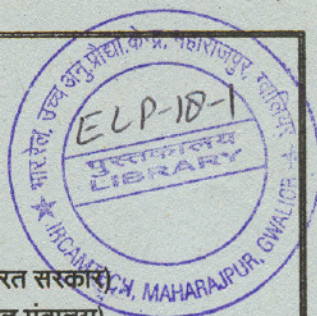


ELP-18/1



सत्यमेव जयते

GOVERNMENT OF INDIA (भारत सरकार)
MINISTRY OF RAILWAYS (रेल मंत्रालय)



MAINTENANCE HANDBOOK FOR AIR COMPRESSOR AND ITS MOTOR

(एयर कम्प्रेसर एवं इसकी मोटर के
अनुरक्षण हेतु हस्तपुस्तिका)

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Centre
for
Advanced
Maintenance
TECHnology



Excellence in Maintenance

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FOREWORD

With increasing electrification of various trunk routes on Indian Railways, reliability of electric locomotives has become an important issue. To improve it further, the equipment on electric loco have to be maintained in good fettle. It thus becomes imperative that the maintenance staff is imparted latest instructions on maintenance. This handbook is written to achieve this objective for one of the important sub-assembly on the locomotive i.e. compressor and its motor.

The handbook details out maintenance, testing, trouble shooting as well as important Do's and Don'ts during repair and maintenance. This will certainly assist the staff in ensuring excellent reliability of this equipment and thus bring about overall benefit to the railways.

CAMTECH, Gwalior

Date : 22.09.99

D.K. Saraf

Director

मशीनरी
कार्गो कट्टर

मशीनरी कट्टर
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PREFACE

The air compressor and its motor on electric locomotive are important equipment and its proper upkeep and maintenance is necessary to ensure good reliability and availability of electric locomotives. This handbook on maintenance of air compressor and its motor has been prepared by CAMTECH with the objective of making our maintenance personnel aware of correct maintenance and overhaul techniques to be adopted in field.

It is clarified that this handbook does not supersede any existing provisions laid down in the "Maintenance manual of electric locomotive" and "A.C. traction manual".

I am sincerely thankful to electric loco directorate of RDSO/LKO and IRIEEN/NKRD for their valuable comments. I am also thankful to all field personnel who helped us in preparing this handbook.

Technological upgradation and learning is a continuous process. Hence feel free to write us, for any addition/modification in this handbook or if you have any ideas. We shall highly appreciate your contribution in this direction.

CAMTECH, Gwalior

Date : 2nd July '99

Khushi Ram

Jt. Director

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CHAPTER 1

GENERAL DESCRIPTION

1.1 AIR COMPRESSOR MODEL TRC 1000 MN

The compressor model TRC 1000 MN is a three cylinders, two stages, reciprocating, air cooled and splash lubricated compressor driven by an electrical motor through a bibby coupling. It consists of three cylinders arranged in 'W' form on a crankcase. Oil bath air filters are fitted to the suction side of the LP cylinder heads. The discharge ports of the LP cylinder heads are connected to the inter-cooler for effective cooling. Inter-cooler is connected to the suction port of HP cylinder head. The discharge port of the HP cylinder head is fitted with an air after-cooler. The compressor is coupled with motor and mounted on a rigid, compact base. The air filter and other pipefitting are all clamped properly to arrest vibration. A fan with a fan guard is provided to direct cool air on to the compressor unit. The fan draws the air over the motor there-by cooling the motor also. An eyebolt is used for lifting the motor, which is provided, at terminal side of the motor.

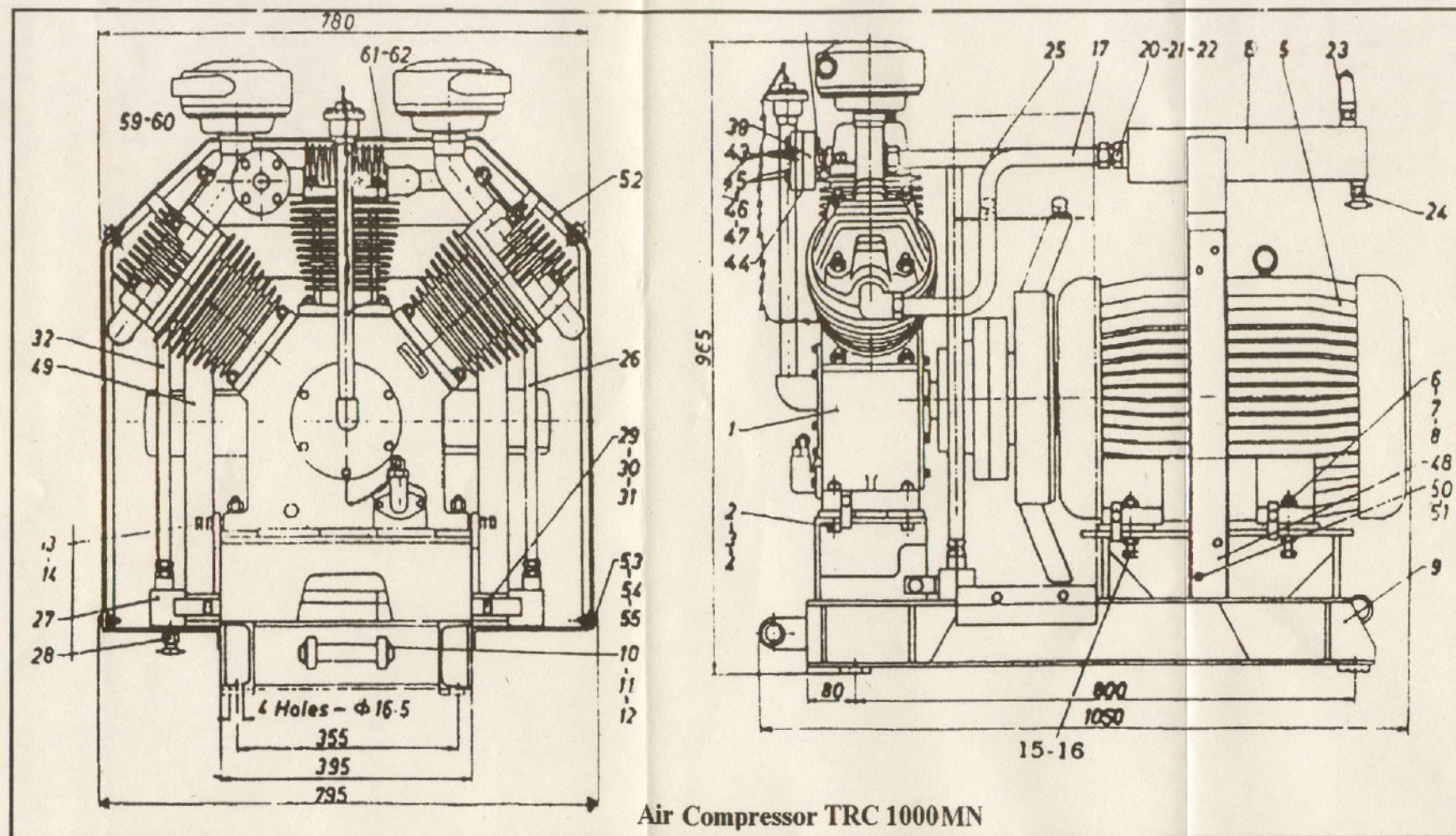


Figure 1.1

Details of figure 1.1 are given below :

I-1	Compressor unit
2	Hexagonal head bolt 1/2" BSW x 3
3	Spring washer 1/2"
4	Hexagonal head nut 1/2" BSW
5	Motor 14 H.P.
6	Hexagonal head bolt 1/2" BSW x 3
7	Spring washer 1/2"
8	Hexagonal head nut 1/2" BSW
9	Base complete
10	Round rod
11	Plate washer
12	Split pin (dia 3/16" x 2")
13	Hexagonal head bolt M10x 30 (vibration arresting)
14	Hexagonal head nut M10
15	Hexagonal head bolt M10x45
16	Hexagonal head nut M10 (locking)
17	Pipe assembly (R.H.)
19	Inter cooler complete
20	Ermeto 1" x 1" BSP
21	Ermeto cone
22	Ermeto nut
23	Safety valve assembly 3/8" BSP
24	Drain valve assembly 1/4" BSP
25	Pipe inter cooler to HP cylinder
26	Pipe HP cylinder to after cooler

27	After cooler complete
28	Drain valve assembly 1/4"
29	Hexagonal head bolt M10x25
30	Spring washer M10
31	Hexagonal head nut M10
32	After cooler pipe (to delivery)
40	Ermeto cone 1"
41	Ermeto nut 1" BSP
42	Flange with elbow
43	Packing
44	Hexagonal head bolt M10 x 35
45	Spring washer M10
46	Hexagonal head nut M10
47	Cooler holder No. 1
48	Cooler holder No. 2
49	Spring washer M10
50	Hexagonal head bolt M10 x 35
51	Fan guard assembly
52	Hexagonal head bolt M10 x 20
53	Spring washer M10
54	Hexagonal head nut M10
58	Name plate
59	Rivet
60	Name plate (unit)
61	Rivet

1.1.1 Crankcase

The crankcase is made of high-grade cast iron and housed the crankshaft assembly. The cylinders are fitted on to it in a 'W' form. It acts as the sump for the lubricating oil, and is provided with drain plug and a dipstick assembly with minimum and maximum level markings to check the oil level. A breather maintains a partial vacuum in the crankcase to facilitate better lubrication.

