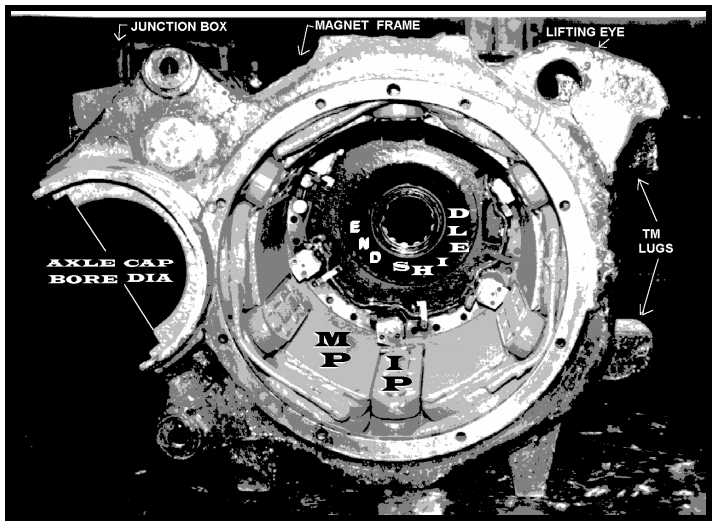


Figure 1.4

1.5.2 **Armature**

It is the rotating member of the motor, consisting of a number of copper conductors suitably placed and connected so as to form a closed winding. The armature consisting of slots, teeth, winding and the core is shown in figure 1.5. The rotating armature is subjected to an alternating flux varying at frequency of 20 to 50 Hz, depending upon the number of poles and speed (f= PN/120), which gives rise to eddy currents and hysteresis losses in the armature core and teeth. The eddy-current loss is directly proportional to the square of the thickness. Therefore the armature is built up of 0.4 to 0.5 mm thick magnetic steel laminations, insulated from one another by a thin layer of class `H' varnish. The punching are keyed to armature shaft. Longitudinal ventilating ducts are provided in the core to improve the cooling.

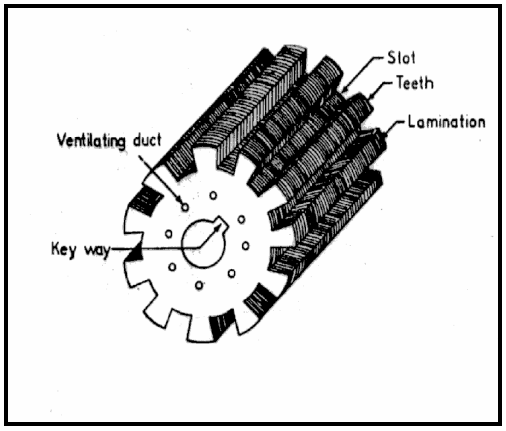


Figure 1.5

Assembled hot in a press, the laminations are maintained by a cast steel armature head at pinion end, and at other, by the cast steel armature sleeves retained on the shaft by set ring and retaining ring at pinion end.

1.5.2.1 **Armature Winding**

It is composed of high conductivity electrolytic copper conductor, with 2/3-tape kapton, bunch insulation being made by:

- Glass mica silicon tape on the involute portion.
- Nomex silicon mica wrapper in the slot portion.

The coils are maintained in the slots by moulded "Durestos" slot wedges or laminated fibreglass slot wedges and by poly glass tape. The Choice of armature winding is decided as following:

- When the armature current is not high, a simple wave winding is preferred. But for high armature current, number of parallel path should be more, as a result lap winding is preferred because number of parallel path equals to number of poles.

- Also depends on the no. of poles & the speed of the machine, normally the current per parallel circuit should not exceed 250 Amps.
- The armature current to be handled by the brush, should not be more than 400 Amps.
- The pitch of the Commutator segment should be within a range of 5 to 10 mm. In case of TAO-659 Tration Motors , Armature winding is Lap progressive type, with Nos. of parallel paths.

1.5.3 Armature Bearings

The armature is supported on two roller bearings mounted on cast steel end shields. Fitment of these bearings must be in parallel. Greasing gun is used for greasing the bearings. Labyrinth type oil seals are fitted and evacuation of used grease is ensured by the service greasing overflow outlets.

1.5.4 Commutator

Commutator of TAO-659 TM consisting of a 276 nos. of copper segments, properly insulated from each other. The function of a Commutator is to invert DC input wave to an AC wave in the armature winding.

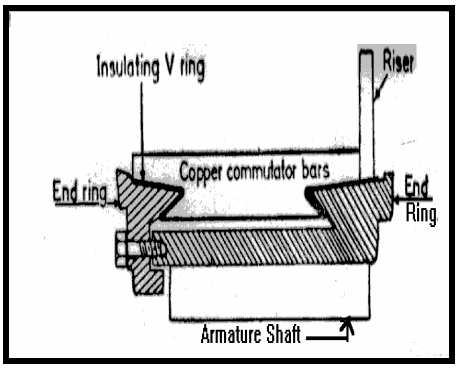


Figure 1.6

It is built up of a number of small wedge shaped segments of high conductivity hard drawn copper, insulated from each other by mica or micanite separators of about 0.8 mm thickness to avoid jumping of brushes and resultant sparking. The Commutator segments are assembled over an insulated steel cylinder of V-cone shaped. The assembly is forced and press fitted on the shaft.

The ends of the armature coils are directly soldered to the Commutator base, when the Commutator diameter is approximately equal to the armature diameter. However, when the difference in the two diameters is appreciable as in case of TAO-659 Traction Motors, the ends of the armature coils are connected to the Commutator with the half of risers shown in figure 1.6.

1.5.4.1 Commutation

The emf generated in the armature conductor of DC machine is alternating and as such the current in a particular conductor is in one direction when the conductor is moving under the north pole and in the reverse direction, when it is moving under south pole. This reversal of current in a coil will take place when the two Commutator segments to which the coil is connected are being short-circuited by a brush. The process of reversal of current in a coil is termed `COMMUTATION'.

The reversal of high current in an inductive circuit in such a short time may pose certain difficulties causing considerable sparking at two brushes. From the physical considerations, the commutation process is of complex nature, in which various mechanical, thermal, electrochemical & electromagnetic factors are closely interwoven.

The rapid reversal of current in the armature core sets up a self-induced emf, generally called reactance voltage, which tends to delay the current reversal in the coil. As a result, the current in the short circuit coil does not attain its full value in the reverse direction by the end of short circuit. This is the basic cause of sparking at Commutator. Hence the reactance voltage is mainly responsible for sparking at the brushes of DC machines.

1.5.4.2 **Method of improving Commutation**

Sparking at the brushes can be minimised with an improvement in the commutation by providing special commutating poles (interpoles), placed mid way between the main poles and wound with comparatively few turns and connected in series with the armature winding. For DC generators, their polarity should be the same as the next main pole in the direction of rotation. For DC motors, the polarity should be opposite to above .The field produced by the interpole winding opposes the armature field.

The mmf developed by the interpole must be stronger than the armature mmf in the neutral zone, because this mmf has to cancel the armature mmf and in addition induce an emf in short circuited coil which opposes reactance voltage and the voltage drop at the brushes. If the mmf on the interpole is too weak, it would lead to retarded commutation and if it is too strong accelerated commutation is achieved. In both the cases sparking will be occur at brushes

and Commutator. Hence, the mmf on the interpole must be estimated correctly, so as to achieve sparkles commutation.

Use of high reactance brushes (carbon brushes) and using brushes wide enough to cover two or three segments, further improve commutation.

1.5.5 Brushes and Brush Holder

Brushes are needed to collect the current through rotating Commutator or to lead the current to it. Normally brushes are made up of carbon and graphite. So that the Commutator surface is not spoiled.

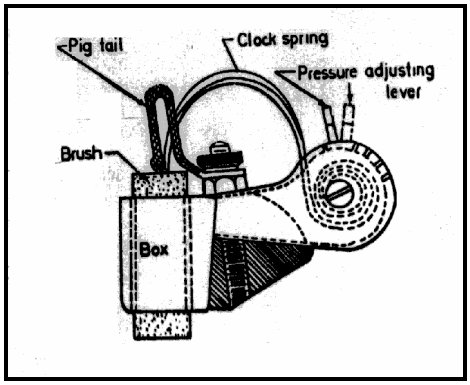


Figure 1.7

This brush is accommodated in brush holder as shown in figure 1.7, where a spring presses it against the Commutator. A flexible copper conductor securely fixed into brush is used to make the connection between brush and its brush holder.

The numbers of brush holders are usually equal to the number of main poles in DC machine. The brush holder is one of the major component/part of the rocker assembly. One brush holder in TAO-659 contains set of 3 brushes.

1.5.6 Rocker assembly

It is a circular steel ring on which 06 numbers of brushes holders, insulators and copper connecting leads are fixed. It serves is to keep the gap between brush-holders and to maintain the neutral axis. This ring has facility to rotate so that each brush can be seen or replaced through inspection cover.

