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**MAINTENANCE HANDBOOK FOR  
CONVENTIONAL AC COACHES**  
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Centre  
for  
Advanced  
Maintenance  
Technology



*Excellence in Maintenance*

Maharajpur, GWALIOR - 474 020

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**MAINTENANCE HANDBOOK FOR  
CONVENTIONAL AC COACHES**

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## 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 travelling 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*  
*Date : 15.07.99*

*D.K. Saraf*  
*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 conventional 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*  
*Date : 05.07.99*

*Khushi Ram*  
*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/CAC/1.0/C.S. # XX date-----

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

## CORRECTION SLIPS ISSUED

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## **CHAPTER 3**

### **MAINTENANCE OF A.C. COACHES**

#### **3.1 IMPORTANT POINTS FOR MAINTENANCE OF AC COACHES**

- Provide proper facilities - tools, space, staff and machinery.
- Follow proper maintenance schedule - Original performance data should be available like HP, LP currents etc.
- Check records of each run and act before the trouble.
- Stock sufficient spares for maintenance.
- Observe muck in the compressor crank case and locate its source.
- Take care while installation and repairs so that dirt, moisture do not get into the system.
- Replace shaft seal at every POH.
- Keep motor compressor aligned.
- Clean filter and condenser after every trip or as earliest possible.
- Bend pipes using bending tools in cold conditions. Do not fill sand, resin, lead etc.



- Observe 100 Hrs. (initial) commissioning run and check muck.
- Change oil and run for another 50 Hrs. Repeat until muck is reduced to reasonable level.
- Adjust expansion valve, if required.

### 3.2 MAINTENANCE SCHEDULE FOR AC COACHES

The following are the various maintenance schedules carried out on air-conditioned coaches.

- 3.2.1 Trip schedule.
- 3.2.2 Monthly schedule.
- 3.2.3 Quarterly schedule.
- 3.2.4 P.O.H.

#### 3.2.1 Trip Schedule

##### 3.2.1.1 Axle pulley

- Examine the indicating white mark on the pulley axle and ensure that the pulley has not slipped. If pulley has slipped, take necessary corrective action.
- Tap with hammer & judge the tightness by sound.
- Check the lock nuts and split pins for availability and tightness.

### 3.2.1.2 Belts

- Check condition of belt for frying of edges etc. in accordance with para 3 of code of practice for `V' belt.
- Check the belt for over turn and correct, if necessary.
- Tension should be felt by hard striking it slightly. Belt in correct tension will respond “alive” & “spring-back”.

### 3.2.1.3 Alternator

- Clean all dust by dry compressed air externally.
- Check the condition of outgoing cables. Ensure that flexible pipe carrying the cables is connected properly to prevent damage to insulation.
- Check the suspension pin, bush and securing nut.
- Check the pulley fixing, connecting on lock washer and locking screws. If lock washer is damaged, replace it.
- Inspect the terminal box for presence of water and drain out, if necessary.
- Check main suspension lugs of alternators for signs of crack.
- Carryout visual inspection for signs overheating and presence of fumes. Blow off dust if required.

- Clean the regular box externally & remove all the dust particularly from heat sink.
- Check safety chains & chain fixing nuts, bolts and split pins.
- Check tension rod fixing pin, alternator with washer & split pin.

#### 3.2.1.4 Battery

- Check the level of electrolyte in all the cells and top up with distilled water, if necessary.
- Check specific gravity and voltage of 4 pilot cells.
- Check the top of cells & arrange for cleaning of dust etc. by wet cloth ( shown in fig.3.1)
- Check suspension of battery box for signs of any crack, corrosion, rusting & take remedial action, if necessary.



Figure 3.1

### 3.2.1.5 Compressor Motor

- Examine the coupling for any indication of looseness or slip and rectify, as necessary.(shown in fig.3.2)
- Check the starting resistance connectors for tightness.
- Carryout visual inspection for signs of overheating and presence of fumes. Blow of dust if required.



Figure 3.2

- Check the direction of rotation for correctness.

### 3.2.1.6 Condenser Motor

- Open the inspection cover and examine the condition of Commutator motor. Clean with O-O sand paper or pumice Stone, if necessary. Clean all dust with dry compressed air(shown in fig.3.3).
- Check the fan blades for tightness.
- Carry out visual inspection of the signs of overheating and presence of fumes. Blow of dust if required.