1.1.2 Cylinder and cylinder head

The cylinders and cylinder heads are made of high cast iron to ensure high wear resistance. They have close deep fins for effective cooling. The cylinder bore is precision honed. Cylinder head suction and delivery air passages are generously curved for easy airflow without any restriction.

1.1.3 Connecting rod, crank shaft assembly

The crankshaft is provided with single row heavy-duty ball bearing at both ends. The big end of main connecting rod is provided with steel bearing rollers and small ends are provided with needle roller bearings. The crank webs are forged out of chromium steel case hardened and precision ground.

1.1.4 Piston and piston rings

The pistons are of automotive type, low expansion aluminium alloy. They are provided with plain compression rings, stepped compression rings and slotted oil control rings. The rings are made of special quality close-grained cast iron. These are designed for controlling wear and reducing oil consumption to a minimum. The gudgeon pins are of chrome steel, case hardened and precision ground.

1.1.5 Disc valves

Special type of concentric disc valve is used for low pressure and high-pressure cylinders. The springs used are of high quality steel. All the individual components are easily accessible and so the valve can be maintained very easily.

1.1.6 Inter cooler, safety valve and after cooler

The inter cooler consists of a series of copper tubes on which fins are wound for effective cooling. It is mounted above the motor. It connects the discharge of the LP cylinder heads to the suction of the HP cylinder head. It is provided with a safety valve and drain valve. The after cooler is also made of copper tubes with fins wound on them and arranged together for better cooling. A drain valve is also provided on the after cooler.

1.1.7 Coupling

The flexible resilient coupling, connecting the motor and the compressor consists of two hubs. Each hub is provided with a number of grooves to hold a spring, which transmits the rotation from the motor to compressor.

1.1.8 Fan and fan guard

Aluminium fan is fixed on the motor shaft to supply air for efficient cooling. A fan guard made of steel sheet with enough strength is mounted as safety measure.

1.1.9 Oil bath air filter

Oil bath air filters are provided at the suction of the LP cylinder heads. First the suction air passes through the oil bath and then the wire mesh. While passing through the oil bath, all dust particles in the air are absorbed by oil, and few oil particles mix with air are separated during its passage through wire mesh, and suction air becomes free from dust and oil particles.

1.2 AIR COMPRESSOR MODEL TRC 2000

The air compressor model TRC 2000 is a two stage, forced feed lubricated, air-cooled and reciprocating air compressor. It comprises of a crankcase, crankshaft assembly, connecting rods, pistons, combined cylinders, cylinder head etc.

An air filter is fitted to the suction side of the low-pressure chamber of the cylinder head. An inter cooler assembly is provided in between LP and HP. The unit is provided with an after cooler also. A dynamically balanced fan is provided for cooling the compressor. Gear type oil pump is fitted at the free end of the crankshaft for lubricating all the moving parts of the unit. Electric motor is coupled by means of resilient flange coupling. The compressor along with the motor is mounted on the rigid compact base.

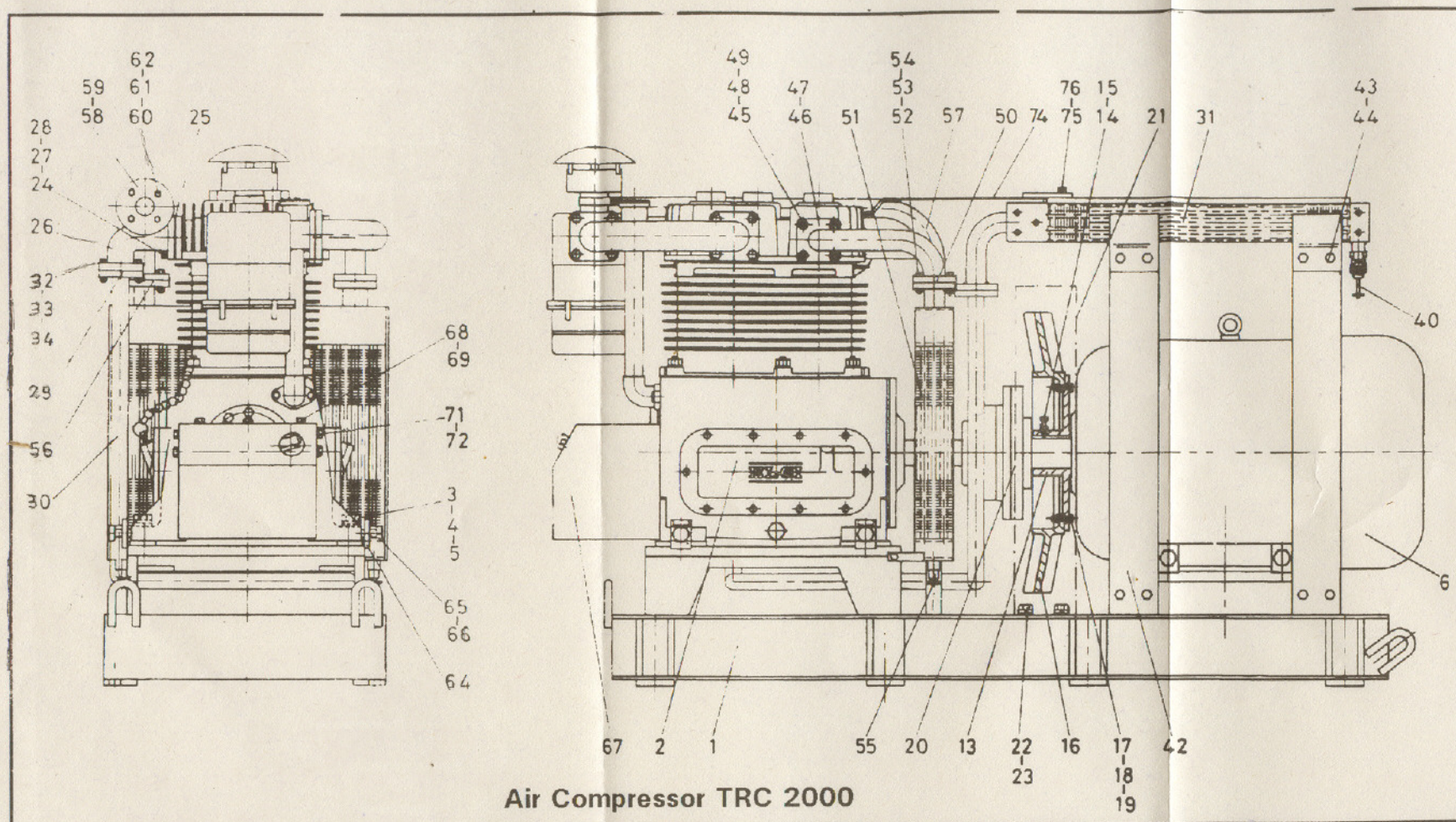


Figure 1.2

Details of figure 1.2 are given below :

1	Base complete
2	Compressor block assembly - TRC 2000
3	Hexagonal head bolt M16 x 90
4	Spring washer M 16
5	Hexagonal head nut M16
6	Motor - 27.5 HP
13	Fan flange
14	Hexagonal head bolt M8x35
15	Hexagonal head nut M8 (locking)
16	Fan
17	Locking plate
18	Spring washer M8
19	Hexagonal head bolt M8 x 25
20	Resilient coupling assembly - ER 158
21	Fan guard
22	Hexagonal head bolt M8 x 20
23	Spring washer M8
24	Stud M10 x 45 (cylinder head to distance flange)
25	Gasket
26	Distance flange

27	Spring washer M10
28	Hexagonal head nut M10
29	Gasket (delivery pipe)
30	Delivery pipe complete (cylinder head LP outlet to inter cooler inlet)
31	Inter cooler complete
32	Hexagonal head bolt M10 x 45
33	Spring washer M10
34	Hexagonal head nut M10
40	Safety valve assembly 3/8" BSP
42	Inter cooler support lug
43	Hexagonal head bolt M10 x 30
44	Spring washer M10
45	Stud M10 x 45
46	Gasket (cylinder head to delivery distance manifold)
47	Delivery distance manifold
48	Spring washer M10
49	Hexagonal head nut M10
50	Gasket (delivery distance manifold to after cooler)
51	After cooler complete
52	Hexagonal head bolt M10 x 45
53	Spring washer M10

54	Hexagonal head nut M10
55	Drain valve assembly 1/4" BSP
56	Gasket ((delivery pipe-outlet)
57	Delivery pipe (outlet)
58	Packing (outlet flange)
59	Delivery outer flange
60	Hexagonal head bolt M10 x 45
61	Spring washer M10
62	Hexagonal head nut M10
64	Vibration arresting adjuster
65	Hexagonal head bolt M10 x 45
66	Hexagonal head nut M10 (locking)
67	Protecting cover (oil pump)
68	Hexagonal head bolt M6 x 16
69	Spring washer M8
70	Hexagonal head nut M6
71	Hexagonal head bolt M8 x 20
72	Spring washer M8
74	After cooler guard
75	Hexagonal head bolt M8 x 20
76	Spring washer M8

