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GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

(For official use only)

MAINTENANCE HANDBOOK FOR ROOF MOUNTED AC COACHES

CAMTECH/99/E/CAC/1.0

Centre for Advanced Maintenance Technology

उच्च अनुरक्षण प्रौद्योगिकी केन्द्र

Excellence in Maintenance

Maharajpur, Gwalior - 474 020

FOREWORD

The population of air-conditioned coaches on Indian Railways is ever increasing. The coaches occupy a place of pride on our Railway system due to their excellent upholstery and cleanliness. A large number of foreign tourists coming to India enjoy their trips traveling on these coaches. It is therefore crucially important that we always keep these coaches including the air-conditioning system in good fettle.

This handbook has therefore been prepared by CAMTECH to provide useful guidance for proper maintenance of Air-conditioning system of coaches. The book also contains a list of do's and don'ts and other vital information such as details of fuses. Even a ready to refer trouble shooting chart is also included in the handbook . I am sure that our field personnel will find it immensely beneficial and this will result in higher reliability of AC system on our coaches.

CAMTECH, Gwalior *D.K. Saraf*
Date : 15.07.99 *Director*

PREFACE

The proper upkeep and maintenance of air-conditioning equipments is necessary to ensure good reliability and availability of AC coaches. This handbook on maintenance of roof mounted AC coaches has been prepared by CAMTECH with the objective of making our maintenance personnel aware of maintenance techniques to be adopted in field.

It is clarified that this handbook does not supersede any existing provisions laid down by RDSO or Railway Board.

I am sincerely thankful to Electric Power Supply 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 & learning is a continuous process. Hence feel free to write to us for any addition/modification in this handbook or if you have any new ideas. We shall highly appreciate your contribution in this direction.

CAMTECH, Gwalior *Khushi Ram*
Date : 05.07.99 *Jt. Director(Elect.)*

ISSUE OF CORRECTION SLIPS

The correction slips to be issued in future for this handbook will be numbered as follows :

CAMTECH/99/E/RMPU/1.0/C.S. # XX date----------

Where "XX" is the serial number of the concerned correction slip (starting from 01 onwards).

CORRECTION SLIPS ISSUED

Sr. No. of C.Slip	Date of issue	Page no. and Item no. modified	Remarks

CHAPTER 1

INTRODUCTION

The Packaged Air Conditioner (PAC) is a modular type completely assembled and factory gas charged with hermetically sealed refrigerant. This design uses the environment friendly Refrigerant R-22. Being a sealed system with short connecting piping, incidence of leakage is almost eliminated. Due to its being mounted on the roof, damage due to flash flooding, cattle runs, flying ballast and condenser clogging is eliminated.

Terminals are provided for connecting power from mains to Control Panel and for connecting control panel to PAC unit. Terminals are also provided to connect the wires from thermostat and other safety controls located inside the PAC unit to the control panel.

Identical numbers are used on terminals provided in the PAC unit as well as in the Control Panel. This enables connections from the control panel to the PAC unit on 1 to 1, 2 to 2, 3 to 3 bases to simplify wiring connection in the field.

The PAC unit is provided with a trap door at the bottom side to provided convenient access to the blower assembly, controls and heaters located inside the unit. This trap door opens in the corridor area under the PAC unit.

The control panel is also factory assembled and internally wired. It is self diagnostic through audio visual use of LEDs and alarms. Control panel has green LED lights to indicate `ON' position and Red lights to indicate `FAULT' conditions. Hooter is provided to sound alarm in case the heating elements get over-heated.

A manual over-ride switch is provided at the top left side of the panel for bypassing thermostat in case of failure and to manually operate the PAC unit for testing. A second switch is provided, so that 'Cooling' & 'Heating' manual modes can be selected.

Two four position Rotary switches are also provided at the inside of the panel to manually select operation of compressor No. 1 or compressor No.2 or both compressors together. It also has a provision to switch off both compressor if so required.

CHAPTER 2

SALIENT FEATURES

High savings: Light in weight, saves fuel for hauling. Weighs 1400 Kg (as compared to 2700 Kg. for conventional A.C.) saves more than Rs. 20,000/- per year per coach in diesel fuel.

Quick pay back: The unit pays for itself in less than one year. Rajdhani hauling 18 coaches weight reduction is 1.7x18=30.6 MT which equals weight of one coach. One additional coach can bring huge revenue.

Environment: Uses more environment friendly refrigerant R--22 in small quantity less than 3 Kg.

Ease in : Installation The unit is factory made, assembled & gas charged and tested for performance prior to delivery. Installation requires simply lowering the unit in the false ceiling above the toilet are on both ends of the coach and connecting it to wire harness, drain pipe and flexible duct. It takes slightly more than 6 hours to air-condition a coach.

Low down time: Replacement of the PAC unit can be done in less than four hours.

Better passenger: The PAC unit remains outside the comfort zone and therefore, there are no chances of water drip on passengers.

Hygienic Free air : Fresh air is taken from the roof which supplies cleaner, fresh, free of the toilet smell as prevalent in conventional system.

Refrigerant Leak: Hermetically sealed system has no fittings or shaft seals, thus this presents little potential of gas leaks and avoids major break downs.

Low Maintenance: The unit is almost maintenance free since it uses 3 phase AC motors - no commutators or brushes to wear out.

Rapid Heat : Mounted on the roof, thus no dust dissipation collected in condensers, therefore, requires no maintenance or water spraying on condenser coils, giving rapid and better heat

Safe Operation: No chance of damage to flash floods, cattle runs or flying ballast.

Energy Efficient: Compact and modular with short Refrigerant Efficient pipes, thus loss of capacity through longer connecting pipes is eliminated.

Capacity control : Use of 4 compressors per coach offer 25% to control 100% capacity and standby facility, saving electricity. Compressors are started through time delay relays to reduce peak current draw.

CHAPTER 3

INSTALLATION

3.1 Install PAC unit through the roof opening in the coach using a crane and spreader bar assembly (as shown in Figure 3.1) engaged to the four lifting hooks provided on the top of PAC unit. Bolt tight Rubber-in-shear mountings fixed to the coach supporting members. Connect flexible ducts through the partition wall in the coach to the supply air duct and return grills openings.

3.2 Install the control panel in the space provided and bolt it tight to the supporting frame members.

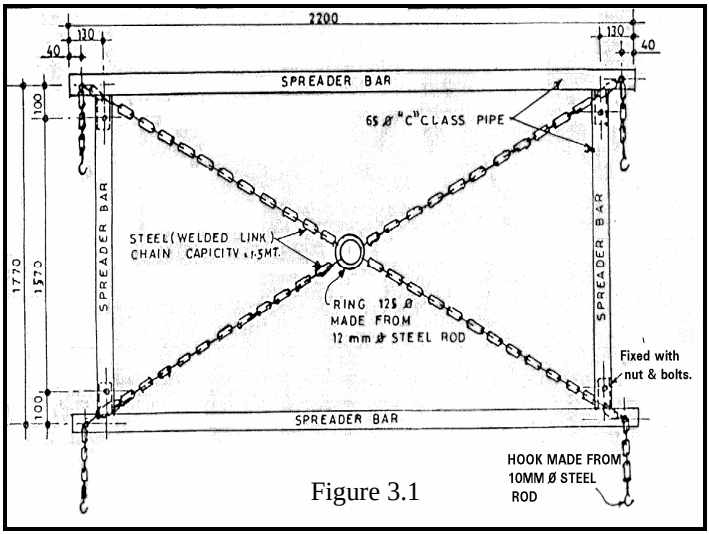

Figure 3.1

3.3 Install the top cover on PAC unit on the roof of the coach and ensure proper water proofing. Make sure that ventilation area for Condenser Air Inlets and Condenser Air Outlets are not obstructed and condenser fans can rotate freely. Also ensure that fresh air intake opening are not blocked or covered.

3.4 Ensure that the trap door and opening for the filters are not obstructed and that covers of these openings can be removed freely.

3.5 Also ensure that filters can be pulled out easily.

3.6 Connect thermostat and control panel to their respective matching terminals in the PAC unit. Connect numbered power terminals of the PAC unit to respective numbered terminals in the control panel.

3.7 Re-check and tighten all screws, terminals, fuses and all control and power connections for their correctness.

3.8 Connect the power supply (415 V AC, 3 phase, 50 Hz) to the power input terminals.

CHAPTER 4

OPERATION

4.1 START UP

4.1.1 Ensure that the power ON/OFF rotary switch RSW-1 in "off" position.

4.1.2 Place the compressor operation selector switches RSW-6 and RSW-7 to "Normal" for operation of both Compressor. (These Rotary Switches are located inside the Panel).