Figure 3.3

### 3.2.1.7 Evaporator motor

- Open the inspection cover and examine the condition of Commutator. Clean with O-O sand paper or pumice stone, if necessary. Clean all carbon dust with dry compressed air.
- Check the bearing noise.
- Check the blower fixing for tightness.
- Carry out visual inspection for signs and presence of fumes. Blow off dust if required.

### 3.2.1.8 Compressor

- For proper lubrication of compressor SMI No. RDSO/AC/AMI/6 circulated vide EL/7.1.75 may be followed.
- Examine the reading of HP, LP & OP gauges recorded during the journey for abnormality and take action, as necessary.
- Examine flexible type coupling and replace, if necessary.
- Clean the compressor externally with compressed air.
- Check for signs of leakage at joints and shaft seal to take remedial measure where necessary.
- Examine the fixing arrangements, check the condition of the anti vibration mountings for tightness of the fixing bolts.

- Check for proper working of capacity control solenoid valves.

### 3.2.1.9 Condenser

- Clean the condenser fins thoroughly with high pressure water jet.
- Check and ensure that the protection plates and grills are provided on the three sides of the frame.
- Examine the fins for external damage due to flying ballast and clean dust from the fins so that air passes through the fins uniformly.
- Check suspension of the condenser for sign of any cracks corrosion or rusting & take remedial action.

### 3.2.1.10 Dehydrator and Liquid Receiver

- Check the sight glass for leakage, rectify if necessary (fig 3.4).
- After 10 minutes of starting the compressor the level of liquid refrigerant should be at about the bottom of the lower glass of the liquid receiver.

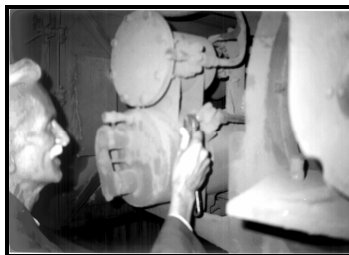


Figure 3.4

- After 15 minutes of starting the plant feel by hand the outlet and inlet to dehydrator for temperature difference. The outlet should not be colder than inlet. If so, the dehydrator cum filter require a change.

### 3.2.1.11 Filters

- Remove fresh air and return air filters and replace it by spare clean unit.
- Check and ensure that fresh air dampers are in working order.

### 3.2.1.12 Thermostats

- If the report of the attendant indicates that thermostats do not work at all, examine the thermostats for break in mercury column etc.. Replace the thermostats, if necessary.

### 3.2.1.13 Panel board

- Clean the panel with vacuum cleaner.
- Check the working of all indicating lamps, replace where necessary.
- Check the availability of spare fuses in the place provided for the same and replace it where necessary.
- Check for availability of arc-chute and provide where necessary.
- Check and clean the contacts of contractor 12, 13 & 13 A if necessary.
- Check the operation of cooling pilot relay by short circuiting CT terminals . Remove short after the check.



### 3.2.1.14 **Lights and Fan wiring**

- Check for earth leakage in the wiring with test lamp. Rectify if necessary.

### 3.2.1.15 **Lights and Fans**

- Check all the lights and fans for proper working. Rectify or replace as necessary.
- Clean the fan and light fittings externally.
- Check all switches, fan regulators, cell bell push buttons and call bells for proper working. Replace if necessary.

### 3.2.1.16 **Pre cooling Unit**

- Clean dust of rectifier unit externally with compressed air.
- Check presence of water in terminal box, drain out if necessary.
- Note down the ambient temperature and observe the pull down time at medium thermostat setting.
- Check suspension of battery charger for sign of any crack, corrosion or rusting & take action if required.
- Check the pre-cooling, pins and its fixing arrangement.

### 3.2.1.17 General

- Check log sheet of last trip and attend to all the faults recorded.
- Run the plant for half an hour. Check system specially the following :
  - Suction pressure gauge reading should be 37-40 lbs
  - Delivery pressure gauge reading should be 150-170 lbs.
  - Oil pressure should be minimum 3 Kg. Above suction pressure.
  - Feel Temperature - suction should be cold and sweaty. Delivery should be very hot and liquid line should be warm.
  - Feel by hand the expansion valve. It should be cold.