1.3 TECHNICAL DATA

Sr.No	Description	TRC 1000 MN	TRC 2000
a. Compressor			
1.	Type	Reciprocating, air-cooled, 'W' type oil splash lubricated.	Reciprocating, air-cooled, 'inline' type forced feed lubricated.
2.	Working pressure	10.5 kg/cm ²	10.5 kg/cm ²
3.	Displacement	1308 lpm	2739 lpm
4.	Free air delivery	1000 lpm	2000 lpm
5.	No. of stage	2	2
6.	Cylinder bore and stroke	100x60x100 : 85 mm	LP 197x90 mm & HP108x90 mm
7.	Compressor speed	980 rpm	1000 rpm
8.	Net weight	405 kg.	950 kg.
9.	Type of valve	Disc valves	Individual disc valves

Sr.No	Description	TRC 1000 MN	TRC 2000
10.	Type of drive	Coupled with motor by a resilient flange coupling.	Directly coupled with motor by a resilient flange coupling.
11.	Crank case oil capacity	Min. 770 ml Max. 1050 ml	Min. 5000 ml Max. 7500 ml
12.	Recommended oil	Servo press 150	Servo press 150
13.	Opening pressure of safety valve on inter cooler	6 kg/cm ²	6 kg/cm ²
b. Motor			
01.	Type	TEFC, Squirrel cage induction motor, three phase, star connected.	TEFC, Squirrel cage induction motor, three phase, star connected.
02.	Power	14 HP	27.5 HP
03.	Rated current	24/21 Amps.	42 Amps.
04.	Insulation	Class 'F'	Class 'F'

Sr.No	Description	TRC 1000 MN	TRC 2000
05.	Speed	980/965 rpm	980/965 rpm
06.	Rating	Continuos	Continuos
c. Coupling			
01.	Type	ER-136, Spring type resilient coupling	Spring type resilient coupling
02.	Weight	13.6 Kg.	29.5 Kg.
03.	Recommend d grease.	Ball bearing grease LMM	Ball bearing grease LMM
d. Wear limit in cylinders			
01.	Up to +0.127	Change new standard piston rings	Change new standard piston rings.
02.	From +0.127 up to 0.254	Bore the cylinder to + 0.25 mm and fit 10 over size piston with corresponding piston rings.	Bore the cylinder to + 0.25 mm and fit 10 over size piston with corresponding piston rings.
03.	Up to 0.381	Change new 10 over size piston.	Change new 10 over size piston.

Sr.No	Description	TRC 1000 MN	TRC 2000
04.	From 0.381 up to 0.50	Bore cylinder to + 0.5 mm & fit 20 over size piston with corresponding piston rings.	Bore the cylinder to + 0.5 mm and fit 20 over size piston with corresponding piston rings.
05.	Beyond 0.50	Change cylinder & piston assembly	Change cylinder & piston assembly
e. Cylinder, piston and piston ring sizes in mm.			
01.	Cylinder bore diameter.	LP 100 + 0.01 HP 60 + 0.00	LP 196.85 + 0.025 HP 107.95 + 0.025
02.	Piston diameter	LP 99.85 ± 0.005 HP 59.92	LP 196.62 to 196.67 HP 107.83 to 107.85
03.	Piston ring butt clearance	Normal LP 0.018 to 0.18 HP 0.08 to 0.18 Maximum LP 0.40, HP 0.40	Normal LP 0.58 to 0.84 HP 0.33 to 0.58 Maximum LP 0.90, HP 0.70
04.	Piston ring side play in groove.	Normal LP 0.04 to 0.08 HP 0.06 to 0.09 Maximum LP 0.12, HP 0.12	Normal LP 0.03 to 0.08 HP 0.03 to 0.08 Maximum LP 0.15, HP 0.20

CHAPTER 2

MAINTENANCE PRACTICES

2.1 INSPECTION SCHEDULES FOR COMPRESSOR

The unit should be properly maintained as per the under mentioned schedules.

2.1.1 During trip schedule

- Clean the compressor thoroughly.
- Check oil level in crankcase. If required replenish with correct grade of oil upto the maximum level.
- Clean oil-collecting tray.
- Drain inter cooler and after cooler.

2.1.2 During IA, schedule

Check the compressor for satisfactory operation as following :

- Ensure all trip inspection checks.
- Check operational noise and vibration.
- Check tightness of mounting bolts and fasteners.
- Check air leakage at pipelines and safety valve.

- Clean suction filters thoroughly and refill oil to the correct level.
- Replenish coupling spring with correct grade of graphite grease on condition basis.
- Check suction, discharge operations and general performance of the compressor.

2.1.3 During IB, schedule

- All check points indicated under IA schedule to be carried out.
- Dismantle breather valve. Clean it and check for perfect seating of the valve.
- Check the safety valve setting.
- Open up coupling cover to check shaft alignment and ensure that springs are lubricated.
- Coupling grease seal to be checked.

2.1.4 During IC, schedule

- Ensure all bi-monthly checks and the following additional points.
- Remove all the disc valves by removing the cylinder heads, detailed below.
 - Dismantle the valves.
 - Check the springs, top plates and bottom plates for any scratches or damage in the seating of valve plates, lap if any.

- Replace damaged springs.
- De-carbonise and thoroughly clean all parts in kerosene.
- Reassemble the valve and assemble it to the cylinder with new packing.
- All the pipelines to be checked for leaks at joints and packing renew as necessary.
- Replenish the coupling spring with correct grade of graphite grease.

2.2 OVERHAULING OF COMPRESSOR

2.2.1 AOH Schedule

- The compressor should be completely stripped by an experienced staff.
- All parts to be thoroughly cleaned, examined and repaired in a clean surrounding.
- Check the crankshaft assembly thoroughly.
- Fix the crankshaft assembly between centres and shake the connecting rod. There should not be any shake in the connecting rod about the crank pin.
- Check small end needles roller bearings. If there is any major repair the same to be attended immediately.

2.3 REPAIRING OF COMPRESSOR

2.3.1 Dis-assembling

2.3.1.1 General

- Before dismantling the unit empty the air receiver.
- Open the drain plug and drain all lubricating oil, from the crankcase.
- Open drain valves to ensure that inter cooler and after cooler are free of compressed air.

2.3.1.2 Accessories

- Take out oil bath filter and its fittings. Loosen simultaneously both the Ermeto nuts and remove the pipefitting.
- Examine the cone seating and replace, if worn out.
- Remove safety the valve from inter cooler and dismantle it. Examine the spring and valve seat.
- Clean all the parts and replace damaged parts with new ones.
- Reassemble and set the opening pressure. Check for correct operation and then lock this adjustment with the lock nut.

2.3.1.3 Cylinder head, disc valves, cylinder

- Loosen the four hexagonal nuts on the cylinder head and remove the cylinder head.
- Now remove the disc valve. Proper care should be taken not to damage the disc valves.
- Position of the springs should be carefully noted since it will help during re-assembling . *Refer figure 2.1*
- If damaged, the springs should be replaced with new ones.
- Check and replace packing with new ones.
- Loosen the four hexagonal nuts provided at the bottom of the cylinder and then gently lift and remove the cylinder.
- If the cylinders are highly fixed to the crankcase rotate the fly end hub. The cylinder will automatically come up.

Detail of disc valve assembly diameter 100

1	Bottom seat plate
2	Stud M10 x 35
4	Bottom plate for suction valve
5	Suction valve spring
6	Suction valve plate
7	Delivery valve plate
8	Delivery valve spring
9	Pin
10	Top seat plate
11	Spring washer M10
12	Hexagonal head nut M10

Detail of disc valve assembly diameter 60

1	Bottom seat plate
2	Stud M8 x 32
4	Suction valve spring
5	Suction valve plate
6	Delivery valve plate
7	Delivery valve spring
8	Top seat plate
9	Spring washer M8
10	Hexagonal head nut M8

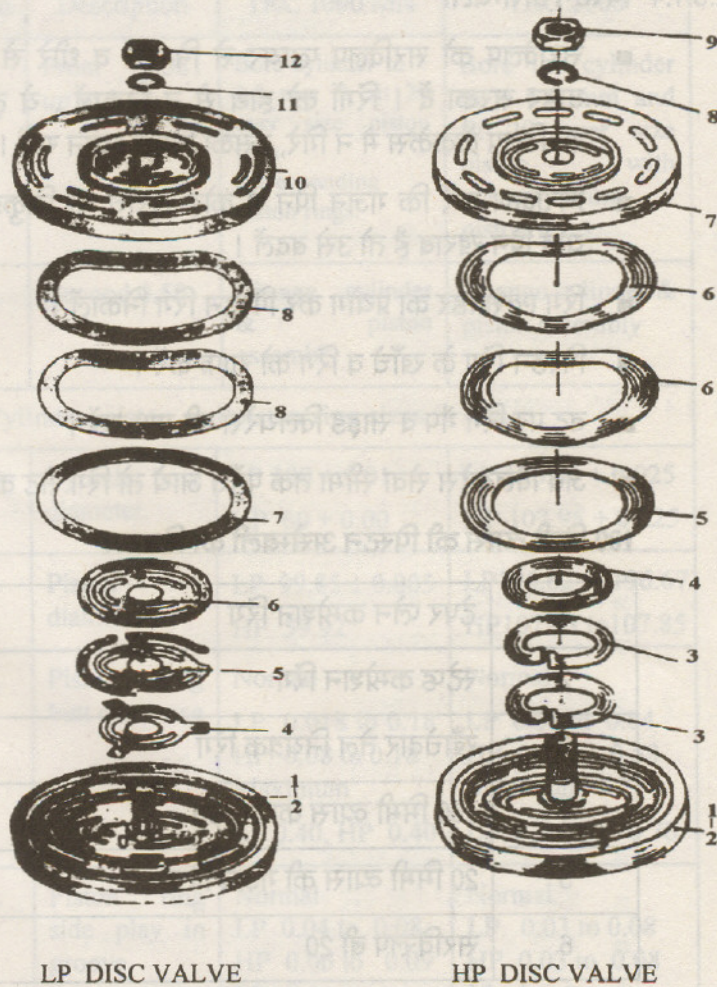


Figure 2.1

2.3.1.4 Piston Assembly

- Remove the circlip by using a circlip plier and gently knock out the gudgeon pin. The rings should not be removed by hands, as it is likely to break. Care should be taken not to drop the circlips inside the crankcase.
- Inspect for scratches or slackness in the gudgeon pin boss. Change the pin, if worn out.
- Remove piston rings using ring expander.
- Clean the piston rings and ring grooves in the piston.
- Measure the ring gaps at the butts and side clearance.
- Replace rings as set when limiting clearances have been reached. *Refer para 1.3 technical data page 13 & 14 for detail.*