4.1.3 Ensure that 3 phase 415 V, 50 Hz A.C. Power supply is connected to the Control Panel and turn the power "ON" by rotating switch RSW-1, RYB lights will be lit. If `POWER ON' green light do not light up, check 110 Volts AC fuse for control supply & ensure that 110 Volts A.C. power is available. In case any phase is missing or is reversed in the incoming Power. Negative Sequence Voltage Sensing Single Phasing Prevent SPP-3 through its interlock in the control Circuit, will not permit the AC unit to start until condition of phase sequence is corrected.

4.1.4 Rotate the 4 position Rotary Switch RSW-3 from `AC OFF' to `VENT' position. At this stage Blower will start and the green light for `BLOWER' will light up.

4.1.5 Rotate 3 position Rotary Switch RSW-3 to `COOL/HEAT' position.

4.1.6. Rotate the 4 position rotary switch RSW-4 to auto position.

4.1.7 At this stage if cooling is required Green lights indicating COOLING will light up.

If `COOLING' green light is LIT, following will happen :-

- Condenser Fan-I & CONDENSER FAN-2 will turn ON & Green lights indicating CD-1 & CD-2 will light up.
- After a time-delay COMPRESSOR-I will switch ON along with green light `CP-I'.
- After another time -delay COMPRESSOR-II will switch ON alongwith Green light `CP-2'.

Note : If compressor do not run, check compressor selector switches RSW-6 & RSW-7 for proper setting. (These are located inside the control panel). These should be set at `NORMAL'.

4.1.8 If "Heating" Green Lights Lit, following will happen:

- HEATER-I and HEATER-II (3 KW each) will switch on the Green lights "HTR-I" and "HTR-II" will light up.
- The AC unit will now continue to operate automatically and will be controlled by the thermostat to control temperature as per the preset point selected (High, Medium or Low).

4.1.9 Interlocking of Air Safety Relay is provided so that in case of "Loss of Air", all functions of the AC unit are disabled.

4.1.10 The control circuit is automatic. In case of power failure, the machine will automatically restart after the power supply is restored.

4.2 IN COOLING CYCLE

If the motor of either condenser fan overloads, respective "CD-1" trips or "CD-2" trips, Red Lights will light up and both compressors will be disabled.

If COMPRESSOR-I or COMPRESSOR-II motor overloads, "CP-I" or "CP-2" Red Light will light up and respective compressor will be disabled.

If the high pressure control of COMPRESSOR-II sees abnormally high head pressure (above 400 PSI), RED light "HP-2" will light up and the respective compressor will be disabled.

If the low pressure control of COMPRESSOR-II sees abnormally low suction pressure (less than 35 PSI). "LP-I" or "LP-2" Red Lights will lightup and respective compressor will be disabled.

4.3 IN HEATING CYCLE

If surface temperature of HEATER-I or HEATER-II exceeds 200 °C "HTR-1" or "HTR-2" Red Light up and respective Heater will be disabled.

4.4 SINGLE PHASING/PHASE REVERSAL PROTECTION (SSP-3)

In case a phase is missing or reversed in the incoming power, the Negative Sequence Voltage Sensing Phasing Preventor installed in the control circuit will not allow the AC unit to start until the condition is corrected Red light L-2 on the face SPP-3 (located inside the panel) will turn on.

If single phasing occurs in the power of COMPRESSOR-I or COMPRESSOR-II the respective Negative Sequence current sensing Single Phasing Preventor SPP-1 or 2 will disable the respective compressor and Green Light indicating "CP-1 or CP-2 Healthy" on the panel front will turn off, and red light L-2 on face of SSP-1 or 2 will turn on. In case wither compressor draws excessive current, it will be disabled and Red light L-3 on SPP-1 or 2 light up. SPP-1 & 2 are located inside the panel and L-2 & L-3 are located on these controls. Reset this control after correcting fault.

Similarly Single Phasing Preventor Cum Overload Relay installed in the power circuit of the BLOWER MOTOR, CONDENSER FAN-1 MOTOR, and CONDENSER FAN-22 MOTOR will protect against single phasing or overloading by tripping.

CHAPTER 5

DESCRIPTION OF REFRIGERATION CYCLE

The refrigerant gas (R-22) is compressed by the Compressor. This compressing of gas increases its temperature higher than the outside ambient temperature due to heat of compression. This hot compressed

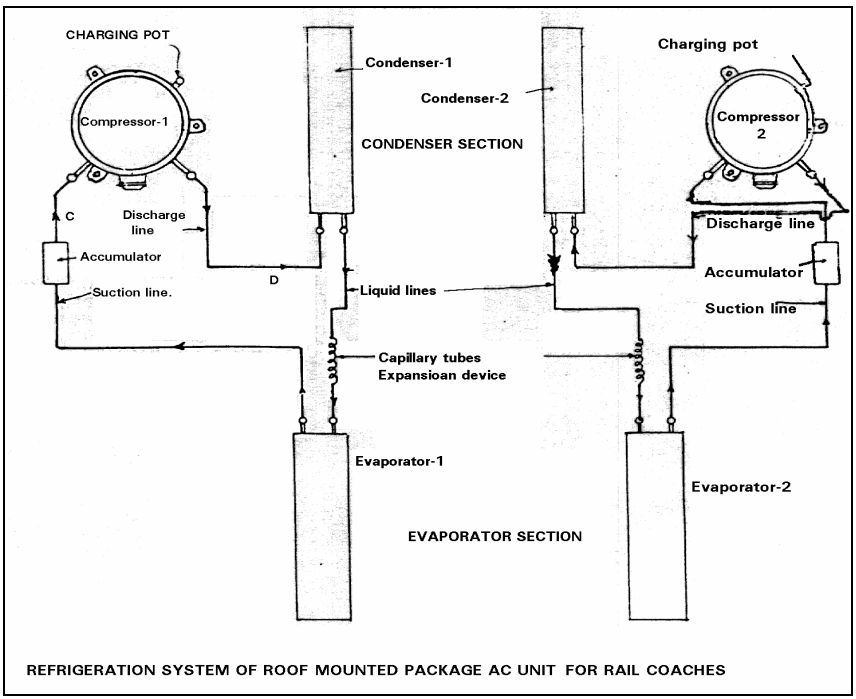

Figure 5.1

refrigerant vapour is injected inside the tubes of the Condenser Coil. Air is blown across the condenser Coil causing refrigerant to cool down and therefore, condense from vapour to liquid refrigerant inside the condenser Tubes.

The high pressure condensed liquid refrigerant now flows through a "RESTRICTOR" (Expansion device). The other end of the "RESTRICTOR" is connected the tubes of Evaporator (cooling) FIN-ON-TUBE coil.

The other end of the Evaporator coil connected to the suction port of the Compressor which sucks the refrigerant and drops the pressure inside the Evaporator coil. Drop in pressure causes evaporator of the liquid refrigerant to gas which makes the Evaporator coil extremely cold due to heat of vaporisation.

Air to be cooled or conditioned is below across the Evaporator coil. The heat from this air is absorbed the evaporating refrigerant causing the air to cool down.

The refrigerant gas sucked by the compressor is again compressed to high pressure and pushed into the condenser coil completing the refrigerant cycle.

The package air conditioning unit has two equal and independent hermetically sealed refrigerant circuit as shown in Figure 5.1.

CHAPTER 6

GENERAL MAINTENANCE

The roof mounted unit is a factory assembled, gas charged and hermetically sealed refrigerant system. The general diagram is shown in Figure 6.1.

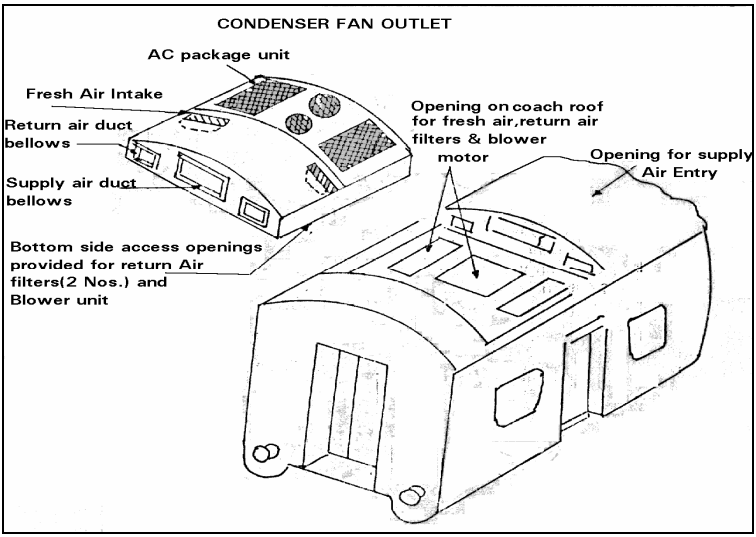

Figure 6.1

It has two hermetically sealed three phase reciprocating compressors, two vertical flow condenser fans and one blower unit as evaporator fan. Condenser fan motor (1400 rpm) are TFFC-IP55 water proof three phase.