### 3.2.2 Monthly Schedule

In addition to the trip schedule, following are also to be attended.

#### 3.2.2.1 Axle pulley

- Ensure 3 mm gap between the two halves of the pulley. Check tightness of an axle pulley bolts by 30 Kg--m torque wrench.

### 3.2.2.2 Belts

- Check tension of belts in accordance with para 4.2.33 of code of practice for V belt i.e. for the exact measurement of static tension, apply force 'P' with a spring balance at the centre of the span in direction perpendicular of the span until the belt is deflected from the normal to the extent of 16 mm per meter of span. The force 'P' should be between 31.4 to 47.0 kg. If the belts are loose, replace them.

### 3.2.2.3 Regulator Box

- Clean all dust with dry compressed air externally.
- Open the cover and check sealing rubber gasket for sign of fraying on permanent set. Drain out water if any & dry.
- Clean all the dust with dry compressed air preferable a hand blower from inside to remove all dust particularly from heat sink electronic component and terminal board.
- Check that the voltage and current setting potentiometer have not been disturbed and is in locked position.
- Check the field fuses and phase fuses in case of KEL make and only field fuse in case of Beacon

regulators and ensure that only specific HRC fuses have been used.

- Check all the electrical connections for tightness.
- Check the regulator with the test kit.

#### 3.2.2.4 **Alternator**

- Lubricate the threads of the tension rod and adjusting nut.

#### 3.2.2.5 **Battery Charger**

- Ensure the coarse & fine control switch is in position No.1
- Check and clean all connections and contacts.

#### 3.2.2.6 **Battery**

- Check specific gravity and voltage of all cells.
- Check the inter-cell connection for looseness and crack in containers and rectify, as necessary.
- In case of sulphation of terminals remove the connectors, clean, put back and apply petroleum jelly.
- Examine condition of battery boxes. Paint if necessary.
- Check vent plugs. Tighten if necessary. Replace if missing.
- Check the cells by cell tester. Replace effective cells.

### 3.2.2.7 Compressor Motor

- Check tightness of the coupling and mounting bolts by 30 Kg.m torque wrench and tighten, as necessary.
- Open the inspection cover and examine the condition of Commutator. Clean with O-O sand paper or pumice stone, if necessary. Do not remove the dark tan film unnecessary. Clean all carbon dust with dry compressed air.
- Check condition of carbon brushes. Replace if necessary.
- Check condition of carbon brushes. Replace, if necessary.
- Check the terminal connections in the terminal box and tighten, if necessary.
- Examine the incoming loads for proper connection, and tightness. Check the flexible conduit for proper anchoring at both ends.
- Measure the spring tension of brush holder. If less than the recommended value by manufacturer, replace the spring.
- Check suspension of compressor motor unit & for any signs of cracks, corrosion rusting and take remedial action.
- Check the alignment of the compressor and motor.

### 3.2.3.8 Condenser Motor

- Check the incoming leads for proper connection and tight. Ensure that the grommet is in position and the flexible pipe is connected properly at both ends.
- Check the spring tension as recommended by the manufacturer.
- Check the carbon brushes, replace, if necessary.

### 3.2.2.9 Evaporator Motor

- Check blower for looseness.
- Check the spring tension as recommended by the manufacturers.
- Flush the drip tray. Check drain pipe of drip tray for clogging.

### 3.2.2.10 Compressor

- Check tightness of bolts of anti-vibration mounting with 30 kg. M. torque and tighten, if necessary.
- Check the tightness of nuts and bolts of compressor head and covers.

- Check oil and liquid levels and note any signs of leakage.
- Clean the oil strainer with petrol or CTC (Carbon Tetrachloride).

#### 3.2.2.11 Panel board

- Clean contact tips of all contractor, replace where necessary.
- Check all the electrical connection for tightness and tighten if necessary.
- Check the relays and contactor for their proper functioning.
- Check the resistance in the thermostats circuits.
- Check the diodes provided on the panel board.
- Check the rotary switch. The polarity change connection should be effective.

#### 3.2.2.12 Light and fan

- Open the inspection cover of each coach fan and examine the condition of Commutator. Clean with O-O sand paper if necessary. Replace the carbon brush , if necessary.
- Remove the tube light, night light covers and clean the lamp, tube and cover from inside.