Details of piston assembly diameter 100

1	Taper plain compression ring
2	Stepped compression ring
3	Slotted oil control ring
4	Piston diameter 100
5	Gudgeon pin diameter 20
6	Circlip B20

Details of piston assembly diameter 60

1	Plain compression ring
2	Stepped compression ring
3	Slotted oil control ring
4	Piston diameter 60
5	Gudgeon pin diameter 18
6	Circlip B18

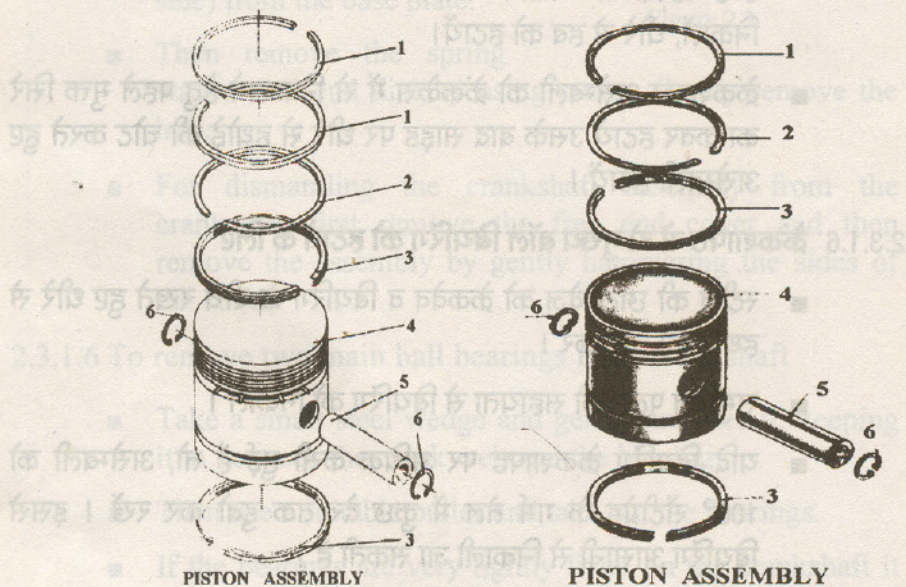


Figure 2.2

2.3.1.5 Crankshaft assembly

- Unscrew the hub cover bolts of bibby coupling and bring the cover to one side and remove the spring from the hubs.
- Now remove the compressor block along with hub (compressor side) from the base plate.

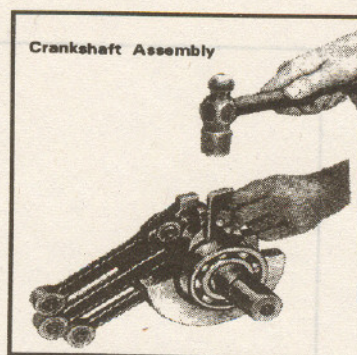


Figure 2.3

- Then remove the spring washer and end disc by using puller. Gently remove the hub.
- For dismantling the crankshaft assembly from the crankcase, first remove the free end cover and then remove the assembly by gently hammering the sides of the cover.

2.3.1.6 To remove two main ball bearings from crankshaft

- Take a small steel wedge and gently hammer it, keeping it in between the crank web and the bearing.
- Then use a suitable puller and take out the bearings.
- If the bearings are very tightly fixed on the crankshaft it is advisable to immerse the assembly in hot oil at 100 °C for some time and then remove the bearings. This facilitates easy removal of the bearings.

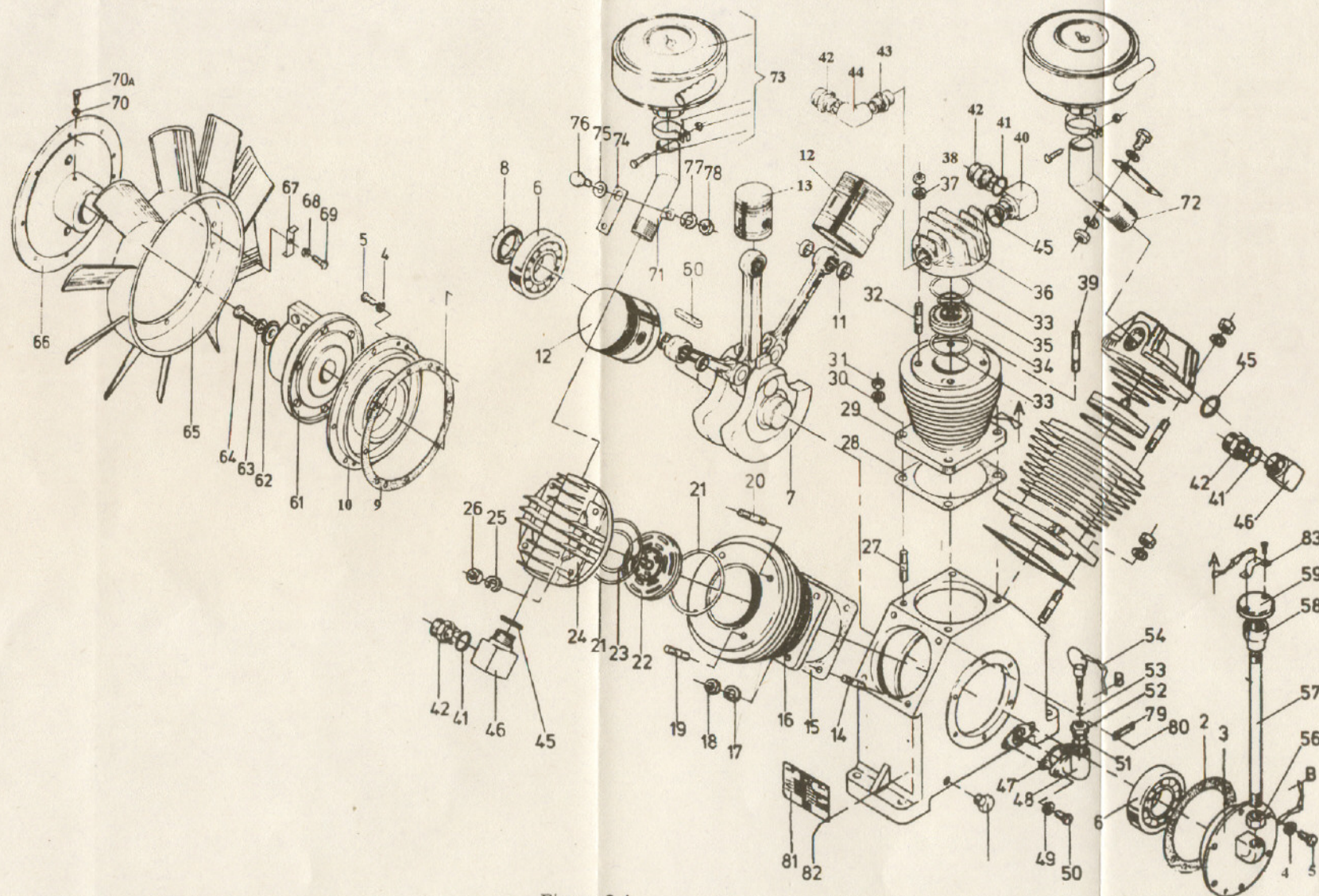


Figure 2.4

2.3.2 Re-assembly

2.3.2.1 General

- Before assembling, all the parts should be thoroughly cleaned in kerosene, dried by compressed air and oiled.
- The bearings should be thoroughly cleaned in diesel, dried and oiled.

2.3.2.2 Fitting the bearings on connecting rod and crank shaft assembly

- Heat the ball bearings uniformly using a hot plate heated by a flame or electrically. The bearings may also be heated by immersing them in hot oil at 110 °C to 120 °C.
- Shrink fit them on the crankshaft.

2.3.2.3 Assembling of connecting rod and crankshaft assembly in crankcase

- Take the crankshaft connecting rod assembly, clean thoroughly in kerosene and dry.
- Oil the bearings and check for any tightness by rotating them by hand. They should have free rotation.
- Ensure that the splasher pin is secured in position and flat sides are perpendicular to the axis of the shaft.

- Fix the fly end cover on the crankshaft assembly through fly end cover hole on the crankcase.
- Fix the free end cover on the other side.
- Then fix the bolts with spring washer and tighten them uniformly.