There are two independent refrigerant circuit in each PAC unit having a compressor, condenser coil and evaporator (cooling) coil. The condenser fans and evaporator blower are common. Each circuit has its own fresh air and return air filters. Each evaporator (cooling coil) fits in its own drain pan. Each drain pan has its own drain outlet.

The condenser fans and compressors can be accessed from the top of the unit where as the return air filters can be pulled out from under the unit in side the coach in corridor. The blowers, heaters and safety controls can be accessed by opening the access door at the bottom of the unit. The fresh air filters can be reached by opening return air access doors on each side at the bottom of the unit. The terminals are located inside a junction box under the unit and can be accessed by opening the cover of this junction box or termination box.

Since the PAC unit is a modular hermetically sealed type, it requires minimum maintenance. The refrigerant system is Hermetically sealed and has fitting or gauge ports. The safety devices are provided to protect against abnormal operating refrigerant pressures, loss of air and over heating of heating elements. Over current, single phasing, voltage fluctuation. Diagnostic visual console is provided on the phase of electrical panel for indication of normal operation and fault conditions.

CHAPTER 7

ROUTINE MAINTENANCE

(Schedule of activities)

7.1 Trip Attention

- Remove dust and dirt from the panel.
- Ensure that all the safety/protection devices are in the working condition and not in the by-passed condition.
- Defective/by-passed components should be replaced.
- Clean the filters if required.
- The defects noticed during the run should be attended.

7.2 Monthly

- Remove dust and dirt and clean the panel completely with vacuum cleaner.
- Remove the fresh air and return air filters. Replace them with pre-cleaned filters.
- Run the plant for half and hour and check the current drawn by various equipment with the help of clamp tester.

Normal currents for various equipment are as under:

Package in cooling mode :	10 - 21 Amps (SIDWAL) 18 - 20 Amps. (Feeders)
Compressor motor :	7.5 to 9.0 Amps.
Condenser motor :	1- 1.5 Amp (Feeders) each 1.8- 2.3 Amp(SIDWAL) each
Blower motor :	2.0 - 2.3 Amp. Each
Heaters :	8 Amps. each.

- Operation of safety cut-outs

7.2.1 **OHP 1-2**

Switch "ON" the heaters with blower off (take out blower fuses and short the vane relay terminals) Keep the package in manual heating mode. The heaters should trip.

7.2.2 **HP1-2**

Switch "ON" the compressor with condenser fan OFF. Take out the condenser fan motor fuses. Keep the package in manual cool mode. Compressor should trip in 3 minutes. HP cut-outs should be reset after each trip.

7.2.3 **LP Cut-out (1-2)**

Switch “ON” the compressor and condenser with blower OFF. Take out the blower motor fuses and short the vane terminals (44-45). Keep the package in manual cool mode. Compressor should trip in 3 minutes.

7.2.4 **SPP**

Create single phasing in compressor circuit by taking out the one fuse. Compressor should trip and SPP RED LED should come on.

Create single phasing in blower motor and condenser motor circuit by taking out one fuse. Motor should trip and O/L indication should come.

7.2.5 **Timer**

Check the timers for their operations. Timer 1 should have delay of 2 minutes and timer 2 should have a delay of 4 minutes.

7.2.6 **Control PCB**

Keep the package in the auto mode. Run the blower. Short points 3 & 4 on PCB. The compressor should come “ON”. Open the points 5 & 6, heater should come on.

7.2.7 **Drip Tray Drains**

Pour water into drip tray and ensure free flow.

- The defects noticed during the run should also be attended.

Note : All the items of trip maintenance should also be carried out.

7.3 Annual Overhauling

The AC Package units should be overhauled completely once in a year which include all the necessary replacement of spares. Consumable, accessories to make the AC Package unit of AC coach fit to run and bring it close to new package.

Following activities should be carried out.

- Check all the motors for abnormal sound and replace the bearing of condenser and blower motor if necessary.
- Replace fresh air and return air filters with new one.
- Check the setting of LP & HP cut-outs with standard pressure gauge and adjust of necessary.
- Clean cooling and condenser coils, repair unit if required including topping up of gas.
- Insulation resistance of all the motors to be checked with megger.

- All the terminals connections at the motors terminals and terminals block should be opened, cleaned and reconnected properly.
- Replace anti-vibration mountings of compressor, condenser and blower motors.
- Top up gas if necessary.

Note : All the activities carried out in monthly attention should be carried out.

CHAPTER 8

POH SCHEDULES

8.1 SEQUENCE OF WORKS TO BE TACKLED DURING POH

8.1.1 Pre-Inspection

On arrival to shop, place the coach on the pit line and inspect the electrical and air-conditioning equipment. Conduct the cooling test as per annexure A. If the cooling time is less than the specified values, any further attention to refrigeration circuit is not necessary, except cleaning. Check operation of all protections and note down the defects and deficiencies. In case connection from alternator terminals and remove belt tensioning device.

8.1.2 Lifting

Lift the roof mounted unit with the help of one Ton lifting arrangement as per procedure given below and place it on the wheeled trolley to take to the shop for overhauling.

8.1.3 **Precautions/Procedure for removal of AC Package**

- Remove panelling/industrial lock to access the Evaporator unit from bottom in the doorway ceiling.
- Disconnect the condensate drain pipe connection.
- Disconnect all electrical connections to package unit.
- Dismantle the first piece of main duct. Disconnect the supply duct and return air duct bellows.
- Remove top cover provided above the package unit. Remove rubber packing also, provided to prevent water leakage.
- Unscrew the 8 nos. Of mounting bolts of AC package unit.
- Do not use fork lift.
- Lift the package unit carefully using suitable crane of 1 Ton capacity. Arrangement as per RCF drawing No. XZ003801 for lifting Rig may be used.
- Do not drop the package unit on the ground while handling.

8.1.4 **Striping**

During this activity, the following air-conditioning and electrical equipment will be removed :

- Fresh and return air filters
- Water raising apparatus
- Battery and battery box
- Battery charger
- A/C control panel and power panel
- Invertor units
- Carriage fans

8.1.5 **Dusting**

With the help of compressed air, remove the dust of the conditioned air duct.

8.1.6 **Cleaning and Overhauling**

8.1.6.1 **Cleaning**

Before overhauling, measure the insulation resistance of all the electrical equipment such as alternator, motor and wiring to know the condition of equipment. Check and clean all the under frame suspension arrangements, lugs and terminals. After POH, test the wiring for insulation and fit the pre-cooling plugs.

8.1.6.2 **Equipping**

In this activity fit all the refrigeration and electrical equipment to its respective positions. Connect all the wiring and flanges in the refrigeration system wherever necessary.

8.1.7 **Special Items**

8.1.7.1 **Check for corrosion in trough**

It is necessary to check steel trough which is provided below AC package unit during every POH of AC coach. If any corrosion is observed, then it should be patched up with 2 mm thick sheet of stainless steel.

8.1.7.2 **Check for Corrosion of Welded Joints of AC Package unit Structure**

The welded joints of AC package unit structure should be examined carefully for presence of corrosion and such corroded members shall be replaced/rectified.

8.1.7.3 **Check for Accumulation of Water of Condensate Drain Pipe and trough Outlet**

Clear the condensate drain pipe and trough outlet pipe with the help of compressed air. It is also desirable to blow compressed air into the pipes from below, every two months to avoid any choking of pipes due to accumulation of dust etc.

8.1.7.4 **Detoriation of Rubber lining**

If there is any Detoriation or cracks in rubber lining provided on AC package unit, it should be replaced.

8.1.8 **Procedure for Lowering the AC Package Unit**

8.1.8.1 Before lowering package unit, check opining and stainless steel through for corrosion. Jig to drawing No. XD000201 may be used for ensuring the squareness of the opening.

8.1.8.2 Package unit is mounted on strengthening frame with the help of 8 nos. of mounting pads. (Resistoflex- STB-0069 Type-70). Mounting pad should preferably be replaced.

8.1.8.3 While lowering unit, care should be taken that it does not touch/interface the coach at any place. The unit should sit properly on mounting pads.

8.1.8.4 Lower the AC unit on the coach and secure it with 8 nos. of bolts as per drg. No. CC44162.

8.1.8.5 Provide rubber sheet seal on the strengthening frame as shown in the drg No. CC44162.

8.1.8.6 Connect transition duct and return air duct bellows with the unit with D-panel.

8.1.8.7 Make electrical connections as per circuit diagram issued for a particular type of coach and package unit.

8.1.8.8 Connect condensate drain pipe of package unit with piping arrangement provided in lavatory areas. Ensure the gradient of drain pipe to avoid filling of condensate tray.