### 3.2.3 **Quarterly Schedule**

In addition to Trip and monthly schedule, following are also to be attended :

#### 3.2.3.1 **Axle pulley**

- Check grooves for wear by templates in accordance with para 5.2 of code of practice for 'V' belts.

#### 3.2.3.2 **Alternator**

- Disconnect the regulator and measure the insulation by 500 V megger. If less than 2 Mega ohm, remove and heat in oven at 80°C for 12 Hours.



### 3.2.3.3 **Battery**

- Remove inter-cell connections, take out the cells, clean thoroughly the cells, inter-cell and end cell connectors and fit back in the coach. Use petroleum jelly.

### 3.2.3.4 **Compressor, Condenser and Evaporator Motor**

- Disconnect the motors, measure the insulation with 500 V megger, if less than 2 Mega ohm remove and head in air over at 80°C for 2 Hours.
- Check for the positive locking of rockers.
- Lubricate the bearings of all motors with recommended grease.

### 3.2.3.5 **Condenser**

- Check condition of body frame and replace condenser, if necessary.

### 3.2.3.6 **Dehydrator and liquid receiver**

- Clean the strainer in the dehydrator cum filter unit, where filter is separate from dehydrator.

### 3.2.3.7 **Evaporator and Expansion Valve**

- Clean the strainer used before expansion valve.
- Clean the assembler of evaporator coil and surroundings with vacuum cleaner.

- Clean the dip-tray and drain pipe thoroughly and check for water leakage.

#### 3.2.3.8 **General**

- Adjust the air distribution by measuring the temperature off each compartment.

## **CHAPTER 4**

### **POH OF AC COACHES**

#### **4.1 SEQUENCE OF WORK TO BE CHECKED DURING POH**

##### **4.1.1 Pre-Inspection**

Place the coach on pit line and inspect electrical and AC equipments. Note down the defects and deficiencies. Disengage the 'V' belt tensioning gear on both the bogies. Disconnect the alternator connections, and remove belt tensioning device.

##### **4.1.2 Lifting**

Remove the alternator cables and carry out visual inspection on conduit and refrigeration pipes. Remove the alternators from bogies. Replace alternator, regulator and tensioning gears with over hauled alternator, regulator and tensioning gear. During this activity carry out repairs, if any, to suspension arrangement of under carriage. Send the alternators, regulators to stop for overhauling.

### 4.1.3 Stripping

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

- Fresh air and return air filter
- Compressor and its motors.
- Condenser including liquid receiver cum dehydrator and condenser motors.
- Evaporator unit and its motor.
- Water raising apparatus.
- Battery and battery box (Repairs of battery box).
- Battery charger-cum-pre-cooling transformer.
- Thermostats.
- Control panel.
- Expansion valve.
- Gauges and cut-outs.
- Carriage fans.
- Berth light fittings.
- Ammeters and Voltmeters of power panel.

### 4.1.4 Dusting

With the help of compressed air remove the dust etc. of cool air ducts.

#### **4.1.5 Cleaning and Overhauling**

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

#### **4.1.6 Equipments**

In this activity fit all the refrigeration and electrical equipments to its respective position. Connect all the wirings and flanges in the refrigeration system wherever necessary. Charge the gas into the system.

#### **4.1.7 Static Testing**

Run the plant through pre-cooling terminal and check for proper functioning of electrical and AC equipments.

#### **4.1.8 Simulating Testing**

Check the alternator output on different load conditions. Check both the alternators for load sharing with the help of dyno-drive motors.

#### **4.1.9 Final Inspection**

In this activity join the connections of alternators and fit the belt tensioning device. Provide the new 6+6 'V' belts for alternators. The coach shall be jointly inspected with division's staff and the performance of electrical and refrigeration equipments shall be

recorded as per prescribed proforma. Any attention, if required to the equipments shall be given before despatch of the coach from workshop.

## 4.2 **OVERHAULING ACTIVITIES OF MAJOR AIR-CONDITIONING EQUIPMENTS**

### 4.2.1 **Axle Pulley**

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

4.2.1.1 Replace the pulley if any groove is damages/broken.

### 4.2.2 **Belts**

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

### 4.2.3 **Brushless Alternator**

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

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

- Serial number and name plate 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 with shock pulse meter.