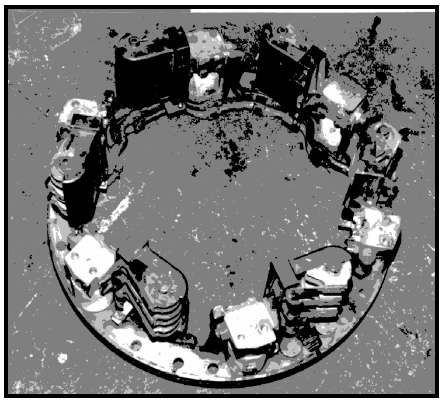


Figure 1.8

It has following major components:

- Rocker ring.
- Brush holders.

- Insulators - These are glass bonded mica insulators.
- Connecting leads- made of electrolytic grade copper rods.
- Final assembly.

All six brush holders are positioned exactly 60° apart, on the rocker ring with the help of insulator. The concentricity of all the inner faces of the brush holders with respect to diameter of the rocker ring should be within required limit. The maximum error allowed in the pitch of leading edges of the carbon brushes is 0.1 mm. which works out to 0.029 degrees (0 degree, 1 minute, 47 seconds) maximum angular deviation from 60°. This is permissible between the centre lines of any two adjacent brushes.

1.5.7 End shields

The TM TAO -659 has two nos. of cast steel end shields at both the ends i.e. at pinion end & at Commutator end. Both are mounted with roller bearings for supporting the armature.

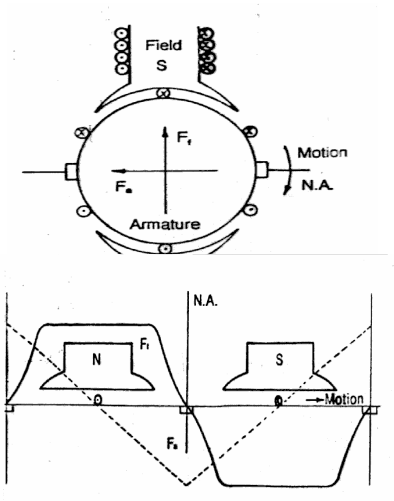
A grease nipple and bearing covers are also facilitated for greasing the bearings during maintenance schedule and for protecting the bearings from dust & foreign bodies.

1.5.8 Pinion

It is made of high-speed carbon steel, shrinkly fitted on the armature head of TM. This pinion has 15 or 21 teeth and is directly geared up with the gear of the wheel set and responsible for driving the wheel set and ultimately the locomotive.

1.6 WORKING PRINCIPLE OF D.C. MOTOR

The field system is stationary supplied through main poles on stator frame. The armature winding is a closed winding through the Commutator, which is supplied through the brushes, which are placed along the neutral/axis on the Commutator. The mmf produced by the



field (F_f) along the magnetic axis while the current flowing through the armature produces an mmf (F_a) directed along the brush axis. The two mmfs are in space quardrature and occur simultaneously in the motor. They react with each other and develop a torque under whose action the armature rotates. A voltage induced in armature can be determined by the Fleming's left-hand rule. The mmfs and the direction of rotation of the armature are illustrated in figure 1.9.

1.6.1 Speed Torque characteristics Of DC Series Motor

The filed winding is connected in series with armature as shown in figure 1.10, hence the armature current (I_a) and the field current are the same. Back emf (E_b) of DC motor is given by:

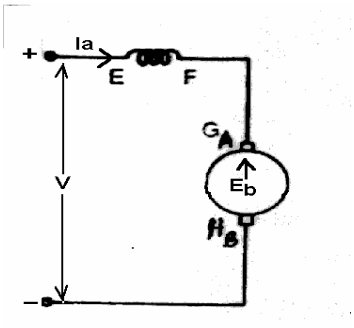


Figure 1.10

$E_b = V - I_a R_a$ (Neglecting small field resistance)

$E_b I_a = VI_a - I_a^2 R_a$ (Mechanical power developed)

Where, VI_a = Total electrical power supplied

$I_a^2 R_a$ = Power wasted in armature (armature copper losses).

If, T_a is the Torque developed by armature running at the speed of `N' numbers of revolutions per minute then,

Mechanical power developed, $E_b I_a = 2 \pi N T_a / 60$ Watts

or, $T_a = (60 / 2 \pi). E_b I_a / N$

and $E_b = P \phi Z N / 60 A$

Therefore $T_a = 0.159 P \phi I_a Z / A$ N-m.

In case of DC series motor , $\phi \propto I_a$

Then $T_a \propto I_a^2$ and

$N = E_b 60 A / P Z \phi$

$= K E_b / \phi$

ϕ = flux

Z = No. of armature conductors.

P = No. of poles.

A = No. of parallel paths.

R_a = Armature resistance

K = A constant.

At light loads I_a and hence ϕ will be quite low and E_b will be high, therefore `N' may become quite high. However as the load on the motor increases, speed will decrease rapidly & with further increase in armature current, the increase in flux is quite small because of saturation effect & hence the curve flattens out (as shown in figure 1.11).

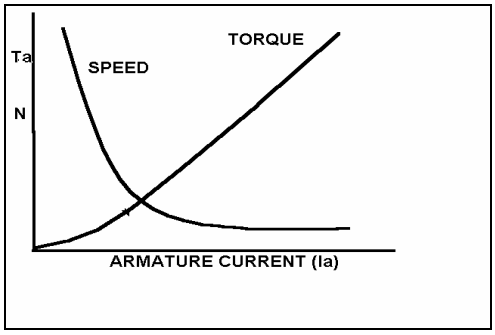


Figure 1.11

Similarly we see that at low speeds, high torque can be obtained, and with increase in speed, less torque is developed. This characteristics is particularly useful for traction purposes, because requirement of torque if high at starting, whereas once the train is in motion the low friction resistance reduces the torque requirement for a given load.

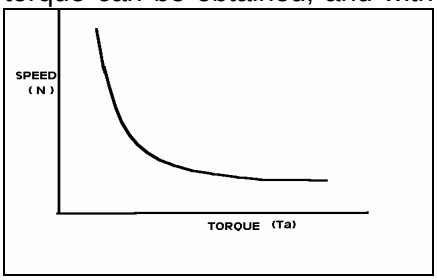
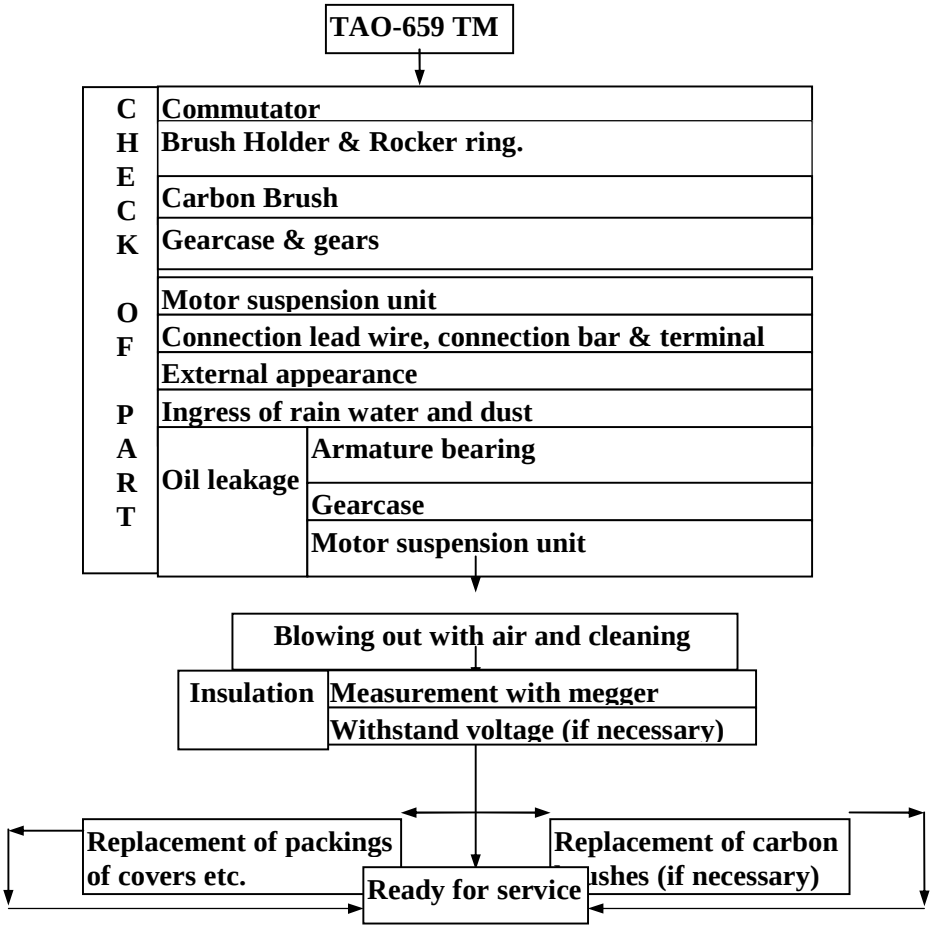


Figure 1.12

This characteristics (as shown in figure 1.12) clearly indicated that DC series motor should never be started without load, which is the case in traction.