8.1.8.9 Place roof top cover above the unit, after the unit is scaled by means of Rubber sheet in evaporator areas.

8.1.8.10 Test the unit for water leakage. If any leakage are observed, remove the top cover and plug the leakage, suitable sizes of rubber sheet may be used.

8.1.9 **Static Testing**

Run the plant through pre-cooling terminals and check for proper functioning of electrical and air-conditioning equipment, including all the protections.

8.1.10 **Simulating Test**

For self generating type of coaches, check the alternator and invertor output on different load conditions. Check both the alternators for load sharing.

8.1.11 **Final Inspection**

The coach shall be jointly inspected with division staff and the performance of electrical and refrigeration equipment shall be recorded as per proforma at annexure B. A list of equipment changed with their S.No. will also be handed over alongwith the coach. Any attention, if required to the equipment shall be given before despatch of the coach from workshop to division.

8.2 **OVERHAULING ACTIVITIES OF MAJOR GENERATING AND AC EQUIPMENT**

8.2.1 **Axle Pulley**

Check the axle pulley for slipperage, tightness and physical damage to grooves. Ensure availability of locking nuts and split pins in position. Check the alignment of axle pulley with alternator pulley and adjust, if required. Change the rubber packing.

8.2.1.1 Replace the pulley if any groove is damaged/broken.

8.2.2 **Belts**

Replace the whole set of belts by new 6+6 matched set of belts.

8.2.3 **Brushless Alternator**

8.2.3.1 The machine received for overhauling should be externally cleaned with wire brush and wiped before dismantling.

8.2.3.2 Carry out visual inspection of the machine and record the following :

- Serial number and name particulars of the machine.
- Check if the rotor rotates freely.
- Replace the suspension bushes.
- Check insulation resistance.
- Check continuity of the field and stator.
- Check alternator tension rod.
- Check the bearing noise shock pulse meter.

8.2.3.3 Carry out the following electrical checks and record the following :

- Open the cover of the terminal box and check whether the internal termination and terminal board are intact
- Tighten all the connections on the terminal board.
- Using a 500 V megger, check continuity between

- Field terminal F+ and F-
- Stator terminals U to V., V to W and W to U

- Check the insulation resistance between

  - Stator terminal and frame of machine
  - Field terminals and frame
  - Field terminals and stator terminals.

(**Note** : Minimum insulation resistance should not be less than 1.0 mega-ohms under worst weather conditions)

8.2.3.4 **Overhauling**

- Clean and regrease the bearing after removing the bearing from the bearing housing. Multipurpose grease No. 2 should be used.

- Clean the mating surface of the end shield. Before assembly, the surface should be coated evenly with gasket shellac.

- While removing and placing the rotor, care should be taken to see that the rotor does not rub over the field coils.

- If any grease has crept into the stator surface, clean it before assembly.

- If stator and rotor parts are found rusty clean and slightly coat with Dr. Beck make Elmo 65E/R insulating varnish or with Meggarlac.

- Apply the insulating varnish (air drying) of recommended grade. Impregnation of the varnish shall be done in an air circulating oven.

- Change the alternator suspension nylon bushes 100% and change the suspension pin on condition basis.

8.2.3.5 **Testing**

After complete assembly, the testing of the alternator should be conducted at the test bed. A variable speed dyno drive motors shall be provided for running the alternators. The alternator shall be tested on load at different speeds. The following points shall be checked during the test.

- Proper functioning of the regulator.
- Proper generation at cut in speed
- Full generation (MFO speed)

8.2.4 **RECTIFIER REGULATOR UNIT**

8.2.4.1 Check the terminals and blow out the dust.

8.2.4.2 The wiring of the regulator shall be done systematically. Replace the damaged wiring/ terminals.

8.2.4.3 Check the PCB circuit with PCB testing kit or multimeter to sort out defective components. Replace the defective components.

8.2.4.4 Apply silicon grease at contact point of rectifier with the heat sink.

8.2.4.5 Check field transformer correct voltage. Replace, if found defective.

8.2.5 BATTERY AND BATTERY BOX

8.2.5.1 Remove the cells from the battery boxes on arrival of the coach in workshop and bring them in the battery shops for maintenance.

8.2.5.2 Record voltage and specific gravity of each cell.

8.2.5.3 Clean interior of the cell thoroughly. Wash top of the battery with a 10% solution of soda and a wire brush. During such cleaning operation, it is necessary to ensure that the vent plugs are mounted on the cells so that the water does not enter into cell.

8.2.5.4 Battery boxes shall be cleaned/repaired and re-painted with anti corrosive epoxy based paint after removing the battery.

8.2.5.5 Top-up cells where even necessary with distilled water. The level should be corrected such as indicated by the float.

8.2.5.6 If there is corrosion/sulphation on the inter-cell-connectors etc, clean them thoroughly and protect from further corrosion by applying petroleum jelly or Vaseline. Cell

connectors and fasteners should be changed on condition basis.

8.2.5.7 Replace defective floats and vent plugs, if any.

8.2.5.8 Clean vent plugs and floats guides and ensure that vent holes are in order.

8.2.5.9 Record lug date to determine the life of the battery.

8.2.5.10 Charge the battery fully till 3 constant half hourly readings of voltage and specific gravity indicating the conditions of fully charged cell are recorded.

8.2.5.11 Discharge the battery at 10 hrs. Discharge rate. While discharging, record the voltage and specific gravity.

8.2.5.12 Record the capacity of the battery during discharge. It should not be less than 80% of the rated capacity.

8.2.5.13 In case while discharging, any of the cells fall below 1.8 volts, disconnect the cell from the circuit for treatment with one or two cycles of slow charge and discharge as per maintenance manual.

8.2.5.14 After two cycles of charge and discharge, recharge the cells fully.

8.2.6 **Compressor**

8.2.6.1 There is no need to open the refrigeration system of the AC package units it is complete sealed at factory. Conduct the cooling test as per Annexure A. If the time required to cool the coach is less than the recommended value of condenser and evaporator, the compressor will have to be changed.

8.2.6.2 **Procedure for replacement of Compressor**

- Braze a 1/4" (6 mm) OD copper tube fitted with shut off valve at one of the ends. Connect the shut off valve through a charging line to an empty refrigerant cylinder and keep in a cold iced water container until all gas is extracted. Weight the cylinder before and after. Ensure that weight gain is minimum 2600 grams. A gas compressor can also be used to extract the gas and forcing it into the empty cylinder.

- Unsolder the suction and discharge lines and disconnect the electrical wiring from the compressor.

- Remove the compressor and clean the cylinder using carbon tetrachloride (CTC) with the help of circulating pump. It is advised that CTC flushing should not be done with compressor in circuit.

- Install a new compressor, and resolder the suction and discharge lines. Make the electrical connections. Use high quality silver based copper solder with minimum 40% silver.

- Test for leakage under 30 kg.cm^2 pressure using Nitrogen/Carbon dioxide gas cylinder fitted with a two stage pressure regulator.
- Create a vacuum of 50 micron for 15 minutes with the help of two stage rotary vacuum pump to extract the moisture from inside of the refrigeration system.
- Charge the quantity of refrigerant gas (R 22) as per recommendation of the manufacturer. Charging slub-tube on the compressor should be 1/4" OD and of heavy gauge. Pinch off charging tube nearest to the compressor body so that it remains as short as possible. Longer stub tube can break due to vibrations. Place slight amount of solder at the pinch point for strengthening.

8.2.7 **Condenser**

8.2.7.1 Clean the condenser coil with steam of 10 kg/cm^2 pressure to remove all dirt and mud. The coil should be cleaned thoroughly. This can be done without removing the coil from their places.

8.2.8 **Evaporator**

8.2.8.1 Clean cooling coil with steam at 10 kg/cm^2 pressure to remove all dirt and mud. The coil should be cleaned thoroughly through and through. This can be done without removing the coil from their places.

8.2.9 **Motor for Condenser and Evaporator**

8.2.9.1 Check for abnormal noise vibrations, burning smell.

8.2.9.2 Check foundation bolts for looseness and tighten, if necessary.

8.2.9.3 Check the terminals after opening terminal box cover and see for tightness.

8.2.9.4 Check the condition of terminal lugs.

8.2.9.5 Check the earth connection of the motor body.

8.2.9.6 Clean the motor by blowing compressed air.

8.2.9.7 Lubricate the motor bearing by approved lubricant. Use lubricating gun for greasing.

8.2.9.8 Check the alignment and re-align the driving and driven shaft.

8.2.9.9 Check the coupling for looseness and tighten if necessary.

8.2.9.10 Check the dust for crack and for loose/missing fixing bolts.

8.2.9.11 Measure the insulation resistance of winding with a 500 V megger. If the insulation resistance is less than 10 M ohms run the motor for half an hour for drying. If insulation level does not improve revarnish the armature.