2.3.2.4 Bibby coupling assembling procedure

- Check parallelism by using a straight edge over top of the hubs at each quarter points (90° apart). Maintain gap of 0.8 to 1.2 mm between two coupling hubs by using feeler gauge.

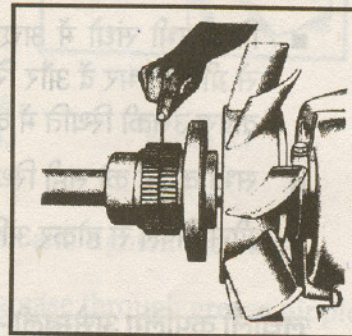


Figure 2.5

- Fix dial gauge on the compressor side hub taking reference from motor hub outer diameter.
- Check angular alignment by rotating fan and dial gauge. Take reading at each quarter points at 90° apart. Keep this alignment below 0.08 mm maximum.

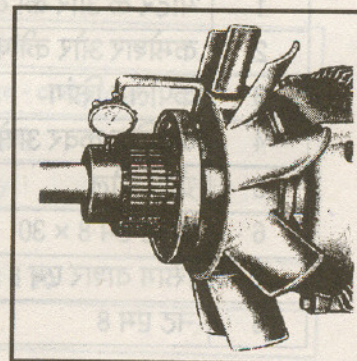


Figure 2.6

- After alignment tighten the foundation bolts of compressor and motor rigidly.
- Lock the motor and compressor by means of lock nuts provided at both sides.
- Then thoroughly pack the grooves with grease. Press spring into its position. Apply grease liberally on it.
- Draw the covers into position and tighten the bolts.
- Inject maximum amount of grease through grease nipple.

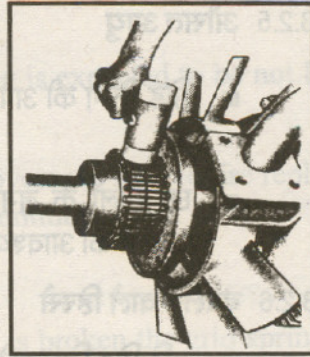


Figure 2.7

Details of resilient coupling assembly - ER 136

1	Coupling hub - motor side
2	Coupling hub with flange - compressor side
3	Coupling spring (grid type)
4	Coupling cover assembly
5	Grease seal
6	Hexagonal head bolt M8 x 30
7	Spring washer M8
8	Hexagonal head nut M8

2.3.2.5 Average Life

- Average life of grid spring is expected to be not less than 12,000 running hours.
- The coupling hubs and covers are not require replacement earlier than six years of continuous use.

2.3.2.6 Replacement Item

- If any ring of grid spring is broken the grid spring should be replaced.
- If a tooth or a number of teeth of coupling hubs are broken the hub should be replaced.

2.3.2.7 Alignment of motor and compressor

Only appropriate tools to be used while assembling fan flange and coupling over the motor shaft. Fan with flange should be changed as assembly to avoid unbalance or after changing the fan with flange. The shafts of compressor and motor should be perfectly levelled and aligned.

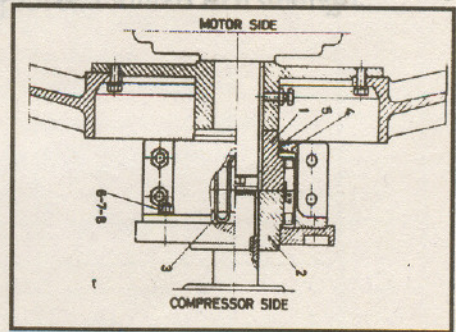


Figure 2.8

2.4 PRESERVATION

2.4.1 Short duration (less than one month)

Allow the unit to run on no load condition for some time. Then close the unit and keep it under shelter, free from dust and moisture.

2.4.2. Long duration (more than one month)

Remove the air filters and pour 50-ml of rust prevention oil through suction port for each LP cylinders. Remove the suction pipe of HP cylinder, pour rust prevention oil for the HP cylinder and then allow the unit to run for a few minutes. Disconnect the unit from power supply. Drain oil from the crankcase. Now assemble the suction pipe end air filters and cover the whole unit. Keep the unit under shelter. The unit should be thoroughly cleaned and examined every month for corrosion prevention and free rotation.

2.5 TORQUE CHART

Tightening torque for various fasteners used in the compressor are given in the following chart.

Sr. No.	Location	Thread size in mm	Tightening Torque Kg.m
01	Crankcase	1/2" BSW	5.0
02	Motor	1/2" BSW	5.0
03	Cylinder	M 12x1.75	5.0
04	Cylinder head	M 12 x 1.75	5.0
05	End cover (free end)	M 8 x 1.25	2.5
06	End cover (fly end)	M 8 x 1.25	3.0
07	Disc valve diameter 100	M 8 x 1.5	2.5
08	Disc valve diameter 60	M 8 x 1.25	1.75
09	Bibby coupling	5/6" BSW	3.5
10	Drain plug	3/8" BSW	3.0
11	Dipstick housing	M 6 x 1 mm	2.0

2.6 STANDARD AND SPECIAL TOOLS

2.6.1 Standard tools

Sr. No.	Tool	Size
01	Double end spanner	10-11, 18-19, 20-22 mm 25-28 mm , 38-41 mm
02	Box spanner	13 mm & 19 mm
03	Stud tightening spanner	12 mm
04	Ring expander	100, 60 mm diameter
05	Circlip plier	
06	Pipe wrench	225 mm
07	Screw driver	150 mm

2.6.2 Special tools

- Gun assembly lever type
- Pusher with nut for compressor side coupling
- Pusher with nut for motor side
- Puller assembly for fan flange
- Puller assembly for coupling hubs
- Ring gauge for 60 dia (Rings inserting tool)
- Ring gauge for 100 dia (Rings inserting tool)
- Spacer flange for pusher common for compressor and motor sides.

2.7 INSPECTION SCHEDULE FOR MOTOR

2.7.1 Electrical connections

The connection on the terminal box of the motor should be in accordance with the wiring diagram, which is pasted on the inside portion of the terminal cover. Connect earth wire to the terminal marked with earth symbol on the terminal box. The main body of the motor should also be connected to earth with a cable of suitable cross section as per IS 900. All fixed electrical connections should be checked for tightness. To change the direction of rotation of the motor any two of the supply leads (phases) should be inter-changed.

2.7.2 Maintenance

Motors should be cleaned by blowing dry air at regular intervals to keep the ventilating passages clean. While re-greasing, clean the bearings and bearing covers well and then fill only recommended grade of grease.

In case the motor is stored idle for long period or if it is transported under very damp condition, the insulation resistance should be checked before connecting it to the supply. The insulation resistance of the motor should be measured between the windings of the motor and its frame by means of megger.

The motor can be dried by placing heaters or lamps around it and inside also or by blocking the motor so that it could not rotate and then apply such a low voltage to the

stator terminals that full load current flow in the stator. Care must be taken during the drying out of the windings that the temperature of the induction coil should not exceed 155 °C by placing motor in oven for a required time.

2.7.3 Common troubles in electrical motors

When an electric motor fails to start, does not run properly or it runs slowly, trouble may be as following :

- Burnt out fuse
- Worn out bearing
- Over load
- Open phase
- Shorted coil or group
- Loose rotor bars
- Frozen bearing
- Wrong internal connections.
- Defective control
- Grounded wiring.
- Reverse phase.
- Open parallel connection.
- Incorrect voltage or frequency
- Single phasing
- Tight bearings.

2.8 CLASSIFICATION OF DEFECTS

2.8.1 Winding failure

- Insulation failure
- Stator winding inter turn short circuit
- Open circuit
- Earthed by one phase, two phase or all three phases
- Smoke emission
 - Due to overheating
 - Due to burning.
- Overhang portion burnt.
- Out going leads damaged.
- Burnt due to loco burning
- Due to ageing effect.
- Stator winding failure due to locked rotor.

2.8.2 Single phasing

- Due to breakage connecting lead wire.
- Due to loose terminals / stud breakage.
- Due to breakage of lugs.

2.8.3 Star point failure

- Open circuit due to burning.
- Brazing failure.

2.8.4 Rotor failure

- Due to bar lifting.
- Due to end ring cracking.
- Due to brazing failure.
- Rotor shaft bent, broken/loose.
- Bar cracking.

2.8.5 Bearing failure

- Due to improper interference fit.
- Due to abnormal sound.
- Due to less grease.
- Due to excess grease.
- Bearing worn out/cage broken.
- Bearing seized.

2.9 COMMON METHODS FOR FAULT LOCATION

2.9.1 Mechanical

- Inspection of the motor to detect such mechanical troubles as broken or cracked end plates, badly bent shaft, broken or burnt leads.
- Test the motor for bearing troubles.

2.9.2 Electrical

2.9.2.1 Ground test

This test is performed to discover whether internal wires are not touching the iron cores of the rotor or stator. This is accomplished by using a test lamp. One lead of the test lamp is connected to the winding and the other lead to the stator core or motor frame. If the lamps light, the winding is grounded.

2.9.2.2 Open circuit test

An open circuit in electrical motors, is a usual case of loose or directly connected or broken wire. To determine whether the winding is open the leads of the test lamp are connected to the ends of the winding. If the lamp lights, it means circuit is complete.