CHAPTER 2
INSPECTION SCHEDULE

2.1 MAINTENANCE ACTIVITIES WITH TM IN POSITION (AT A GLANCE)



2.2 DURING IA AND IB SCHEDULE

2.2.1 Commutator

- Examine thoroughly the Commutator surface with the help of torch or hand lamp light through inspection cover for grooves fusion and high mica, any flash mark, crushed segments and creep.
- Riser for solder run out and flexible contact as per SMI -34 .
- Examine front cone for proper glaze.

- Polish /clean complete Commutator surface by taking slight movement of locomotive.

2.2.2 Brush Gear

- Measure and record size of all carbon brushes (condemn limit 27 mm.) .
- Examine brush holder insulators for proper glaze.

2.2.3 Inspection Cover

- Ensure existence, condition and proper fitment of both top and bottom inspection cover.

2.2.4 Arcing Horns

- Condition of arcing horns & clearance
- Check flexible assembly.

2.3 DURING IC SCHEDULE

In addition to above, the following points also to be inspected and work to be carried out during IC schedule.

2.3.1 Commutator

- Clean commutator with sprit / petrol and cloth.
- Inspect visually commutator end banding and risers for any abnormality.

2.3.2 Brush Gear

- Measure brush box to commutator clearance and adjust if required.
- Measure spring pressure on brushes, 2.2 to 2.4 kgs. and check up condition.
- Examine the condition of pig tails and replace carbon brushes if reached to condemning size.
- Check up spring pins by hand .

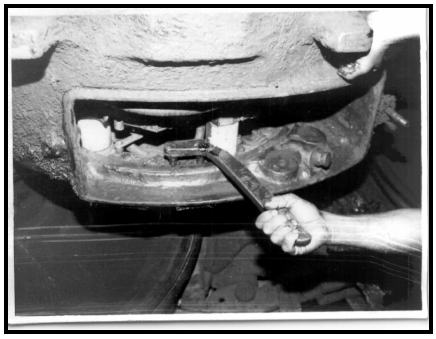


Figure 2.1

- Rotate rocker arm of all six TMs and Check brush holders and insulators. Rocker ring should be unlocked first, using the tool, as shown in figure 2.1.

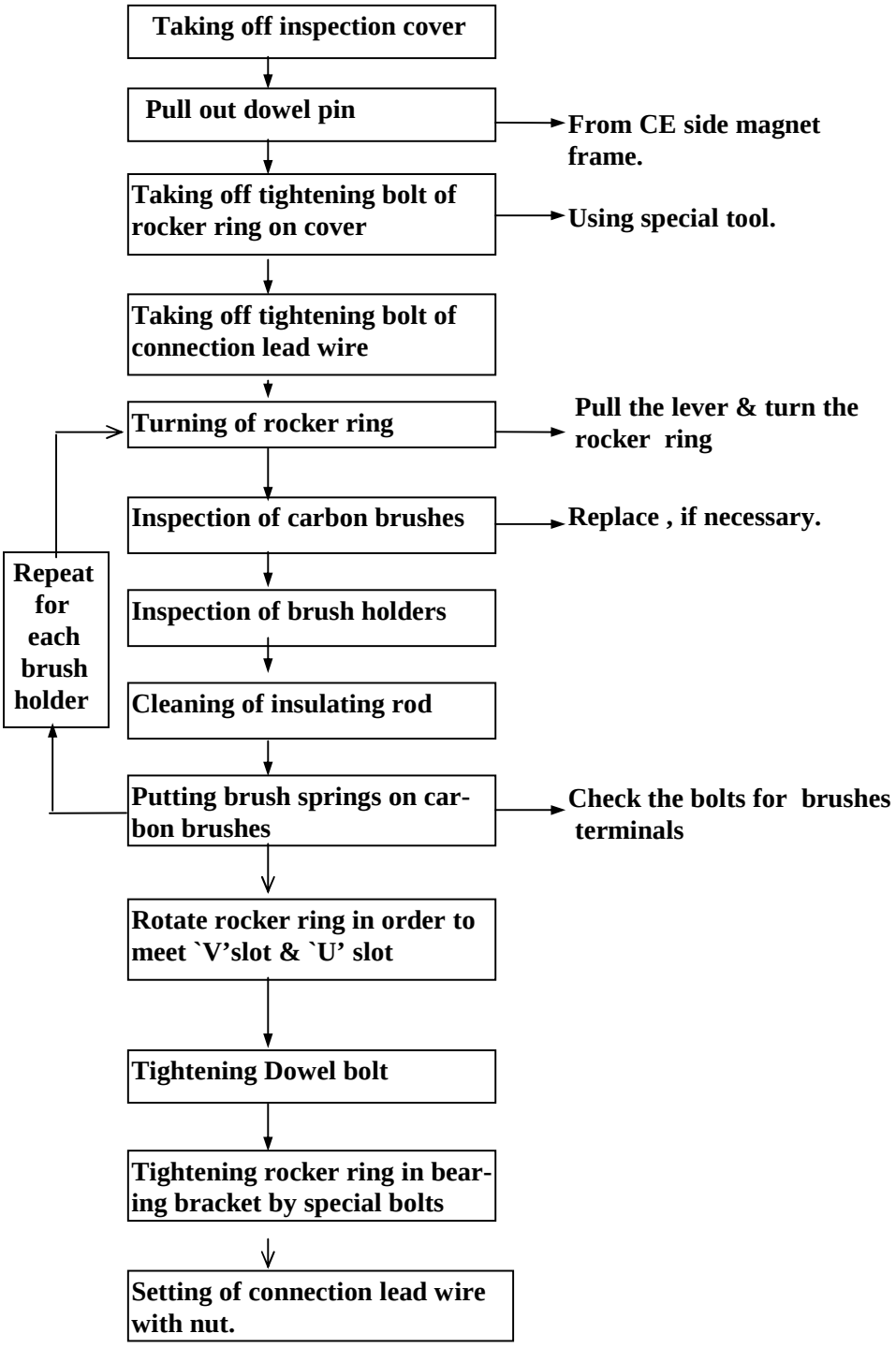
2.3.3 Arcing Horns

- Check arcing ring for flash marks.
- Clean V- cone.

2.3.4 **Terminals**

- Examine outgoing interpole leads for any cracks etc.
- Check the cover gasket of terminal cover , replace if required.
- Check connections tightness.
- Check tightness of wooden cleats.
- Check the gasket of inspection cover and ensure air tightness.
- Check setting of inter pole and field both .
- Meggering of TMs.
- Greasing of both end bearing

2.4 FLOW CHART FOR CHECKING BRUSH HOLDER & CARBON BRUSHES



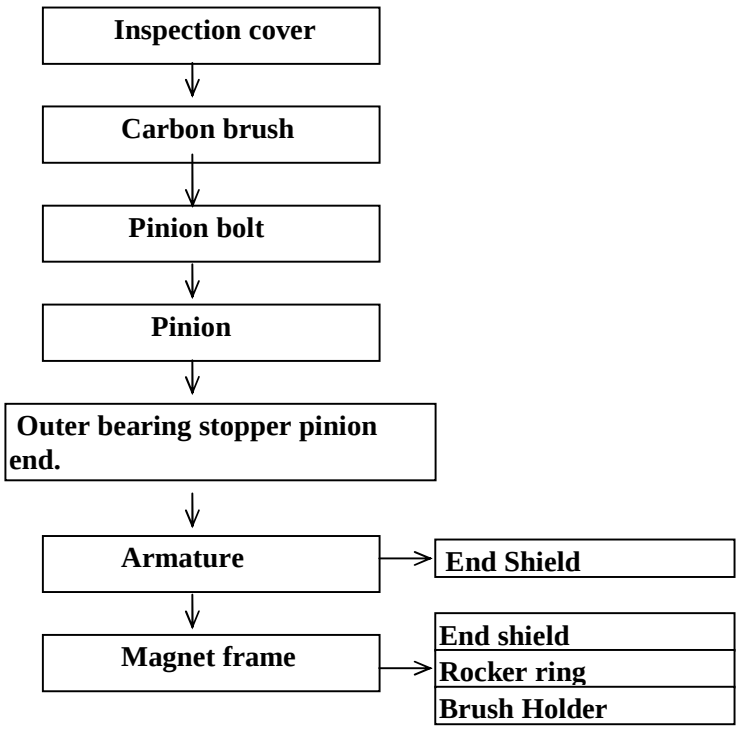
2.5 STEPS FOR INSPECTION OF TAO-659 TM ITEMS