8.2.9.12 To avoid brinelling, the armature must be rotated periodically by quarter to half of the revolution.

8.2.9.13 It has been observed that bearing greasing deteriorate when in the use and ceases to be effective as a lubricant with the lapse of time. The deterioration might show in the form of dry cakes/flakes in sodium base grease whilst in the lithium base grease starts thinning and its oil contact separates out of the rest of the grease.

8.2.10 **A/C Control and Power Panel**

8.2.10.1 Completely isolate the panel from power supply and its loads. Contacts of the contactors shall be removed and cleaned by means of clear rag socked in petrol. Any contacts which are burnt should be replaced, after which they should be lightly covered with Vaseline.

8.2.10.2 Similarly, dismantle the contacts of the relays and clean them by means of clean rag soaked in petrol. Any contacts which are burnt should be replaced.

8.2.10.3 Check the flexible braided connections. If found damaged, replace the same.

8.2.10.4 The pin holding the pull off spring on the armature frame-work of the contactor should be pulled out of its slot and the armature hinge in removed. This should be examined for wear and if necessary, replace by a new pin tightly covered with Vaseline.

8.2.10.5 Measure the insulation resistance of each relay and contactor. If the insulation value is less than 2 meg. Ohms, replace the coil of the respective unit.

8.2.10.6 Check whether all connections are tight. If found loose, tighten the same.

8.2.10.7 Replace all the fuse links.

8.2.10.8 Check rotary switch for proper working.

8.2.10.9 Check clean and tighten all connections.

8.2.10.10 Check for defective ammeters and voltmeters, if necessary, replace the defective one.

8.2.11 **Cut Outs**

8.2.11.1 Clean the contacts with CTC/Petrol and test for correct operation of settings. Calibrate with the standard gauges. Also test in series.

8.2.12 **Precooling Transformer Rectifier Unit**

8.2.12.1 Open the canopy and clean externally with compressed air.

8.2.12.2 Dismantle the unit as per manufacturer's instructions.

8.2.12.3 Remove and clean the contacts by means of a clean rag soaked in petrol. Any contacts which are burnt should be replaced and covered with Vaseline.

8.2.12.4 Clean the transformer, rectifier and rotary switch. Check for operation, if defective, change it.

8.2.13 **Invertor Unit**

8.2.13.1 Open the front panel doors and clean with compressed dry air. In case the compressed air pressure is too high cover the nozzle with thin cloth to reduce the pressure.

8.2.13.2 Clean the semi-conductor devices heat sink with compressed air. In case the dust is not removed completely from fins use hard hair brush and again clean with compressed air. Do not use any chemical for cleaning the heat sink.

8.2.13.3 Check that all connectors PCB are tight and no insulation is damaged on cables, boards and insulators etc.

8.2.13.4 Check for normal routine performance test as per manufacturer's instructions.

8.2.14 **Fans, Light etc.**

8.2.14.1 Dismantle the lower guard, upper guard, blade and fan motor.

8.2.14.2 Check the guard assembly, repair/replace if necessary.

8.2.14.3 Check the blade angle with a measuring gauge. Correct the same, if necessary.

8.2.14.4 Check the insulation resistance of the fan motor. The IR value should not be less than 2 meg. ohms as specified in IS: 6680-1992.

8.2.14.5 Check the fan leads and change it if necessary.

8.2.14.6 Check the armature winding and field coils, repair/replace, if necessary.

8.2.14.7 Check the commutator for grooving, pitting marks, ovality, blackish etc. Skim or polish the commutator as required.

8.2.14.8 Check the carbon brush and carbon spring. Replace by correct grade of carbon brush as recommended by RDSO. The fan spring should meet the requirements given in IS: 6680. Replace the same if necessary.

8.2.14.9 Apply air drying insulating varnish if IR value of the armature and field coils is low, give impregnation treatment in an air circulating oven.

8.2.14.10 Clean the ball bearing, check for noise, replace if necessary or grease it with recommended grade.

8.2.15.11 **Testing**

- Check the load current at rated voltage. The wattage of the fan should not exceed the value specified in IS: 6680.
- Check the air delivery of one or two fans from a batch to ascertain the correctness of the blade angle. The value of the air delivery shall not be less than that specified in IS: 6680.

8.2.16 **Wiring**

8.2.16.1 **Light Fittings**

The light, fittings, reflectors, clear arcalic sheet cover, glass globe, holders etc. Shall be checked and cleaned. Any defective part shall be replaced. Anti theft arrangement for fluorescent light fittings shall be checked as per ICF Drg. No. TCF/SK-7-6-079.

8.2.16.2 **Coach Insulation**

Insulation resistance of the coach shall be measured with 500 V megger. IR value will be minimum 2 meg. Ohms but it should not be less than 1 meg. Ohm under highly humid/wet weather.

8.2.16.3 **Cable Termination Joints**

- All cable joints shall be checked. Loose joints and cables having damaged insulation shall be replaced/repaired. All cables ends shall be properly socketed with crimping type copper sockets.

- Surface of copper sockets and busbars shall be cleaned to remove the oxide film from the jointing surface before making a bolted joint and shall be coated with corrosion resistant conducting grease of approved make to prevent reformation of oxide film.

8.2.16.4 Fire retardant PVC grommets to BS:1767 or grade 6 of IS: 5831 shall be provided at all cable entry points in metallic members.

8.2.16.5 The underframe wiring if running loose shall be provided in rigid steel conduit.

8.2.16.6 All inspection covers shall be opened to check the distribution boards and condition of wiring.

8.2.17 **Air-Filter**

8.2.17.1 Replace the filter with new one in case of synthetic type filters.

8.2.17.2 In case of wire mess type filters, wash the filter in hot water first, then with detergent and ageing with hot and cold water. Dry the filter and replace them in the unit.

8.2.17.3 The manufacturer's instructions for any other specified type filter, shall be followed.

8.3 FINAL TESTING OF AC COACH AFTER POH

- Visual inspection of coach for proper fitment of equipment.
- Ensure that refrigerant pipes are properly clamped.
- Suction pipe for proper lagging.

- Check safety chain and tension rod of BL alternators for proper fitness.
- Underframe cables leading to alternator are properly cleated.
- Check earth leakage by two lamp method.
- Check central panel and ensure that proper MCB fuses are provided.
- Check contactors, relay and switches for correct sequential operation.
- Check heaters for correct operation.
- Check hooter for proper operation.
- Start the plant and check condenser motor, compressors, blower motor for any abnormality.
- Check leakage air from doors.
- Ensure that batteries are in fully charged condition.
- Run the plants with dynodrive motors for 8 hrs. At different speed.
- Ensure that both the alternators are sharing load equally during run. If not set both the alternator panels.

CHAPTER 9

SYSTEM DEHYDRATION

It is well established that moisture in a refrigerant system in detrimental to the efficient running of the equipment. Moisture(water) reacts with the chlorine and fluorine ion in the fluorocarbons, hydrolysing them to form highly reactive hydrochloric and hydrofluoric acid. These acids react with the metallic components leading to corrosion, this because more pronounced at higher temperatures. The chemicals so formed form sludge which in turn can cause a restriction of the pipelines, or block the expansion device or the filter/drier. It can cause reduced lubrication in the compressor moving parts resulting in excessive wear of the compressor.

Water droplets mix with the oil forming an amalgam which reduces the lubrication properties of the oil thus increasing the compressor wear. The water droplets also are responsible for "freeze-up" condition in which case the water freezes at the capillary stopping the flow of the refrigerant for the time till the ice melts after which the cooling is resumed.

To minimise the chances of water entering the system the following care should be taken :

- All unassembled components such as coils, filter dryers, accumulators, compressors and connecting pipes should be kept with their opening sealed and if possible charged with dry nitrogen at about 1-2 kg/cm^2 gauge of the oil surface.

- Oils absorb moisture from the air and hence should be stored in closed containers with only a minimum air space on top of the oil surface.

  It is usual to remove the moisture from the system by any of these methods or their appropriate combination depending upon the time and equipment available and the degree of vacuum desired.

  1. By blowing dry air/nitrogen through the system.
  2. By pulling vacuum through the system.
  3. By heating the system to high temperature while pulling the vacuum.

The most effective way to dehydrate a system is to heat system and pull a vacuum. The system is made to stand at this vacuum for about 4 hours. If the pressure does not increase it is a sure indication that the residual moisture is within control and there is no leakage in the system.