2.9.2.3 Short circuit test

Two or more turns that connect each other electrically cause a short circuit. This condition may develop in the new winding, if the winding is tight. This can be tested by using an internal growler or by detecting the hottest coil. The voltage drop test and field strength test can also be used.

2.9.2.4 Polarity test

Reversal results from wrong connections between poles, which are best, discovered by means of a polarity test. This polarity test includes two methods.

I. Compass Method II. Nail Method.

- Compass method : The stator is placed in horizontal position and low DC voltage is applied to the winding. The compass is then held inside the stator. Now move it slowly from one pole to another. The compass needle should reverse itself at each pole, if the winding is correctly connected.
- Nail Method : The stator is placed on its side and low voltage of AC or DC is applied to the winding. A nail is placed on the core, so that it extends from centre of one pole to the centre of the next pole. If the adjacent polarity is correct the nail will be attracted to both poles and if the nail is repelled then the polarity is reversed.

2.10 REWINDING PROCEDURE

Many steps involved in the process of rewinding the electric motors are as following :

- Taking data
- Stripping the winding.
- Insulating the stator or rotor.
- Winding the coils.
- Placing the coil in slots.
- Connecting the coils (brazing).

- Testing the winding.
- Varnishing and baking.
- Assembling
- Testing.

During process of stripping following information should be recorded :

- Rating of the motor.
- No. of slots per coil.
- Type of winding.
- No. of the coil.
- Shape of the coil.
- Size and kind of wire.
- Pitch of coil.
- Type of insulation.

Before placing the winding in the slots, first slots to be thoroughly cleaned and then install suitable form of insulation so that wires do not touch any part of the iron core. Now place the winding in the slots.

2.10.1 Baking and varnishing

When all the connections between poles and winding have been completed and tested. The Flexible leads to the power line attached and tied. The stator to be placed in baking oven at temperature approximately 250 °F and preheated for a short period approximately one hour. This removes moisture from winding and increases the penetration of varnish for better insulation.

2.11 SUGGESTIONS TO AVOID PREMATURE FAILURE

The following suggestions may be adopted for preventing premature failures of auxiliary motors:

- In order to ensure desirable life to the auxiliary motors, these should be rewound/repared only by the genuine experienced rewinders/repairers of quality conscious.
- The class of the insulating material and other specifications should be clearly mentioned to the motors, which are to be rewinded or repaired.
- The coil should be tapped in the overhang or alternatively coil separators similar to phase separators should be provided between adjacent coils emerging from the slots.
- Dual coated polyester-imide plus polyamide-imide enamelled wires to be used in place of polyesterimide coating.
- Always do vacuum pressure impregnation of stators.
- Do the surge test at 5 KV on stators after rewinding and during every overhaul.
- Prefer 2 % silvered welding electrodes for brazing copper to copper of star point.
- Locking nut for tightening the lugs should be tighten by torque wrench.
- After rewinding of motor, run test to be carried out for 4 to 5 hours before fitment on the locomotive.

CHAPTER 3

TESTING

3.1 AUXILIARIES AND ARNO TESTING PANEL

This test panel consists of two parts.

- Control and power panel
- Auto transformer

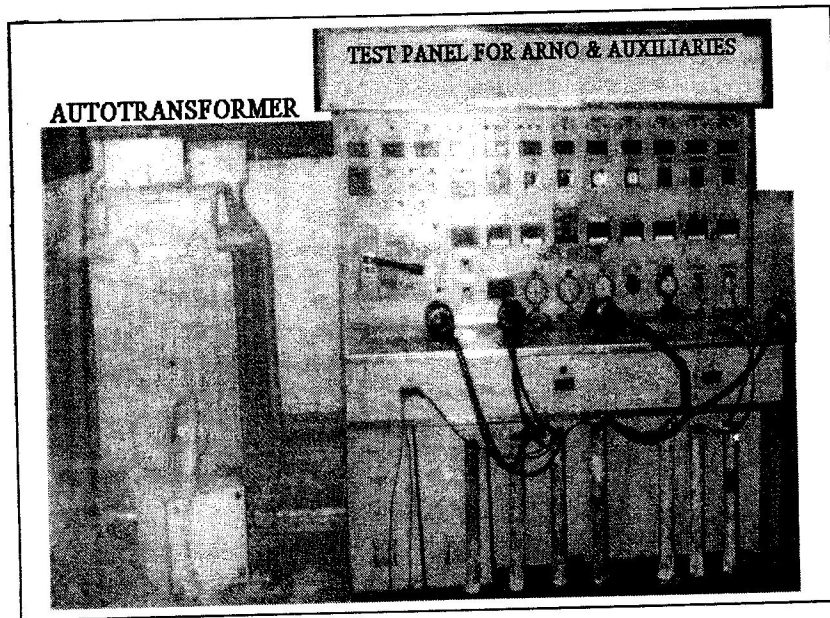


Figure 3.1

REAR VIEW OF TESTING PANEL

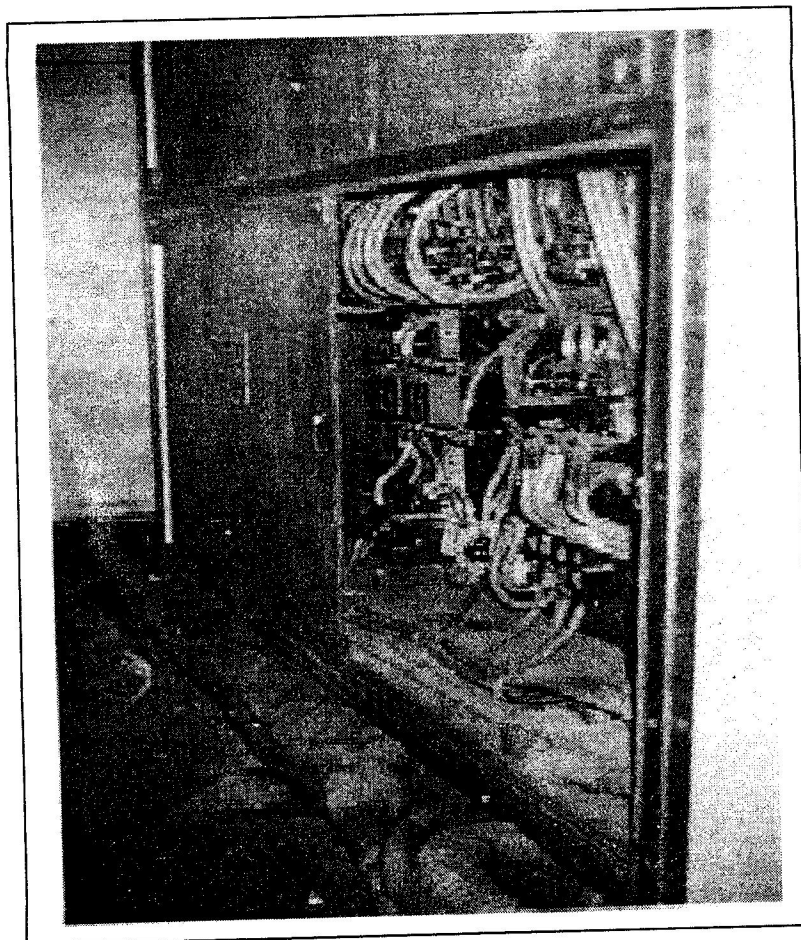


Figure 3.2 REAR VIEW OF TESTING PANEL

3.1.1 Details of electrical circuit for auxiliary and Arno testing panel.

01	FS 1 to FS 3	Female sockets 106 amps. 440 V
02	FS 4 to FS 5	Female sockets 63 amps. 440 V
03	FS 6 to FS 7	Female sockets 63 amps. 440 V
04	FS 8	Female socket with switch 15 amps, 230 V
05	MCB 1	Double pole miniature circuit breaker 15 amps, 230 V.
06.	MCB2	Double pole miniature circuit breaker 10 amps, 230 V.
07.	SDT	Step down transformer 230/110 V
08.	VMS 1 & 2	Volt meter selector switches
09.	AMS 1 to 7	Ammeter selector switches.
10.	MCCB 1 to 4	Moulded circuit breaker 100 A, 440 V
11.	MCCB 5 to 6	Moulded circuit breaker 50 A, 440 V.
12.	MCCB7 to 8	Moulded circuit breaker 20 A, 440 V.
13.	IL 1 to 3	Main 'ON' indicator (LED)
14.	IL 4,5,6	Auto transformer 'ON' indication (LED)
15.	IL 7,8,9	Arno 'ON' indication (LED)
16.	IL 10 to 30	Auxiliaries 'ON' indication (LED)
17.	IL 31	110 V DC 'ON' indication (LED)
18.	PB 1	Auto transformer volts 'Up'.
19.	PB 2	Auto transformer volts 'Down'.
20.	PB 3	Arno 'OFF'.

21.	PB 4	Arno 'ON'.
22.	PB 5	Arno on single phase.
23.	O/L	Over load relay (51 to 45)
24.	TDR	Time delay relay.
25.	LS 3 & 4	Limit switches in terminal box for Arno.
26.	LS 1 & 2	Limit switches in autotransformer.
27.	C 1	Main contactor for Arno.
28.	C 2	Single phasing contactor for Arno.
29.	TL 2 & 3.	Tune lights in top display board.
30.	IL 32	Arno 'OFF' indication.
31.	IL 33	Arno 'ON' indication.
32.	IL 34	Arno on single-phase indication..
33.	VM 1	Voltmeter for mains.
34.	VM 2	Voltmeter auto transformer out put volts
35.	VM 3	Voltmeter for 110 V DC.
36.	AM 4 to 10	Ammeter for auxiliaries.