INSPECTION ITEMS	SERVICE LIMIT	INSPECTION INTERVAL				
		TI	IA	IB	IC	AOH/ IOH
1. **TM on general**						
a) Appearance		0	0	0	0	0
b) Inspection cover.		0	0	0	0	0
c) Loosening of bolts.		0	0	0	0	0
d) Ingress of dust & water			0	0	0	0
e) Condition of lead wire , cleat & contact of terminals.			0	0	0	0
f) Grease adding to armature bearing.					0	0
2. Armature						
a) **Glass band**.						0
b) **Commutator**						
I) Diameter-new 380mm	364 mm					0
ii) Eccentricity	0.1 mm					0
iii) Inequality in diameter	0.06 mm					0
iv) High bar or low bar.	0.005 mm					0
v) Under cutting depth.	1.8 mm					0
vi) Chamfering.	0.4 mm					0
vii) Width of riser.						0
viii) Difference of voltage drop between bars.	5 %					0
ix) Di-electric test.						0
3. **Armature coil**						
a) Cleaning.						0
b) Insulation test						0
4. **Shaft, bearing & pinion**						
a) Diameter of shaft bearing on pinion end.						0
b) Diameter of shaft bearing on commutator end						0
c) Taking off, cleaning inspection & oiling of Brg.						0
d) Radial clearance of roller bearing on PE.						0
e) Radial clearance of roller bearing on CE.						0
f) Ultrasonic testing of armature shaft.						0

INSPECTION ITEMS	SERVICE LIMIT	INSPECTION INTERVAL				
		TI	IA	IB	IC	AOH/ IOH
5. **Stator**						
a) Dimensions of moun--ting parts.						0
b) Dent of pole retaining bolt shall be filled with compound.						0
c) Stator coil,lead wire and connector.						0
6. **Brush holder & carbon brush**						
a) Cleaning & checking.				0	0	0
b) Spring pressure.				0	0	0
c) Dimension of brush holder pocket.					0	0
i) Thickness						
ii) Width						
d) Clearance from comm.					0	0
e) Length of carbon brush				0	0	0
f) Chipping of carbon brush.				0	0	0
g) Breakage of pigtail.				0	0	0
7. **Assembly & testing**						
a) Bedding of carbon brush.					0	0
b) Insulation resistance test.					0	0
c) No load test Examine abnormal vibration & noise.						0
d) Load test						0

2.6 OVERHAULING SCHEDULE

2.6.1 Flow chart for Disassembly



2.7 DISASSEMBLY

2.7.1 Disassembly of Armature

- Remove the carbon brush from the brush holder.
- After removing carbon brushes, wind a press board on the Commutator for preventing the Commutator surface from being scratched.
- Dismount the bearing cover from the end shield utilising the taped hole for pulling out.

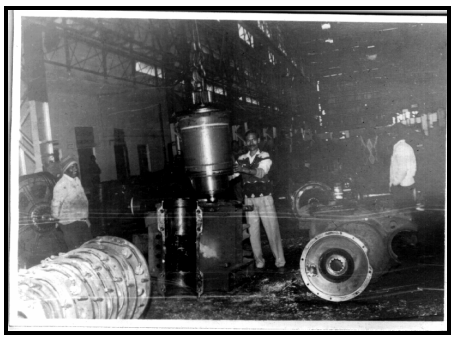


Figure 2.2

- Dismount the outer bearing stopper and thrust collar of roller bearing from the armature shaft.
- Remove all the bolts tightening the bearing bracket i.e. PE end shield by screwing Hex Hd. bolts M-20 into taped holes in the end shield and dismount the end shield.
- Fit the armature lifting hook on the armature shaft at pinion side, lift the armature by crane as shown in figure 2.2, screw the bolts in the taped holes of end shield and turn the armature slowly till the spigot joint & magnet frame comes off; and while checking to see that the armature is turned smoothly, dismount the armature alongwith PE end shield from the stator.
- Place the dismounted armature onthe table with laid down.
- Lay the armature on a wooden table with it supported by core face, as shown in figure 2.3.
- Never support the armature with the coil, glass bind part or Commutator part.

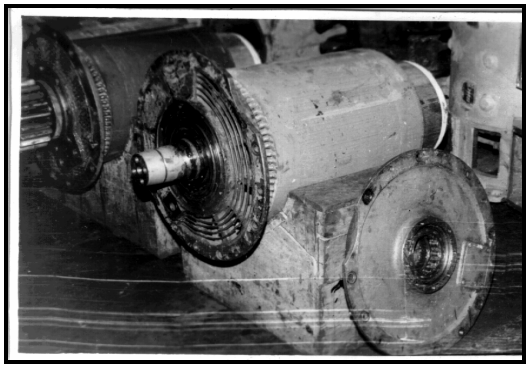


Figure 2.3

2.7.2 Disassembly of End shield (PE) (Bearing bracket)

- For disassembling the end shield from dismounted armature, insert a steel bar (20 mm in dia) inside the end shield bolt hole and extract the end shield crosswise, lifted and supported by crane.

2.7.3 Disassembly of Commutator side End shield

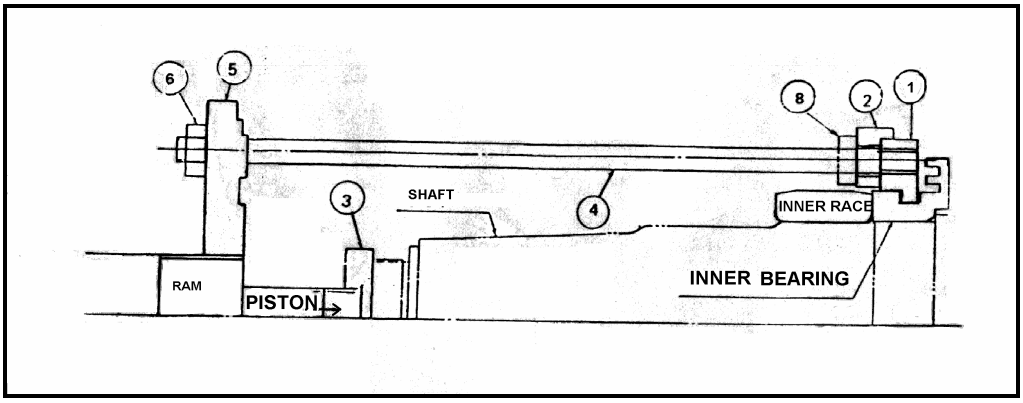
- Dismount the CE, end shield together with outer ring of roller bearing (bearing bracket) from the magnet frame utilising the tapped hole for pulling out. Pay full attention when handling the bearing bracket.
- Remove the rocker ring from the magnet frame.
- Write serial number with white paint on rocker ring and magnet frame.

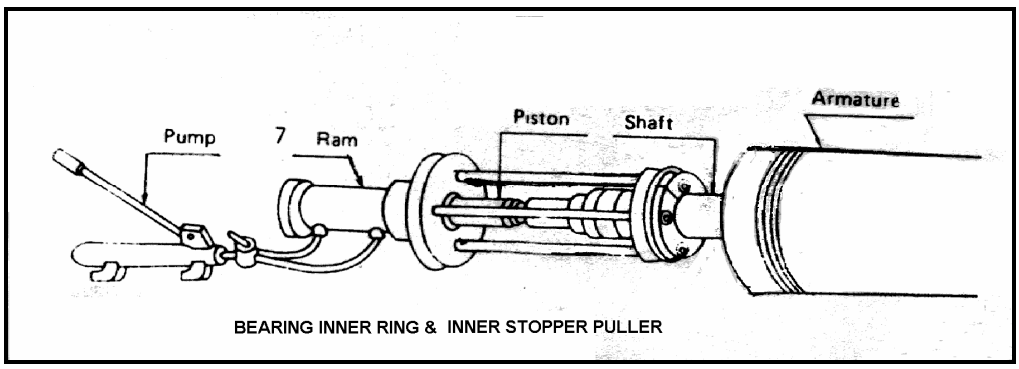
2.7.4 Disassembly of Armature Bearing

2.7.4.1 Pinion End

Remove PE end shield from the armature, the following parts are fitted on armature shaft pinion side, i.e. inner bearing stopper, bearing inner ring and outer bearing stopper.

After dismounting the outer bearing stopper, dismount the inner bearing stopper and bearing inner ring simultaneously by using the exclusive tools as shown in figures 2.4 & 2.5.