The effect of pressure on the boiling point of air can easily be seen from the steam tables. Water boils at 100 Degree Celsius at the atmospheric pressure (760 mm of mercury or 760,000 microns approx.) but at 12.7 mm of mercury it boils at about 15 degree Celsius. The amount of water to be removed remains the same but the process becomes faster if system is heated during evacuation. One has to decide on the suitability of the process depending on the equipment available.

CHAPTER 10

GAS CHARGING IN REFRIGERATION SYSTEM IN THE FIELD

10.1 Charging of gas in a refrigeration system should only be done, by trained technician under guidance of qualified supervisor.

10.2. **EQUIPMENT**

Following items should be collected and kept handy before starting the charging procedure.

- R-22 Gas cylinder with 2.85 kg gas.
- 5 Kg capacity vacuum pump (Vane rotary type).
- Vacuum gauge - Electronic or tube type.
- Pressure gauge both for suction (-30 to 300 psig) as well as head pressure (0 to 500 psig) side of the system.
- Weighing scale.
- Watch.
- Pinching pliers.
- Brazing Equipment.
- Nitrogen Cylinder
- Arrangement for heating (Blow lamp)
- Halogen leak detector.
- Soap solution.
- Charging line.
- Tong tester

- Screw wrench 12", 8"
- Screw driver
- Spanner 12/13, 10/11
- D.E. spanner 22/24, 32/36,

10.3 **Procedure**

10.3.1 **Recovery of the Refrigerant** : Connect the system (or use recovery system condensing unit) with an empty gas cylinder and heat the system mildly. Keeping the empty cylinder cooled. The gas will flow towards the cylinder.

Keep the cylinder on a weighing scale and watch its weight rising. When the weight is constant for 5 minutes, no more gas will flow.

NOTE :

a) While heating the system keep a wet cloth around the vibration isolators to avoid over heating and damage to the isolators.

b) If the gas is contaminated as is clear from blakish colour and foul smell, do not refuse the gas as it is. In that case remove capillary and filter-drier assembly and clean the condenser and evaporator coils and connecting pipes by circulating Carbon-tetra-chloride until clear fluid starts coming out, at the other end.

10.3.2 **Reassembly** : Install new capillary and filter- drier if required and reassemble the system.

10.3.3 **Leak Test** : Disconnect the low pressure cut-out and pressure-charge the system with dry nitrogen at 24 kg/cm^2 (350 psig) and check for leakage with soap solution.

10.3.4 **Evacuation** : After leak test, connect the system on both the low & high side to a vacuum pump for at least 4 hours and pull upto 200 microns (29.9 inch Mercury Column) of vacuum. Use electronic or tube type gauge, for checking vacuum.

10.3.5 **Charging** : Now charge the system with 2.85 kg R-22 gas. This can be done by pulling a vacuum on a 5 kg gas cylinder and charging it with 2.85 kg R-22 gas by weight. (Weight the cylinder before and after filling gas. The difference should be 2.85 kg in weight). Check with halogen leak detector after charging the system.

10.4 Test Run

After the system has been charged, test run the unit and check head pressure, suction pressure and the current consumption. Check the noise levels and the cooling capacity before reinstalling the unit at its location. Should there be any problem then see the trouble shooting manual for a solution.

10.5 Sealing

Seal shut the system by pinching off the charging line and brazing it. Keep the stub of the charging line shortest possible

in length and reinforce it with thick PVC tubing to avoid breakage due to vibrations.

Note :1. Do not use the unit compressor for vacuuming the unit.

2. Do not use refrigeration compressor for pulling a vacuum.

CHAPTER 11

CHANGING COMPRESSOR

Due to extreme care taken during manufacture and an extremely well balanced design of the refrigeration equipment the compressors do not cause trouble but still in rare cases when compressors do fail, the following precautions have to be observed while replacing them.

- Disconnect all electrical power and connections.
- Recover the refrigerant by any appropriate method from the system. The refrigerant from the burnt (cooked) compressor can not be reused. This can be checked from foul smell present.
- Disconnect suction and discharge lines from compressor and remove the mounting bolts and lift the compressor out and seal all openings.
- In case of burn out (burning at high temperature) clean the system by circulating trichloroethylene etc. And high pressure nitrogen until all blackness and foul smell disappears. During cleaning, capillary tubes & filter drier should be removed and discarded.
- If the compressor is not burnt, flush the system with dry nitrogen.

- Install new capillary and filter/drier if required and assemble the system.

- Disconnect the Low Pressure cut out control and charge the system with dry nitrogen at 20 Kg/cm^2 (300 Psig) gauge pressure and check for leakage with soap solution or alternately use a mixture of nitrogen and refrigerant for charging the system and use halide or halogen leak detector. This should be done after disconnecting the lower pressure cut out switch to avoid damage.

- Pull a vacuum of 200 microns and keep the system standing for at least 4 hours. If there is no change in the reading of vacuum gauge than this will indicate the removal of all moisture and no leakage.

- Now charge the system with 2.85 Kg. R-22. This can be done by pulling a vacuum on a 5 Kg gas cylinder and charging it with 2.85 Kg R-22 gas by weight. (Weigh the empty cylinder and then weigh it after filling gas. The differences should be 2.85 kg in weight).

  After the system has been charged, test run the unit and check the machine for the head pressures, suction pressure and the current consumption. Check the noise levels and the cooling capacity before reinstalling the unit at its location. Should there by any problem then see the trouble shooting chart for a solution.

- Seal the system by pinching off the charging line and brazing it. Keep the stub of the charging line shortest possible in

length and reinforce it with thick PVC tubing to avoid breakage due to vibration.

CHAPTER 12

PERFORMANCE OF ROOF MOUNTED AC PACKAGE UNITS

Major problems/short comings experienced by railways with roof mounted AC package units are,

- Gas leakage.
- Water ingress into corridor.
- Tripping of package through safety cut-outs.
- Failure of AC control panel.

12.1 Gas leakage

This problem was more acute in packages of one particular make. analysis of problem indicated that this was due to,

- Packages were not subjected to the vibration test.
- Inadequate securing of refrigerant piping.
- Non-securing of compressor top resulting into excessive vibration in discharge pipe.
- Defective vibration eliminator (particular lot).
- Other manufacturing shortcoming like longer length of charging line, unsatisfactory brazing etc.

The concern firm in consultation with RDSO have carried out following modifications :

- Securing refrigerant piping properly specially at the places where vibration levels were found to be on higher side by IIT, Delhi.
- Securing the compressor at the top and using solid mounting pads.
- To replace packless vibration eliminators with U loop.
- To improve the general workmanship and conducting test more rigidly.

Packages with these modifications have been successfully tested for vibrations. The other make has also been tested for vibration.

12.2 Water ingress into corridor

12.2.1 This problem can be classified into two categories.

I. Problems related to rain water.
II. Problem related to condensate water.

I. Major factors contributing to first problem were :

a) Inadequate/ineffective drainage area.
b) Interfacing between trough and package not water tight.

c) Package not of standard design and not water tight.

a) Inadequate/ineffective drainage area : It is considered to be the major culprit. it is felt that if it is corrected, there will be considerable improvement. Drainage area has been increased to about three times of the earlier and also made effective by taking it vertically downward from the bottom of the trough.

b) Interfacing between trough and package not water tight : In earlier design, packing provided between package and trough was getting dislodged due to sustained vibrations. Now the arrangement has been modified to have single gasket under point pressure mounting with skirting all around the opening.

c) Package not to standard design and not water tight: Water was found to be entering into the corridor through evaporator area and other structural members of the package due to non standard design and evaporator section not being water tight. This stands corrected now.

II. Problem related to condensate water

This problem can be further divided into two categories :

a. Condensate water dropping into corridor.
b. Condensate water carried over by blower and thrown into duct.

Problem `a; has been observed in both packages while problem `b' is confined to only one make of package units.

Cause of the problem as identified are :

- Condensate water collected into drip tray not getting drained off effectively due to non provision/removal of air trap (U-trap) at the outlet of condensate drain or due to improper slop of the external drainage connections. This stands corrected now.
- Defective drip tray design in respect of inadequate depth and covering at the top.
- Clogging of filters - This needs to be looked into Railways.

In the latest packages condensate drain has been taken towards condensate area and provision of U-trap is in the scope of package manufacturer. This expected to eliminate the problem due to negative pressure of blower over drip tray getting partly neutralised by condenser and also the intact provision of U-trap. Design of drip tray has also been modified to provide maximum possible depth. It is felt that if the filters are periodically cleaned problem will not be experienced.

12.2.2 For the existing coaches modifications have been evolved and demonstrated on three ACCN, with full trough. Modification in respect of coaches with half trough are under validation. Modification require two inputs.

a. Modification in trough

b Modification of old packages to make them conforming to design.

While input `a' is to be arranged by Railway on their own, for input `b' RCF has entered into contracts with package manufacturers for which even the cost will be born by RCF.