3.1.2 Installations

- No foundation is required as the panel is a self-supporting type structure.
- Install the panel at a convenient place, minimum 2 feet away from the wall.
- Install the autotransformer on left side of the panel, about 2 feet away from it and wall. Ensure sufficient space around the transformer for natural air-cooling.

- Connect the autotransformer to the panel.
- Connect panel to main distribution board for 3 Φ , 440 V, 250 amps. power supply. For mains incoming supply, terminal block is provided at bottom on right hand.
- Proper earth connections should be done to the panel as well as autotransformer.

3.1.3 Testing procedure

Before switching 'ON' the panel ensure that :

- All the MCCBs and MCBs are in 'OFF' position.
- All the plugs are in disengaged position from the respective sockets.
- Switch 'ON' mains i.e. the main switch fuse unit.
- Switch 'ON' the control mains i.e. MCB. Check the main voltage in different phases by means of selector switch and voltmeter.
- Ensure autotransformer output voltage is 'ZERO'.
- If not, bring it down to 'ZERO' by push button marked 'Auto transformer volts down'.

3.1.4 Procedure for testing of auxiliaries

- Auxiliary motors can be tested both ways either through the autotransformer or direct from mains.
- If the motors are desired to be tested through the autotransformer the terminal connections should be made as follows : 14 to 7, 15 to 8 and 16 to 9.

- If the motors are tested directly through the mains the terminal connections should be made as follows :
14 to 4, 15 to 5 and 16 to 6.
- If the Motors are tested through autotransformer, please ensure that the autotransformer out put voltage is 'ZERO'. If not so bring it down to 'ZERO', before switching 'ON' the MCCBs.
- Suitable plugs of different capacities i.e. 125 amps., 63 amps. and 32 amps. have been provided with leads to connects various motors under test to the supply.
- Each socket is connected through the MCCBs of respective capacity.
- For measuring the current in each phase, ammeters and selector switches are provided.

3.1.5 Procedure for testing of motors

- Keep the MCCB in 'OFF' position.
- Disengage the plugs.
- Connect the plugs - leads to the motor under test.
- Engage the plug into the socket.
- Switch 'ON' the MCCB.
- If it is through the autotransformer, increase the voltage to the rated value.
- For 110 V DC supply, switch 'ON' the MCB marked 110 V DC.
- For 110 V DC supply, the same can be availed from the plug socket provided on the panel.

3.1.6 Procedure for testing of Arno

- Keep the mains in 'OFF' position.
- Connect the leads to the Arno first.
- Engage the plug into the socket, provided on a separate box for Arno testing.
- Close the doors of the terminal box properly, or else, the contactors will not close and operate, as the two limit switches have been provided inside the terminal box to ensure safety of the working staff.
- Set the timer to the desired rating. The timer has been provided on the backside of the panel and can be set from 0-60 seconds.
- Ensure autotransformer output voltage is 'ZERO'.
- If the same is not at 'ZERO' bring it down to 'ZERO' by push button marked 'Arno transformer volts down'.
- Switch 'ON' the mains and control mains.
- Press the push button marked 'ARNO ON ' and see that red LED glows.
- Now increase the voltage upto 50 V and allow Arno to pick up speed. Please ensure that the current to Arno does not exceed 150 Amps, as this may damage the autotransformer.
- After Arno has picked up speed, and the current reduces, increase voltage upto rated value i.e. 380 V.

- Ammeters have been provided to observe the current drawn by each phase.
- After the set time on the timer, one phase gets cut off by opening the contactor C1.
- Now Arno runs on single phase. This is indicated by glowing LED marked 'Arno on single phase'.
- The single phasing can be done manually also by pressing push button marked 'Arno on single phase'.
- The timer coil is connected to the auto transformer output voltage, so that it will operate only when the phase voltage to Arno is above 200 V.
- After completing all tests, switch 'OFF' Arno by pressing push button marked 'ARNO OFF'.
- Decrease autotransformer output voltage to 'ZERO'.
- Disengage the plug from its socket.

CHAPTER 4

COMMON DEFECTS, CAUSES AND REMEDIES

4.1 COMPRESSOR TROUBLE SHOOTING CHART

Sr. No.	Defects	Likely causes	Remedies
01	Pressure build-up excessive	<p>Suction air filter is clogged (oil bath type).</p> <p>Pipe line leaking.</p> <p>Disc valves defective. Carbon deposits too much.</p> <p>Piston rings worn-out.</p>	<p>Clean oil bath filter mesh with petrol or kerosene and change oil.</p> <p>Check and rectify.</p> <p>Remove cylinder head and check disc valves. Do de-carbonisation.</p> <p>Check ring gap. If required, change the rings.</p>
02	Low-pressure safety valve operates though specified pressure is not reached.	Safety valve is not functioning properly.	Check safety valve, components for correctness. Reset to recommended rating.

Sr. No.	Defects	Likely causes	Remedies
03	LP safety valve operates during the compressor running.	Disc valve in HP cylinder is not functioning properly.	Check disc valve components. Clean the dust if any and rectify the defect.
04	Abnormal noise and knocking of compressor.	Connecting rod and crank shaft assembly defective. Journal bearings are worn-out. Gudgeon pin looses in piston. Disc valve defective. Coupling is worn-out (loose on the bore). Key of compressor and motor loose.	Crankshaft assembly should be reconditioned. Change bearings. Change piston check for lubrication. Check and replace parts, if required. Check the couplings and change, if required. Replace with correct size of key.
05	Compressor seizure/piston scoring	Insufficient lubrication or oil becomes too thick. Incorrect direction of rotation.	Maintain correct oil level or change oil with correct grade. Correct the rotation.

Sr. No.	Defects	Likely causes	Remedies
		Insufficient clearance between piston cylinder rings, if fitted new.	Correct as per recommendations. Maintain clearance as per technical data on page 13,14
06	Oil coming along with compressed air.	Excessive oil in the oil bath air filter. Excessive oil in the crankcase. Oil leaking through piston.	Check levels in air filter and maintains to the correct level. Check oil level in the crankcase and maintain to correct level. Remove the piston, cylinder and check the ring gap and piston to bore clearance. Please refer technical data on page 13 and 14.
07	Oil leak through breather	Breather valve not working. Piston ring struck in grooves or broken. Piston to cylinder clearance excessive.	Open, clean and refit the breather. Loosen the piston rings. If broken, change the rings as a set. Check and change as a set.

4.2 MOTOR TROUBLE SHOOTING CHART

Sr. No.	Defect	Likely cause	Remedies
01	Motor fails to start upon initial installation.	<p>Motor mis-wired</p> <p>Motor damaged and rotor is striking stator.</p> <p>Fan guard bent & contacts fan.</p>	<p>Verify motor is wired correctly.</p> <p>May be able to reassemble otherwise, motor should be replaced.</p> <p>Replace fan guard.</p>
02	Motor had been running, then fails to start.	<p>Fuse or circuit breaker tripped.</p> <p>Stator is shorted or went to ground. The Motor make humming noise and the circuit breaker or fuse trips.</p> <p>Motor over heated or load jammed.</p> <p>Starting switch has failed.</p>	<p>Replace fuse or reset breaker.</p> <p>Disassemble motor and inspect windings, internal connections. Blown stator shows a burn mark.</p> <p>Inspect to see that load is free. Verify current drawn by motor versus nameplate rating.</p> <p>Ensure that switch is not loose on shaft. Inspect contacts and connections.</p>

Sr. No.	Defect	Likely cause	Remedies
03	Motor runs but lies down.	Voltage drops. Load increased	If voltage is less than 10 % of the motor's rating. If not, check other equipment, which is taking power away from the motor. Verify the load has not changed. Verify equipment has not got tighter. Verify the airflow has not changed.
04	Motor takes too long to accelerate.	Bad Bearings. Voltage too low.	Noisy or rough feeling bearings should be replaced. Make sure that the voltage is within 10% of motor's nameplate rating.
05	Motor over load protector continually trips.	Load too high.	Verify that the load is not jammed. If motor is a replaced, verify that rating is the same as the old motor.

Sr. No.	Defect	Likely cause	Remedies
		<p>Ambient temperature too high.</p> <p>Protector detective.</p> <p>Winding shorted or grounded.</p>	<p>Verify that motor is getting enough air for proper cooling. Most motors are designed to run in ambient temperature.</p> <p>Replace with a new one of the same rating.</p> <p>Inspect stator for defects loose or cut wires that causes it go to ground.</p>
06	Motor vibrates	<p>Motor bearing defective.</p>	<p>Realign load.</p> <p>Remove motor from load and inspect motor by itself.</p> <p>Verify that motor shaft is not bent. Rule of thumb is .001" run out per every inch of shaft length.</p> <p>Test motor by itself. If bearings are bad, you will here noise or feel roughness.</p> <p>Replace bearings.</p>

Sr. No.	Defect	Likely cause	Remedies
		Rotor out of balance.	Inspect motor by itself on no load. If it feels rough and vibrates but the bearings are good, it shows that rotor is out of balance. Rotor must be replaced or re-balanced.
		Motor has too much endplay.	Rotate shaft with motor disconnected from power. It should move but with resistance. If the shaft moves in and out too freely, this indicate a pre load problem and the bearings needs additional shimming.
		Winding defective.	Test winding for shorted or open circuits. The amps will be high. Replace motor or rewind stator.
07	Bearings continuously fall	Excessive or unbalanced load to motor	Balance and adjust the load.