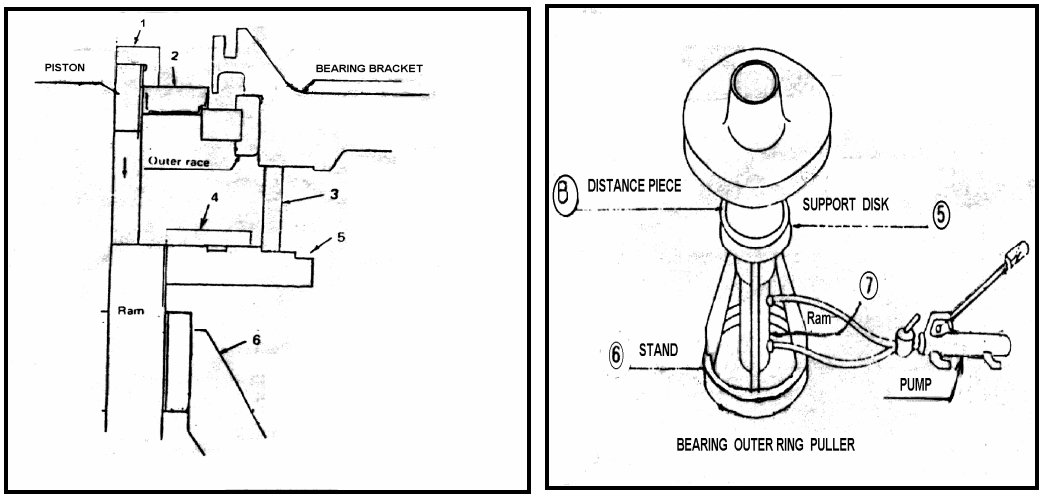




1 - HOOK , 2 - KEEPER PLATE, 3 - NUT, 4- DOUBLE END STUDS
5 - SUPPORT DISK, 6 - NUT M 24, 7 - RAM WITH OIL POWER PUMP
8 - BOLT M 24x40

TOOLS Figure 2.4 ASSEMBLING PROCEDURE :

1. Set hooks (1) on inner bearing stopper.
2. Fix hooks (1) by keeper plate (2)
3. Screw double-end studs (4) in hooks (1)
4. Set support disk (5) on Ram, set nut (3) on piston.
5. Fix support disk (5) by double-end studs (4) & nuts (6)
6. Press piston with handling oil power pump.



1 - NUT, 2 - PULLER, 3 - ABSORBER, 4 - DISTANCE PIECE
5 - SUPPORT DISK, 6 - STAND, 7 - RAM WITH OIL POWER PUMP

Figure 2.5

TOOLS ASSEMBLING PROCEDURE :

1. Set Ram into stand (6)
2. Screw support disk (5) on Ram.
3. Put absorber (3) & distance piece (4) on support disk (5)
4. Set puller (2) on outer race.
5. Put together outer race & puller (2) on distance piece
6. Press piston up through puter race & set nut (1) on piston.
7. Catch rollers by puller (2)
8. Press piston downward with handling oil power pump.

2.7.4.2 **Commutator End**

Similarly dismount the bearing inner ring, inner bearing stopper and bearing outer ring at the same time, after removing CE end shield by exclusive tool according the above procedure.

2.7.5 **Cleaning of Armature Bearing**

To clean the dismounted armature bearings, put them into a vessel containing kerosene heated upto about 60° without degreasing and leave them as they are in kerosene for more than 10 minutes. After that, blow away sticking grease with compressed air. Repeat the procedures more than twice, and then, wash the bearings finally with a clean kerosene, and blow away adhering kerosene completely with air.

For the final washing, always use new kerosene and do not use heavily oxidised or foul one. Wash hands with a degreasing agent such as ethyl alcohol carefully for preventing the bearings from getting rusty.

2.7.6 **Checking of Armature Bearings**

- Check visually for roughness, scratch, bruise, discoloration, rust etc. on inner & outer race too.
- Check while moving the rollers for wear of retainer, looseness of rivets and make sure that there is no abnormality.
- If any abnormality observed in either inner or outer ring, replace with new set of bearings.
- Check for inner & outer ring of same serial number.

2.7.7 **Maintenance of Rocker equipment**

Disassemble the brush holders, insulators, rocker leads and rocker ring. Inspect them visually check the arcing stud and knock pins, polish the insulating rods. Measure the brush spring pressure and length of carbon brushes. The following points should be followed to improve life and service of the rocker assembly during overhauling as shown in figure 2.6.

- Remove old insulation of the rocker leads and taped with kapton tape, GMGS tape and fibre glass tape accordingly.
- Provide Kapton tape & Nomex paper-between rocker cleats.
- Pre heat the leads at 150°C for four hours.

Figure 2.6

- Provide Silconite `E-233' on the rocker leads & bake it at 180°C for four hours or at 150 °C for eight hours.
- Tape should be cleaned for its smoothness by the sandpaper.
- Measure the tension of every spring of brush holder. Tension should be 2.4 to 2.2 Kg.
- Revolving it in every schedule should clean rocker.

2.7.8 Maintenance of Commutator

The necessity of reworking the Commutator surface is determined depending on its condition and the judgement. It must be judged observing the condition of Commutator surface carefully and can be maintained as following.

2.7.8.1 Grindstone

Applying "Grindstone" must rework the commutator exhibiting the following conditions:

- Where the Commutator surfaces is heavily blackened.
- Where the Commutator surfaces is rough owing to minor flashover.

Procedure:

Apply a grindstone to the Commutator in the condition where the armature has been assembled in the motor. The armature to be put on a lathe since there is possibility of eccentricity or unevenness being caused in the Commutator. Moreover, after completion of applying a grindstone, blow away the stone power with air and check carefully the groove inside between Commutator bars to be sure that there is no abnormality.

2.7.8.2 Turning of Commutator surface

In case where the following conditions are recognised, apply turning to the Commutator surface:

- If eccentricity, unequally in diameter, high-bar, low-bar etc are generated in Commutator, cut the Commutator as per given table.

ITEM	CORRECTIVE LIMITS	AFTER TURNING
Eccentricity	Not more than 0.1 mm.	0.03 mm.
Inequality in diameter	Not more than 0.06 mm.	0.006 mm.
Higher, low-bar	Not more than 0.005 mm.	-

- In case that stepped wear is cased in Commutator surface (when `δw' exceeds 0.1-mm max.) shown in figure 2.7)
- In case where it is impossible to rework by a grindstone because the commutator surface is heavily rough
- When reusing the traction motor after a long-term storage (more than 6 months), oxide film is produced on the Commutator surface causes poor commutations.

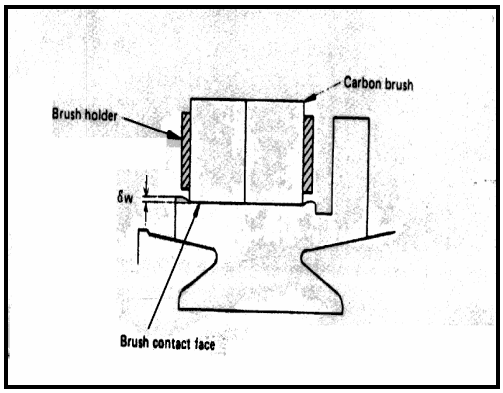


Figure 2.7

- The degree of turning of Commutator surface should be judged according to the conditions of commuter surface, and it must be cut at minimum required limit.

2.7.8.3 **Mica under Cutting and Chamfering**

When the commutator surface is cut the slot between the Commutator bars shallows and chamfering of Commutator bars, too, become small. Therefore after cutting, under cutting chamfering should be performed with suitable tool. Details of under cutting & chamfering are shown below in figure 2.8 and 2.9.

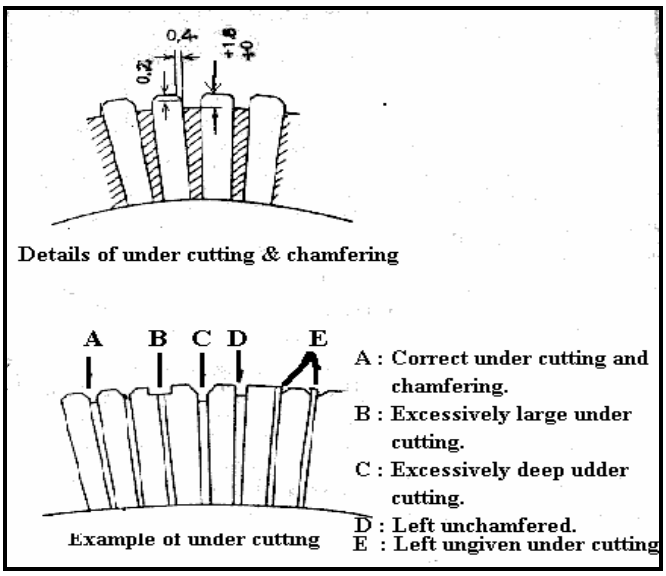
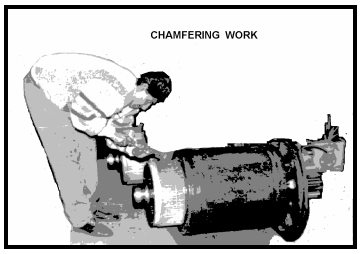


Figure 2.8



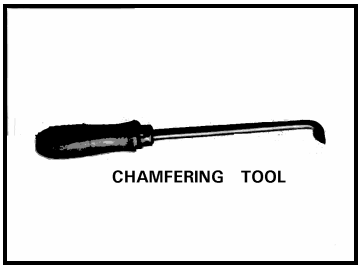


Figure 2.9

2.7.8.4 **Lathing**

When correcting the commutator surface by the lathe, align the armature shaft as shown below in figure 2.10

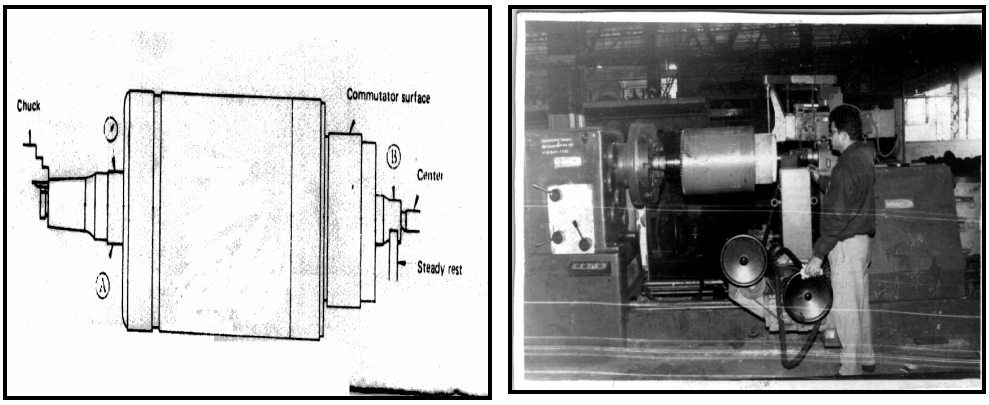


Figure 2.10

Rush the shaft end of armature shaft on the commutator side by the centre of lathe, align the armature shaft by using the bearing fitting portion A, on the pinion side as reference and check the shaft end on the pinion side. Apply a steady rest to the bearing-fitting portion B, on the commutator side.