It has been jointly decided by RDSO & RCF to try out flat roof mounting arrangement of AC package on few coaches for which drawings are to be given by RDSO.

12.3 Tripping of packages through safety cut-outs

This problem was experienced during the peak of summer. To overcome the problem, RDSO's relevant specification has been revised specifying the satisfactory functioning of the package at an ambient of 57°C.

12.4 Failure of AC control unit

Initially AC control panels supplied by different manufacturers were of different designs and lay-outs which were causing lot of problems. Subsequently, RCF standardised the lay-out and design of control panel to have 100% interchangeability among different makes. The procurement of panels was off loaded to industry as package manufacturer did not respond promptly enough and also due to price implications. However, in these panels, problem of co-ordination and poor quality of particular make of switchgear items were reported by Railways. Railways have been advised to replace this particular make of items by Siemens make which can be made available by RCF.

Accordingly a decision has been taken to procure the control panel from package manufacturers alongwith AC packages. Earlier, there were two types of control panels one with 110 V AC control supply and other with 110 V DC supply. Specification of control panel has been revised by RDSO. Now there will be only one type of control panel (with 110 V AC control supply) for both SG and EOG type coaches.

CHAPTER 13

TROUBLE SHOOTING

NOTE : WATCH OUT FOR OVERHEAD HIGH TENSION WIRES		
FAULT	**INDICA-TION**	**EXAMINE/TROUBLE SHOOT AS UNDER**
Water leakage inside coach	-	- Check & ensure return air filters and cooling coils are clean. -Check and ensure that drain pipe connecting the condensation drain pan is not clogged. - Check and ensure that there is a `P' or `U' trap minimum 60 mm in height installed at the condensate drain outlet pipe. -Check & ensure that the trough in which AC Unit is installed is not full of water and that it's drain outlets are not obstructed. The can be done by climbing up on the roof of the coach and looking in the trough.
Blower tripped	(a)Red-light of Overload `ON'	-Check all fuses/MCB's & ensure supply voltage 415 V AC, 3 phase, 50 Hz to the blower motor. -Check supply at the incoming terminals of contactor.

FAULT	INDICA-TION	EXAMINE/TROUBLE SHOOT AS UNDER
		-Check wiring between panel & AC & ensure that blower motor connections are made to its corresponding starter/contactor. -Examine incoming Wires No. 322,323,324 to contactor outgoing wire Nos. 301,302 & 303 and to T1,T2,T3 terminals of Blower Motor be checked. -Check overload relay setting. It should be 3.3 Amps to trip. -Rotate Blower by hand to check for any jammed bearing or loose blower wheel on the motor shaft. -Restart after rectification & check normal current of motor to ensure it is less than 2.6 Amps at 415 V AC.
	(B)Red-light `ON' for 'AIR LOSS'	(Loss of Air across the Evaporator Coil/Heating Element). -Check and see that the return air filters are clean. -Check and see that the cooling coils are clean. -Check all fuses/MCB's & ensure 415 V AC, 3 Phase, 50 Hz supply is available to evaporator motor circuit.
FAULT	**INDICA-TION**	**EXAMINE/TROUBLE SHOOT AS UNDER**
	`	-Check voltage across Blower motor

		terminals on all 3 phase & ensure voltage is within 5% of 415 Volts. -Check direction of rotation of blower motor. -If blower is running, check control wiring & `Air Loss relay' switch for proper operation & connections. -Check & ensure that contactor coils are clean and magnetising. -Check and ensure that air filters are clean. -Check & ensure that return & supply air openings are not obstructed or blocked. -Check & ensure that Blower wheels are tight on the motor shaft. -Restart after rectification. If blower is running properly in the forward direction & still loss of Air indication is present, replace Air Loss Relay Switch & check Elect. Wiring & circuits. -Check availability of 110 Volts supply. -Check 110 Volts feed upper interlock of SPP-3 after the F-11. -With RSW3 at `VENT POSITION', 110 V supply should be available on normally closed interlock O/L1.

FAULT	INDICA-TION	EXAMINE/TROUBLE SHOOT AS UNDER
CD FAN Motor No. I & II nor working	CD 1 or 2 Red-light `ON'	-Check voltage across the condenser fan motor terminals on all the 3 phases & ensure voltage is within 5% from 415 Volts A.C. -Check wiring between panel & AC unit to ensure that motor connections are made correctly. -Check overload setting. It should be 2.2 Amps. -Rotate condenser Fans by hand & check for Jammed bearing, loose or broken fan blades. -Examine control circuit for 110 Volts supply. -Check 110 Volts supply available at C2 & C3 terminals, if not, see connecting wires from terminals 41 & 100. In case is O.K., examine O/L2 & O/L3 interlock bridging 40 with 41 and 40 with 43. Examine upper interlocks of C6 & C7 passing 110 Volts supply from terminal 23 to 36 & 36 to 40. -Restart after rectification and check current of Condenser Fan Motor to see it is less than 2.2 Amps. at 415 Volts AC, 3 phase.

FAULT	INDICA-	EXAMINE/TROUBLE SHOOT AS UNDER

	TION	
CP-1 or CP-II not working	CP-1 or CP-II Red-light tripped on over load.	-Check all respective fuses presence CP-II of 415 Volts AC, 3 Phase supply to Compressor motor -Check & tighten all power load connections at terminals 10,11,12 & 13,14,15, Power Circuit Terminal 310,311,312 - 3331,332,333 - 3352,353,354 & 358,335,336 - 355,356,357 & 358,359,360 for CP-II. - Check overload relay setting. It should be 10 Amps. -Check the SPP-1 & 2 ensure that "Healthy" Green light is ON for both SPP's and O/L reset if required. -Check TDR-1 & 2 for proper rectification and check current of Compressor Motor, it should be less than 10 Amps. at 415 Volts.
HP-I & HP-II High causing CPs to Trip	HP-I or HP-II Red-light `ON'	-This control is set to trip at 400 PSI Head Pressure. **This control causes tripping due to lack of air flow across the condenser coil due to faulty fan, clogged Condenser Coil or faulty Control wiring..** -Check all fuses of condenser motor 1 & 2 circuit & ensure 3 phase 415 volts AC supply. -Check if both fans are running and blowing air upwards.
FAULT	**INDICA-TION**	**EXAMINE/TROUBLE SHOOT AS UNDER**
		-Check Condenser Fan rotation and

		ensure the fans are rotating in forward direction. Reverse phase if necessary. -Check if inlet and outlet air openings are clear for the Condenser coil. -Condenser coil should be clear and not clogged by dust and dirt. -Air flow across Condenser should be minimum 6500 Cu.Mtr./Hr. each side. Passage should not be obstructed. -Check current of Compressor Motor. It should not be more than 10 Amps. -Reset manually the HP control -If all items as above are OK, look for trouble shooting of Condenser Fan motor I & II as already explained above. If everything above checks up O.K., HP control or wiring requires examination.
Heaters not working	HTR-1 or HTR-2 Red-light	-Check all fuses and ensure presence of 415 Volts AC on 3 phase upto Contactor terminals. -Check 1000 CFM air flow across each heating element. -Check and ensure heating elements are clean. -Check electrical wiring of control circuit and ensure that contactor 6 & 7 close. -Examine for defective overheating protective thermostat.

FAULT	**INDICA-TION**	**EXAMINE/TROUBLE SHOOT AS UNDER**
LP-I &	Tripping	This control is set to trip at 35 PSIG

LP-II Suction Pressure Low	CP-2 LP-I or LP-II Red-light ON.	suction pressure. -Possibilities This tripping takes place due to reduced air flow on Cooling Coil, shortage of gas or defective Control wiring. -Minimum air flow on each Cooling Coil should be 1000 CFM. -Check all fuses/MCB's and ensure presence of 415 Volts 3 phase 50 Hz supply to Compressors. -Check and ensure direction of Blower. -Examine and ensure Air Filters are clean. -Check and ensure Return Air temperature to the coil is not below 22°C. -Check ambient temperature outside, it should not be lower than 22°C.. -Check current of compressor motor, It should not be below 6.5 Amps. -Feel the cooling coil by hand when compressor is running. If it is hot, has leaked out. -If all as above is OK, examine Control Circuit explained above, Inspect LP Control for proper operation.

CHAPTER 14

DO'S AND DON'TS

14.1 Do's

- Do keep all the tools, gauges & instruments in working condition.
- Do tighten nuts & bolts fully by applying proper torque.
- Do keep all commonly used tools and gauges in a handy tool box.
- Do ensure that in 3 phase supply the neutral is available.
- Do check continuity only by using series lights bulb of 100 W or higher rating and not with ohm-meter.
- Do work with full confidence.