Sr. No.	Defect	Likely cause	Remedies
08	The motor makes a loud rubbing or grinding noise at start up.	Rotor is striking stator.	Ensure that motor is not damaged in shipment. If you can not see physical damage, inspect the motor's rotor and stator for strike marks. If signs of rubbing are present, the motor should be replaced. Some times simply disassembling and reassembling motor eliminate rubbing. End bolts are also some time knocked out of alignment during transportation.

CHAPTER 5

DO'S AND DON'TS

5.1 GENERAL

5.1.1 Do's

- Read the manual in detail and follow the instructions.
- Clean the air compressor package regularly.
- Use only genuine spares.
- Maintain correct belt tension.
- Maintain correct oil level in the crankcase.
- Use only clean, recommended lubricants.
- Use proper tools.
- Drain the condense daily by opening the drain valve.
- Attend immediately to anything unusual with the air compressor.
- Maintain logbook to monitor operation of compressor.
- Depute qualified technician to attend repairs/service.

- Compressor operates only by trained persons.
- Tag the air compressor and render it in operative by disconnecting power supply.
- Examine the unit for transit damages.
- Fill up the crankcase with servo press 150 oil up to the maximum mark on the dipstick.
- Fill the air filter with servo press 150 oil upto the mark.
- Check level of the compressor by using a spirit level.
- Maintain correct gap (0.8 to 1.2 mm) between the two hubs of the coupling for both parallel and angular alignment in assembling the couplings.
- Ensure that the compressor unit is properly aligned and all bed bolts are fully tightened.
- Rotate the compressor unit by hand and feel whether it is free, except for compression forces.
- Connect the motor to a three-phase supply and ensure anti clockwise rotation when viewed from non-driving end of compressor.
- Start up the unit and drain inter-cooler and after-cooler for a few minutes and also ensure inter-cooler safety valve is free and functioning properly.
- Check for any abnormal noise or vibrations. Rectify the defect, if any.

- Always maintain cleanliness during inspection and checks.
- Use the UN separable rags for cleaning interior parts.

5.1.2 Don'ts

- Neglect the routine attention.
- Allow any leakage in the system.
- Keep any tools or loose items on the compressor.
- Meddle with any adjustment or settings.
- Run the compressor without fan guard.
- Use cleaning agents, when changing oil.
- Do any repair work while the unit is running.
- Over load the compressor for a long period even though it is of continuous rating.
- Start air compressor unless it is safe to do so.
- Attempt to operate the air compressor with known unsafe condition.
- Modify compressor without approval of competent authority.

5.2 PRESSURE RELEASE

5.2.1 Do's

- Manually pop the safety valve when the compressor is operating, at least weekly to make sure that the safety valve is working properly.
- Select appropriate tools during maintenance of air hoses, pipes, valves, filters and other fitting.
- Secure all hose connections by wire, chain or other suitably retaining devices to prevent hose ends from being accidentally disconnected.
- Vent all internal pressure prior to opening any line, fittings, hose, valve, drain plug, connections or other component such as filter.
- Keep personnel out of line with and away from the discharge opening of hoses or tools or other points of compressed air discharged.

5.2.2 Don'ts

- Exceed manufacturer's rated safe operating pressure.
- Use air pressure higher than 2.5 kgf/cm² for cleaning purposes.
- Engage in horseplay with air hoses as death or serious injury may result.

5.3 FIRE AND EXPLOSION

5.3.1 Do's

- Clean up spills of lubricant or other combustible substances immediately.
- Shut-off the air compressor and allow it to cool.
- Keep sparks, flames, other sources of ignition away.
- Keep electrical wiring and other terminals in good condition.
- Keep all terminals clean and tight.
- Keep grounded conductive objects such as tools away from exposed live electrical parts to avoid arcing.
- Keep oily rags, trash, leaves, cotton waste etc. away from the compressor.

5.3.2 Don'ts

- Permit smoking in the vicinity of the compressor.
- Use flammable solvent for cleaning purposes.
- Operate the compressor without proper flow of cooling air, with inadequate flow of lubricant or with de-graded lubricant.
- Attempt to operate the compressor in any classification of hazardous environment.
- Use air from this compressor for respiration.

5.4 MOVING PARTS

5.4.1 Do's

- Keep hands, arms and other parts of the body and also clothing away from fans and other moving parts.
- Make sure all personnel are aware about the compressor.
- Disconnect and lock out all power at source and verify at the compressor that all circuits are de-energised to minimise the possibility of accidental start-up or operation, prior to attempting repairs or adjustment.
- Avoid bodily contact with hot oil, hot surfaces, sharp edges and corners.
- Keep all parts of the body away from all points of air discharge.
- Wear personal protective equipment including gloves and head covering.

5.4.2 Don'ts

- Attempt to operate the compressor with fan, guard removed.
- Wear loose clothing and confine long hair.
- Ignore small cuts and burns as they may lead to infection.

5.5 ELECTRICAL SHOCK

5.5.1 Do's

- Keep all parts of the body and hand held tools or other conductive object away from exposed live parts of the electrical system.
- Maintain dry footing. Stand on insulated surfaces.
- Make all adjustment or repairs with one hand only so as to minimise a possibility of creating a current path through heart.
- Attempt repairs only in clean, dry and well-lighted conditions.
- Disconnect, lock out and tag all power at source prior to attempting repairs or adjustment to rotate the machinery and proper to handling any under grounded conductors.

5.5.2 Don'ts

- Contact any other portion of the compressor exposed to live parts of the electrical system.
- Leave the compressor un-attended with open electrical enclosures.

5.6 LIFTING

5.6.1 Do's

- Make sure entire lifting, rigging and supporting structure in good condition and a rated capacity of at least the net weight of compressor plus 10% allowance for the weight of mud or stored tools or equipment.
- Inspect points of attachment for cracked welds, bent, corroded prior to lifting.
- Make sure lifting hook has a functional safety latch and is fully engaged.
- Air compressors lifted by sling.
- Avoid twisting or swinging of the machine.
- Keep all personnel out from under and away from the compressor when it is suspended.
- Keeps lift operator in constant attendance whenever compressor is suspended.

5.6.2 Don'ts

- Attempt to lift in high winds.
- Lift the compressor higher than necessary.

ANNEXURE A

MODIFICATION CARRIED OUT BY ELGI LTD. ON
TRC 2000

Sr.No	Description	Modification carried out
01.	On lubrication oil filter assembly.	Introduced flange filter housing with packing and wire mesh type re-usable filter element in place of use and throw type for better sealing and performance.
02.	On coupling assembly.	Coupling cover changed from FK type to KX type (IE) single piece to two halves for easy maintenance.
03.	Elimination of oil pressure gauge and introduction of oil pressure indicator valve assembly.	Eliminated oil pressure gauge and introduced pressure indicator valve assembly for easy observation of lubricating oil pressure.
04.	Modification of lubricating oil pump relief valve assembly.	The oil pump relief valve on the pump housing eliminated and introduced new type pressure relief valve assembly in the crankcase to improve the reliability of the pressure relief valve assembly.
05.	On lubricating oil pump gears.	Spur gears changed to helical gear and width of the gears increased from 15 mm to 20 mm.

Sr.No	Description	Modification carried out
06.	On lubricating oil pump housing.	Gear housing width increased from 15 mm to 20 mm to accommodate modified drive, driven gears. Window cover plate is also eliminated.
07.	On lubricating oil pump drive gear.	Drive gear and guide pin made out of two piece changed to integral piece design. Drive plate width also increased to improve the performance.
08.	On combined cylinder.	Mounting holes of cylinder with crankcase increased from 6 holes to 10 holes for better sealing between cylinder and crankcase.
09.	On crank case	Mounting holes of crankcase for cylinder increased from 6 holes to 10 holes for better sealing between sealing and crankcase.
10.	On oil filling port.	1/2" BSP port introduced at the sump cover instead of 1/4" BSP. Accordingly the size of the dipstick is also changed.
11.	On inlet pipe assembly.	Split type inlet pipe assembly consisting of two pipes with flanged ends introduced instead of single piece assembly.
12.	On compiling cover assembly.	1/8" BSP grease nipple position has been changed (i.e. the grease nipples will be in between two fixing bolts.

Sr.No	Description	Modification carried out
13.	On delivery pipe assembly.	Split type delivery assembly consisting of two pipes with flanged ends introduced instead single assembly.
14.	On after cooler	<p>I.a. Stiffener plates and gusset introduced.</p> <p>I.b. Mild steel bushes introduced at the ends of each and every copper tubes.</p> <p>II.a. The height of the after cooler increased from 530 mm to 700 mm.</p> <p>II.b. Due to the increase in height, the discharge pipes and inlet manifold has been changed accordingly.</p>
15.	On Inter cooler	<p>a. Stiffener plates introduced.</p> <p>b. Mild steel bushes introduced at the ends of each and every copper tubes.</p>
16.	On Ø 197 mm Piston assembly	Four nos. of piston rings (two compression rings and two oil scrapper rings) introduced instead of three rings (one compression ring and two oil scrapper rings).