2.7.8.5 **Cleaning**

On the completion of cutting the Commutator surface, clean by blowing air directly to it. To protect the Commutator surface from injuring, a press board and polyester tape should be winded.

2.8 REASSEMBLY OF TRACTION MOTOR - TAO 659

2.8.1 Preparation for Reassembly

- Prepare all parts & tools, necessary for reassembly.
- Clean all the parts.
- Replace all gaskets & spring washers.
- Check the bearing conditions & replace with new, if required.
- Megger stator & rocker assembly and conduct High voltage & High current tests.

2.8.2 Reassembly of Roller Bearing, Rings at PE & CE

2.8.2.1 Inner ring

Put the inner bearing stoppers & inner rings into the oil bath for heating upto 110 °C to 120 °C. Wipe carefully armature shaft, shrink fit inner bearing stopper & inner bearing ring on the armature shaft at both PE & CE, press them by hand till they cool so that gap is not reduced at the stopped part of inner bearing. Stopper & shaft, and between inner bearing stopper & inner bearing ring. Similarly shrink fit the outer bearing stopper.

2.8.2.1 Outer Ring

Fill the interiors of grease holding chamber of end shield and bearing outer ring with the specified amount of grease, than pressure fit the outer ring to the end shield by using exclusive tools.

Never fit the outer race while striking by hammer. Tighten the grease covers by means of bolts.

2.8.3 Reassembly of Armature

Lift the armature by a crane, keep the armature balanced and gently insert it to the stator. Similarly lift the pinion end - end shield by a crane to which the outer ring of roller bearing is forced fitted and filled with specified amount of grease. Mount it to the pinion side of Armature shaft, uniformly tighten the mounting bolts of size M12x20 mm in the following order as shown in figure 2.11.

1 → 5, 2 → 6, 3 → 7, 4 → 8

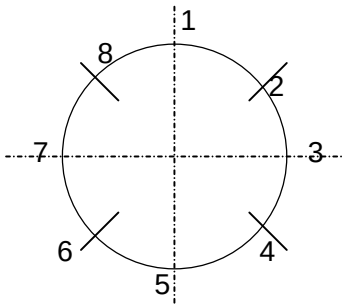


Figure 2.11

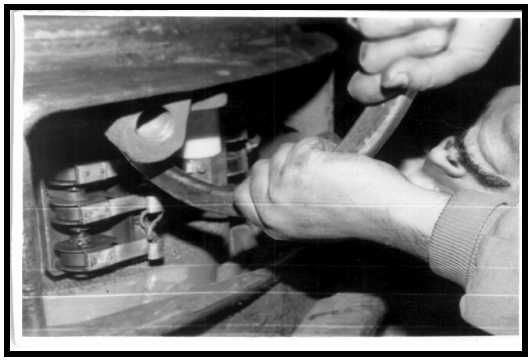


Figure 2.12

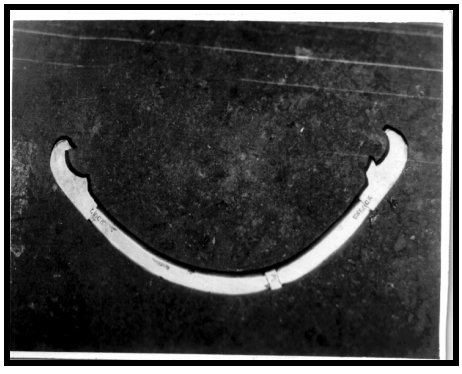


Figure 2.13

Fit all six brush holders to the rocker ring by maintaining clearance between commutator and brush holder from 1.5 mm to 3.5 mm. Then provide the carbon brushes EG 105 or EG 367 in brush holders. Keep the TM on stand, connect the negative and positive leads to the rocker ring on insulators.

Lock the rocker ring by means of rocker pinion and by inserting a locking pin with the help of an exclusive tool as shown in figures 2.12 & 2.13. Fit the TM inspection cover (figure 2.14). Greasing at both PE & CE end bearings to be done with the help of grease gun. Place the TM on test bench, connect the leads and increase the input DC voltage upto 50 V , allow TM to run for four hours, experience the sound of bearings at both ends i.e. PE & CE, observe the temperature rise by thermometer which should not be more than 25°C from ambient temperature. If found within the limit, than check the bedding of pinion on armature shaft as explained below. Cold advances clearance should be 5.6 mm.

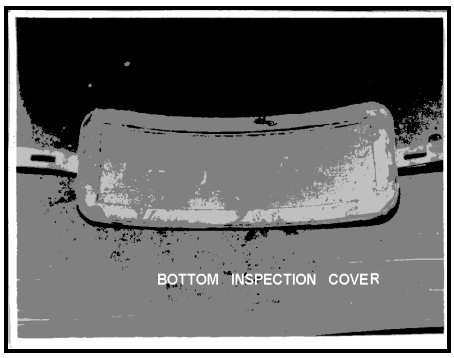


Figure 2.14

2.8.4 Reassembly of Rocker Ring

Assemble the rocker ring assembly having same number to the stator, then tightening rimmer bolt to fix position of rocker ring. Insert round still bar to the bolt hole of end shield ,lift by a crane and mount the end shield, to which the outer ring of rotor bearing forced fitted duly filled with grease and fitted with grease cover to the commutator side of stator by means of tightening of bolts of size m 18x40 or m 18x45 without spring washer. Now keep the stator vertically, keeping commutator end shield at bottom with the help of a crane.

2.8.5 Shrink fit of Pinion

- Wash and clean the pinion with kerosene to remove the grease and oils. Then apply a thin coating of red paint (Fe_2O_3 powder) on the bore surface of the pinion, putting together the tally mark on the shaft and pinion, force fit the pinion lightly on the shaft. Then measure the dimension with depth micrometer and record **`l_o'** as shown in figure 2.15.

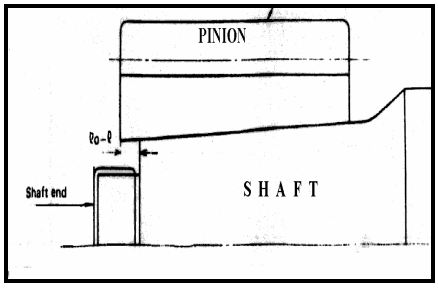


Figure 2.15

- Remove the pinion and check the state of contact between the pinion and the shaft. It is necessary that more than 90% of entire contact area to be actually in contact. If there is insufficient contact, repair the bore surface of the pinion.

- Immerse and heat the pinion for about one hour in oil bath heated to a temperature rise of 140 ±10°C. from room temperature. It is most important to keep the temperature of oil bath accurate.

- Remove the pinion from oil bath and remove oil from pinion surface by air blowing as fast as possible. Perform shrink fitting of pinion immediately by putting together the tally marks on the armature shaft and the pinion and allow to cool naturally.

- After the pinion has cooled off completely, measure and record "**l"** dimension which is depth of shaft with respect to pinion outer surface.

  Make sure that the allowance between the pinion and the armature shaft end is as follows :

  $l_0 - l$ = entering allowance of pinion
  = 1.9 to 2.2 mm.
  where l_0 = dimension before shrink fitting
  l = dimension after shrink fitting

- After making sure that the pinion entering allowance is satisfactory, insert the lock plate and tighten their bolts.

- Now the overhauled and assembled T.M. is sent for testing.