14.2 Don'ts

- Don't wear loose clothes and chappals.
- Don't use defective tools, gauges and instruments.
- Don't use oversize/improper tools.
- Don't apply unsafe method of working.

- Don’t leave tools gauges & instruments at work place after completion of work.
- Don’t leave nuts & screw/bolts half tighten.
- Don’t use nuts & bolts having different pitches together.
- Don’t apply excessive pressure for tightening the nuts, bolts & screws.
- Don’t use Fork lift, lift PAC from top through hooks only.
- Don’t start compressors until the crank case heaters have been kept energised for 2-4 hours.
- Under no circumstances the machine should be run in manual operation for prolonged period of time and without supervision of a qualified technician.
- Don’t allow the refrigerant gas to escape to the atmosphere.
- Don’t use the until compressor for vacuuming the unit.
- Don’t use refrigeration compressor for pulling a vacuum.

APPENDIX - A

CHARACTERISTICS

1. CHARACTERISTICS OF ALL OVER LOADS.

Blower motor	-	2.3 to 3.0 Amps.
Condenser fan motor	-	2.3 to 3.0 Amps.
Compressor motor	-	6.5 to 10.0 Amps.

2 START AND RUN CHARACTERISTICS OF ALL ELECTRICAL MACHINERY

Blower motor	-	2.6 ± 10% FLA & 15 LRA
Condenser fan motor	-	2.2 ± 10% FLA & 12 LRA
Compressor motor	-	8.5 ± 10% FLA & 49 LRA

3. FUSE SIZES

Main power supply	63 Amps.	3 Nos.
Blower motor	8 Amps.	3 Nos.
Condenser fan motor	6 Amps.	6 Nos.
Heaters	10 Amps.	6 Nos.
Crank case heaters	2 Amps.	6 No.

Control circuit 230 V	2 Amps.	1 No.
Control Circuit	4 Amps.	1 No.

DISTRIBUTION LIST

Railway Board, Rail Bhavan, New Delhi

1. Addl. Member (Elect.).
2. Officer on Special Duty (Elect.)
3. Executive Director (EE/G).
4. Executive Director (E&R).
5. Executive Director (Safety).

RDSO, Manak Nagar, Lucknow

6. Secretary to DG for kind information of DG/RDSO.
7. Executive Director (PS)
8. Director (PS)
9. Library

Zonal HQ

10. Chief Electrical Service Engineer,
Central Railway , Parcel Office Building, II - Floor,
CST, Mumbai - 400001.

11. Chief Electrical Service Engineer
Western Railway, Church Gate, Mumbai.

12. Chief Electrical Service Engineer
Southern Railway, Chennai.

13. Chief Electrical Service Engineer
S.C. Railway, Secunderabad.

14. Chief Electrical Service Engineer

Eastern Railway, Fairly Palace, Calcutta.

15. Chief Electrical Service Engineer
South Eastern Railway, Garden Reach, Calcutta - 43

16. Chief Electrical Service Engineer
Northern Railway, Baroda House New Delhi.

17. Chief Electrical Service Engineer
Northern East Railway, Gorakhpur - 273 012.

18. Chief Electrical Engineer
Northern East Frontier Railway,
Malegaon, Guwahati - 781 011.

Divisons

19. Sr. D.E.E.(G)
CENTRAL RAILWAY
DRM OFFICE
JHANSI U.P. 284 001

20. Sr. D.E.E.(G)
CENTRAL RAILWAY
DRM OFFICE
BHUSAVAL - MAHARASTRA - 425 201

21. Sr. D.E.E.(G)
CENTRAL RAILWAY
DRM OFFICE
JABALPUR M.P. - 482 001

22. Sr. D.E.E.(G)
EASTERN RAILWAY
DRM OFFICE

DANAPUR BIHAR -202 392

23. Sr. D.E.E.(G)
EASTERN RAILWAY
DRM OFFICE
DHANBAD BIHAR 826 011

24. Sr. D.E.E.(G)
EASTERN RAILWAY
DRM OFFICE
DHANBAD BIHAR 826 011

25. Sr. D.E.E.(G)
EASTERN RAILWAY
DRM OFFICE
HOWRAH W.B

26. Sr. D.E.E.(G)
NORTHERN RAILWAY
DRM OFFICE
CHEMSFORD RD.
NEW DELHI 110 001

27. Sr. D.E.E.(G)
NORTHERN RAILWAY
DRM OFFICE
HAZRAT GANJ
LUCKNOW 226 001

28. Sr. D.E.E.(G)
NORTHERN RAILWAY
DRM OFFICE
AMBALA CANTT.

29. Sr. D.E.E.(G)
NORTHERN RAILWAY
DRM OFFICE
ALLAHABAD

30. Sr. D.E.E.(G)
NORTHERN RAILWAY
DRM OFFICE
FEROZPUR - 152 002.

31. Sr. D.E.E.(G)
NORTHERN RAILWAY
DRM OFFICE
JODHPUR 342 001

32. Sr. D.E.E.(G)
NORTHERN RAILWAY
DRM OFFICE
BIKANER - 334 001

33. Sr. D.E.E.(G)
NORTH-EARSTERN RAILWAY
DRM OFFICE
LUCKNOW - 226 001

34. Sr. D.E.E.(G)
NORTH-EAST FRONTIER RAILWAY
DRM OFFICE
LUMDING DIVISON
LUMDING

35. Sr. D.E.E.(G)
SOUTHERN RAILWAY
DRM OFFICE
PARK TOWN
CHENNAI - 600 003

36. Sr. D.E.E.(G)
SOUTHERN RAILWAY
DRM OFFICE
MADURAI

37. Sr. D.E.E.(G)

SOUTHERN RAILWAY
DRM OFFICE
TRIVENDRAM - 695 014

38. Sr. D.E.E.(G)
SOUTHERN RAILWAY
DRM OFFICE
PALGHAT - 678 001

39. Sr. D.E.E.(G)
SOUTHERN RAILWAY
DRM OFFICE
BANGLORE CITY - 560 023

40. Sr. D.E.E.(G)
SOUTHERN RAILWAY
DRM OFFICE
TIRUCHIRAPALLI - 620 001

41. Sr. D.E.E.(G)
SOUTH-CENTRAL RAILWAY
DRM OFFICE
SECUNDERABAD - 500 003

42. Sr. D.E.E.(G)
SOUTH-CENTRAL RAILWAY
DRM OFFICE
HUBLI - 580 020.

43. Sr. D.E.E.(G)
SOUTH-EASTERN RAILWAY
DRM OFFICE
KHARGPUR - 721 301

44. D.E.E.(G)
SOUTH-EASTERN RAILWAY

DRM OFFICE
ADRA - 723 121

45. D.E.E.(G)
SOUTH-EASTERN RAILWAY
DRM OFFICE
VISHAKAPATNAM A.P.

46. D.E.E.(G)
SOUTH-EASTERN RAILWAY
DRM OFFICE
BILASPUR M.P

47. Sr. D.E.E.(G)
SOUTH-EASTERN RAILWAY
DRM OFFICE
KHURDA ROAD
ORISSA

48. Sr. D.E.E.(P)
WESTERN RAILWAY
DRM OFFICE
MUMBAI - 400 008

49. Sr. D.E.E.(P)
WESTERN RAILWAY
DRM OFFICE
KOTA

50. Sr. D.E.E.(P)
WESTERN RAILWAY
DRM OFFICE
RAJKOT
GUJRAT

51. Sr. D.E.E.(P)
WESTERN RAILWAY

DRM OFFICE
VADODARA

52. D.E.E.(P)
WESTERN RAILWAY
DRM OFFICE
JAIPUR

53. Sr. D.E.E.(P)
WESTERN RAILWAY
DRM OFFICE
AJAMER

54. Sr. D.E.E.(G)
CENTRAL RAILWAY
DRM OFFICE
SHOLAPUR

55. Sr. D.E.E.(G)
CENTRAL RAILWAY
DRM OFFICE
NAGPUR - MAHARASTRA

Institutions

56 The Director,
IRIEEN, P.Box. No. 233,
Nasik Road - 422 101

57. Principal,

Railway Staff College, Vadodara - 390 004

58. Principal ,
C.E.T.I. Central Railway, Thakurli

59. Documentation Centre/CAMTECH.

60. Library/CAMTECH.

NOTES

ANNEXURE-1

MAINTENANCE

ACCESSIBILITY OF VARIOUS EQUIPMENT

1.	Condenser fans & Compressor	- From top of the unit.
2.	Return air filters	- From under the unit inside the coach corridor.
3.	Blower, Heaters & safety controls	- Access door at the bottom of the unit.
4.	Fresh air filters	- Access door on each side at the bottom of the unit. Terminals are located inside a junction box under the unit. Access by opening the cover of this unit box.