CHAPTER 3

FAILURES AND TESTING

3.1 COMMON FAILURES, CAUSES & REMEDIES

SN	FAILURE/ TROUBLE	POSSIBLE CAUSES AND REMEDIES
1.	**POOR COMMUTA-TION**	**CARBON BRUSH** i) Grade or form : Examine the grade of carbon brushes If found different, replace with the same grade of brushes. ii) Wear/damage : Side wear of carbon brushes makes gap to holder case bigger and so replace with a new one. Iii) Chattering/vibration: Remove oxygenated film of commutator surface or change grid of carbon brushes. iv) Sticking of brushes: Remove dust and check gap to holder case. v) Copper picking or spotting: Copper powder sticks to commutator surface and oxygenated film becomes unequal. Change grade of brush. vi) Unbalance of brush current : Colour change in pigtail of brush. Strike on commutator surface and contact of brush to be checked . vii) Wearing out of brushes: Lift-up of carbon brush causes spark and damage. Replace with a new one. **BRUSH HOLDER** i) Wear of inside of carbon way: Measure the dimensions of brush holder and replace it ,if required. ii) Improper attachment of brush holder : Crookedness, pitch, gap should be examined and adjusted. iii) Improper spring pressure : Check pressure and adjust as designated.

SN	FAILURE/ TROUBLE	POSSIBLE CAUSES AND REMEDIES
		COMMUTATOR i) High bar, Low bar, Deformation, Ovality : Colour change, unequal oxygenated film, abnormal wear of brush may be caused a flash over. Polish the commutator surface with lathe. ii) Joggle wear and roughening of surface : Polish commutator surface with lathe. iii) Bad chamfering / under cutting : Reform with lathe. iv) Shorting the bars by dust and foreigner between bars : Inspect and clean the commutator bars with petrol. v) Abnormal temperature rise : Examine ventilation and load and adjust. vi) Black bar : Adjust commutation. vii) Vibration : Examine radial as well as lateral clearances of bearing , vibration of Bogie frame, unbalancing of armature.
2	**OVERHEAT**	**BEARINGS** i) Bruise, scratch, rust : Replace it with a new one. ii) Improper quality of grease : Replace with new and proper grade of grease. iii) Improper fitting or clearances : Check fitment and clearances and replace it with new and good bearing, if required. **COILS** i) Layer short, insulation breakdown: Find failure part and repair it.

SN	FAILURE/ TROUBLE	POSSIBLE CAUSES AND REMEDIES
3.	**OTHER FAILURE**	**INSULATION BREAKDOWN & EARTHING** i) Coil, commutator, lead wire, inner connection, brush holder: Poor & Overaged condition of insulation, rubbing & cutting marks on insulation. DC component to be systematically examined so as to find troubled part. Repair the damaged part according to insulation. ii) Armature bearing grease : Examine the quality and quantity of grease. Replace if required. iii) Gearcase : ■ Excess charge of gear oil : Check the oil level in gearcase and maintain as prescribed. ■ Bad packing and oil sealing : Replace condemned packing and oil sealing with new.

3.2 TESTING OF TRACTION MOTOR TAO- 659

3.2.1 Insulation Resistance Test

Insulation resistance is measured with 1000 V megger in service, the value should be more than 1 Mega ohm. However if the value is less than 1 Mega ohm it is considered undesirable for service operation. If the insulation resistance drop is due to absorption of moisture, dry out must be carried out.

3.2.2 Dielectric Test

The machine if passed the dielectric test can be supposed to continue the safety operation for a considerable period without electric breakdown. The test voltage to be supplied with testing transformer and duration for various parts of TM is given below.

HIGH VOLTAGE TEST: .

STATOR - 2 KV for 1 minute

ROCKER - 3 KV for 1 minute.

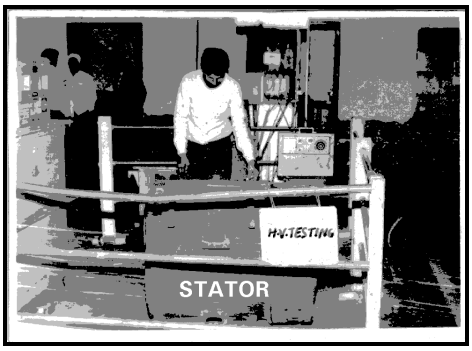


Figure 3.1

HIGH CURRENT TEST :

MAIN POLE 700 Amps for 2 minutes

INTERPOLE 700 Amps for 2 minutes

Figure 3.2

3.2.3 Polarity Test

The polarity test must be done in case the field poles or the lead wires have been replaced. `N' polarity and `S' polarity must be distributed alternately in regular order. The pole, which attracts `S' polarity of the magnetic needle , is `N' polarity and the pole which attracts `N' polarity of the magnetic needle, is `S' polarity.

3.2.3.1 Testing of Neutral Axis

Connect a voltmeter in between `N' and `S' pole of the TM (at brush holder), apply 50 to 60 V DC to the TM field. The voltmeter reading should stand at zero.

3.2.4 Voltage Drop Test for Commutator Segments

Direct current is applied to the armature winding (about 20 to 30%)of rated current of the TM at suitable intervals between the commutator segments. Voltage drop is measured with a millivoltmeter (Multimeter- 50mV) as shown in figure 3.3. The variations in the voltage between commutator segments must be less than ± 5 % of the mean value. If there are extremely large variations in the voltage drop, this means either that the joint on the commutator riser has come loose or that there is a short circuit in the winding.

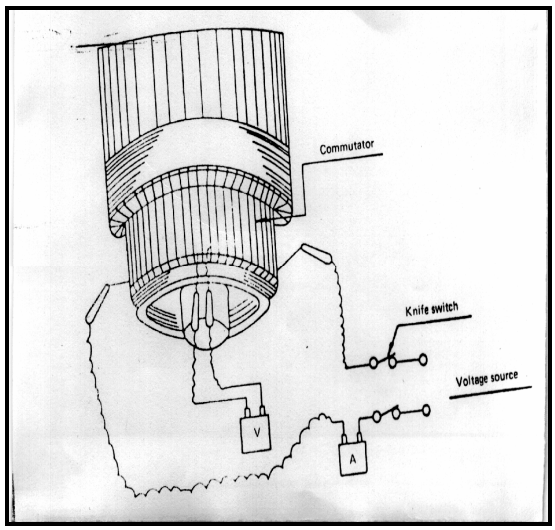


Figure 3.3

Therefore, in such cases a thorough investigation must be made for the cause, and the trouble must be repaired. In making these tests, please note that if an excessively large current is applied, the winding will be over heated.

Precautions: In case of carrying out voltage drop tests of the commutator segments, particular care must be given to the fact that the current must not be switched ON and OFF by means of the electrodes in contact with the commutator. This is because the commutator segment will be damaged by arcing if the electrodes are switched ON and OFF. For this reason, it is absolutely necessary to use the knife switch for the current to ON and OFF.

3.2.5 Ovality Test

Ovality on the commutator surface must be tested by means of an ovality testing gauge which should not be more than 0.06 mm .

3.2.6 Heat Run Test

After reassembling the TM, to conduct the heat run test ,apply 50v DC to the TM and allow to run for four hours. During this testing, experience the temperature rise and bearing noise at both PE & CE , as designated.

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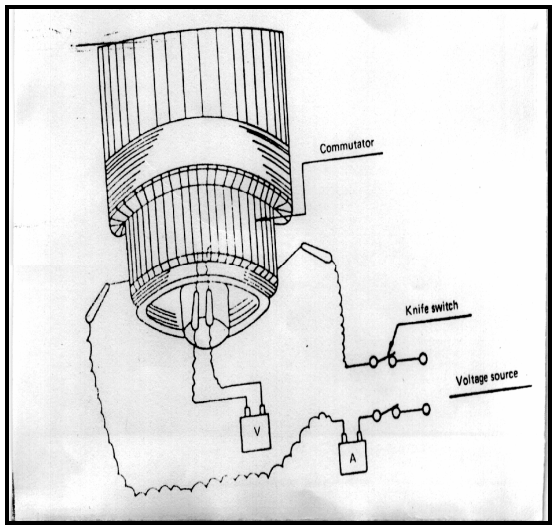

Figure 3.3

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APPENDIX A

LIST OF RDSO's MODIFICATIONS AND MAINTENANCE INSTRUCTIONS

SN	MODIFICATION NO.	DESCRIPTION
01.	RDSO/WAM4/63	Taping of leads of traction motor type TAO-659 to prevent chafing in cleats.
02.	RDSO/WAM4/67	Fixing of Neoprene gasket on the terminal box cover of TAO-659 TM.
03.	RDSO/WAM4/68	Modification to Bellow of TAO-659 TM.
04.	RDSO/WAM4/90	Modification at commutator end of TAO-659 armature shaft and the set ring.
05.	RDSO/WAM4/118	Replacement of flexible contact assembly by a braided shunt in TAO-659 TM.
06.	RDSO/WAM4/158	Modification to negative connection lead of compile coil (lead No. 13) on TAO-659 TM.
07.	RDSO/WAM4/162	Modification to `L' clamp of comm. pole of TAO-659 TM.
08.	RDSO/WAM4/164	Prevention of suspension bearing oil leakage into the stator frame.
09.	RDSO/WAM4/165	Provision of thread locking compound on bolts/screws.
10.	RDSO/WAM4/166	Modified support plate assembly for main pole core of TAO-659 TM.
11.	RDSO/WAM4/167	Modified adjustment punching for main pole core assembly to TAO-659 TM.
12.	RDSO/WAM4/168	Modified adjustment shim and silirite shim for commutating pole core of TAO-659 TM.
13.	RDSO/WAM4/169	Improved insulation scheme for inter-connectors of TAO-659 TM.
14.	RDSO/WAM4/174	Improved inter connector layout for TAO-659 TM.
15.	RDSO/WAM4/186	Modification to the protection screen of pinion End Shield and Air outlet of magnet frame of TAO-659 traction motor.
16.	RDSO/WAM4/188	Adoption of forged armature head on the armature frame of TAO-659 traction motors.
17.	RDSO/WAM4/191	Adoption of Teflon ring in lieu of Teflon band on the ex-

		posed surface of V-cone of traction motor.
18.	RDSO/WAM4/64	Modification (type 1) to inspection covers of TAO-659 traction motors. (Alternative modification sheet (Type 2) which covers use of mild steel inspection cover as developed by Gaziabad shed will be issued separately).
19.	RDSO/WAM4/100	Modification to the protection screen of air outlets of TAO-659 Traction Motor.
20.	RDSO/WAM4/109	Strengthening of Inter-turn insulation of Armature of TAO-659 Traction motor.
21.	RDSO/WAM4/193	Modification to head light circuits of WAM4/WAP/ WAG5/WAG7 Electric Locomotives for working of head lights while passing neutral section.

APPENDIX B

LIST OF RDSO's SPECIAL MAINTENANCE INSTRUCTIONS

SN	SMI NO.	DESCRIPTION
01.	ELRS/SMI/1	Fitting of nuts/bolts/screws.
02.	ELRS/SMI/6	Resurfacing of commutator of TM and its amendment.
03.	ELRS/SMI/13	Tightening & locking of gripping ring in TAO-659 Traction motor.
04.	ELRS/SMI/14	Maintenance of terminal connections of TAO-659 TM, instruction for tightening of the insulators.
05.	ELRS/SMI/15	Sealing of tapped holes for terminal insulators of TAO-659 TM.
06.	ELRS/SMI/7	Providing of essential running clearance between the axle toothed ring of the oil pump drive of the suspension bearing of TAO-659 TM and recess provided in the suspension bearing cap.
07.	ELRS/SMI/25	Millivolt drop or micro-ohm resistance test on traction motor.
08.	ELRS/SMI/29	Resurfacing of commutator speed, feed, tool.
09.	ELRS/SMI/31	Under cutting & chamfering of TM commutator.
10.	ELRS/SMI/39	Checking of airflow in the commutator of TAO-659 TM.
11.	ELRS/SMI/41	Improving the insulation of the stator internal connection of TAO-659 TM & Field Coil Ground Insulation.
12.	ELRS/SMI/42	Non-interchangeability of BHRR on TAO-659 TM.
13.	ELRS/SMI/51	Bar to bar conductor resistance & equaliser resistance test on TM.
14.	ELRS/SMI/53	Insulating scheme using class `H' material at leads of armature coils in TM.
15.	ELRS/SMI/58	Special maintenance instructions for on condition monitoring of bearings.
16.	ELRS/SMI/60	Discontinuing high voltage DE test on overhauled TM.
17.	ELRS/SMI/84	Procedure for drying out of TAO-659 TM.
18.	ELRS/SMI/128	Tan Delta measurement of TM Armature.
19.	ELRS/SMI/151	Testing of brazing joint of field coils circuits of TM type TAO-659 and HS 15250/ HS 1050 Er.
20.	ELRS/SMI/160	Measurement of back lash of traction gears.

21. ELRS/SMI/166 Ventilation of TAO-659 traction motor.
22. ELRS/SMI/167 Precaution while taping of bus bars and clamps of traction motors stators.
23. ELRS/SMI/168 Copper busbar used in stator of TAO-659 traction motors in the locomotives.
24. ELRS/SMI/170 Checks on main pole and interpole coils of TAO-659 TM.
25. ELRS/SMI/171 Fitment of “Mica-lex insulator” on TAO-659 Traction motor.
26. ELRS/SMI/174 Improved interconnector layout for TAO-659 Traction motor.
27. ELRS/SMI/180 Draft rehabilitation procedure for the mechanical portion of traction motor type TAO-659 of BG, AC Electric Locomotives.
28. ELRS/SMI/181 Neutral setting of brush holder revolving ring of traction motor by electrical method known as “KICK METHOD”.

APPENDIX C

LIST OF MACHINE, TOOLS AND SPARES

SN.	DESCRIPTION	Qty.
01	Pinion extractor	02 Nos.
02	Pinion heating oil bath or induction heater	02 Nos.
03.	Auto Transformer rectifier unit. 1000 V, 150 Amp. DC	01 No.
04.	Commutator turning lathe.	01 No.
05.	Mica under cutting and chamfering machine for armature	01 No.
06.	Armature banding lathe.	01 No.
07.	Dynamic balancing machine for armature	01 No.
08.	Vacuum impregnating plant.	01 No.
09.	Baking oven 200°C with trolley.	02 No.
10.	Baking dynamo meter with test bed.	01 No.
11.	Brazing extractor	02 set.
12.	Brazing tongs with transformer.	01 No.
13.	Hand operated shearing machine for insulation.	01 No.
14.	Traction motor assembly fixture.	01 set.
15.	Grease guns	02 sets.
16.	Commutator soldering irons.	06 Nos.
17.	Surge tester.	01 No.
18.	Bearing extractor & insertor for TM	01 No.
19.	Tick welding kit.	01 No.
20.	2.5 KV Megger.	02 Nos.
21.	500 V megger.	06 Nos.
22.	Continuity tester.	02 Nos.
23	Current Transformer set 20 to 2000 Amps.	01 set.
24	Milllivoltmeters 0-75 Millivolt	02 Nos.
25	High Voltage tester 0-75 KV	01 No.
26	Oil tester 0-50 KV.	01 No.
27	Current injection set 2000 Amps, 3 V. DC	01 set.
28	Ultrasonic crack detector.	01 No.

29	Spring balancer 0-5 Kg.	02 Nos.
30	Mano meter	02 Nos.
31	Vibration meter.	01 No.
32	Varnier callipers, Micro meters & feeder gauges.	02 Nos.
33	Revolution counters.	01 No.
34	Commutator profile recorder.	01 No.
35	Torque wrench 0-150 Kgm.	03 Nos.
36.	Two pin spanner for movement of rocker assembly.	03 Nos.
37.	Rocker assembly locking gear opening & tightening spanner.	03 Nos.
38.	Chamfering tool	02 sets.
39.	Mica under cutting tool.	02 sets.
40.	Nose pliers.	05 Nos.
41.	Spanner 24/27 mm	04 Nos.
42.	Spanner 30/32 mm	04 Nos.
43.	Spanner 17/19 mm	04 Nos.
44.	Box spanner 30 mm	04 Nos.
45.	Box spanner 22 mm	04 Nos.
46.	Pliers	05 Nos.
47.	Screw driver.	05 Nos.
48.	One pound hammer.	05 Nos.
49.	Badi one mtr. long. Dia = 1 inch.	04 Nos.
50.	Box spanner 17/19 mm	04 Nos.
51.	Chisels	04 Nos.
52.	Files - Flat, Conical & Square.	02 sets.
53.	`D' clamp for lifting the armature & TM.	04 sets.

APPENDIX - D

SUGGESTIONS FROM VARIOUS ELECTRIC LOCO SHEDS

Sr.No	Shed/Railway	Suggestions
01	ELS/JHS CR	Whenever a loco is failed, following points is to be checked: SL connections, its polarities, Manometer reading, applied voltage on each notch, RC network connections, working of Q-20 relay.
02	ELS/AQ CR	Tracing of Rocker ring can be avoided by Meggering fingers of Brush Holders which will also prevent flashing of Brush Holder. In order to prevent breakage of insulator we are using `C' clamp may be used.
03.	ELS/MGS ER	As MGS shed has experienced that the failure of Rocker ring can be avoided by cleaning of Rocker rings during every inspection schedules, inspite of IC only.
04.	ELS/GOMOH ER	**Check method to find reverser (inter change) of field and armature connection due to human error :** a) Put reverser in idle position (either up or down). b) Switch on the battery. c) Put an insulation strip at reverser armature tips (in other words cut off H_0 side feed from armature side). d) Put test lamp across commutator side tip and earth point. e) If lamp does not glow i.e. connections are correct not to be interchanged. **Time of checking :** 5 to 10 minutes. Check should be carried out in every lifted loco. **When to check :** After the connection of motor, before closing inspection cover.
05.	ELS/TKD WR	Introduce greasing of TM in every IC to compensate evaporation of grease during service. As a preventive measures, metal contains in grease sample in IC to be tasted in order to avoid bearing failure. During fitment of new bearing, measure free diametrical clearance, Swelling of bearing seat inner race, measure end shield bearing housing for correct fitment.
06.	ELS/BZA SCR	Test to be conducted in elaborate manner. Bearing clearance like free diametrical clearance also to be checked.