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

- Open the cover of the terminal box and check whether the internal terminations and terminal board are intact.
- Tighten all the connections on the terminal board.
- Using a 500 V Meggger, check continuity between :
  - a) Field terminal F+ and F-
  - b) Stator terminals U to V, V to W and W to U.
- Check the insulation resistance between :
  - a) Stator terminals and frame of machine.
  - b) Field terminals and frame.
  - c) Field terminals and stator terminals.

**Note :** Minimum insulation resistance should not be less than 1.0 mega ohms under worst weather condition.

#### 4.2.3.4 Overhauling

- Clean and re-grease the bearing after removing the bearing from the bearing housing.
- Clean the mating surface of the end shield, before assembly.
- 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 insulating varnish.
- 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.

#### 4.2.3.5 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).

#### 4.2.4 **Rectifier Regulator Unit**

- Check the terminals and blow the dust.
- The wiring of the regulator shall be done systematically, replace the damaged wiring/terminals.
- Check the PCB circuit with PCB testing kit or multimeter to sort out defective components. Replace the defective components.
- Apply silicon grease for correct point of rectifier with the heat sink.
- Check field transformer for correct voltage. Replace, if found defective.

#### 4.2.5 **Battery and Battery Box**

- Remove the cells from the battery boxes on arrival of the coach in workshop and bring them in the battery shops for maintenance.
- Record voltage and specific gravity of each cell.
- Clean exterior of the cell thoroughly. Wash top of the battery with 10% solution of soda and 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 the cell.

- Battery boxes shall be cleaned/repainted and repainted with anti level corrosive epoxy based paint after removing the battery.
- 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.
- Replace defective float and vent plugs, if any.
- Clean vent plugs and floats guides and ensure that vent holes are in order.
- Record lug date to determine the life of the battery.
- Charge the battery fully till 3 constant half hourly readings of voltage and specific gravity indicating the conditions of a fully charged cell are recorded.
- Discharge the battery at 10 hrs. Discharge rate. While discharging, record the voltage and specific gravity.
- Record the capacity of the battery during discharge. It should not be less than 80% of the rated capacity.
- 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.

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

#### 4.2.6 Compressor

- Remove driving flange and provide 'V' groove pulley. Test the compressor to ascertain its condition. Record the oil pressure during run. For Carrier and ACCEL compressor oil pressure developed should be 45 to 55 psi (3.2 to 3.9 kg/cm<sup>2</sup>).
- Dismantle the compressor completely as per manufacturer's instructions.
- Clean the components with kerosene oil or petrol. Remove the crank shaft and piston. Check the piston ring and cylinder bore for any scoring and excess wear.
- Inspect and check the dimensions of the wearing components. Replace the worn out components.
- Replace following components 100% irrespective of its condition :
  - Piston rings
  - Scraper ring
  - Suction and discharge valve
  - Shaft seal assembly/ 'O' rings
  - Gasket packing
  - Half section bearing

- Self locking nuts
- Lubricating oil
- Replace other components on condition basis. The sealed capacity control valve shall be replaced after ascertaining its performance.
- Assemble the compressor with replaced components and fill it with lubricating oil. Change the lubricating oil and refrigerant suction strainers.
  - In case of carrier 5F 30 compressor match the colour to ensure proper meeting between tapered shaft and corresponding flexible coupling.
  - In case of ACCEL compressor check the end play of crank shaft and replace the thrust plate, if necessary.
  - Check the anti vibration mounting, replace if necessary.
- Following test shall be conducted on overhauled compressor :
  - Temperature rise test
  - Volumetric efficiency test
  - Leak back test
  - Vacuum test
  - Sub merge test

**Temperature Rise Test :** This test shall be conducted with compressor running in free air with both suction and discharge valve open. Run the

compressor till the temperature gets stabled. The temperature will be recorded on the casing cover. Maximum temperature rise at shaft seal shall not be more than 46°C.

**Volumetric Efficiency Test :** The compressor shall be run with air at nominal speed of 1500 rev/min and time taken to attain a pressure of 7 kg/cm<sup>2</sup> shall be recorded when the discharge line is connected to a reservoir of 100 ltrs.

The time taken to attain a pressure of 7 kg/cm<sup>2</sup> in the reservoir should not be more than 53 seconds for ACCEL compressor and 73 seconds for carrier, KPC, Elgi and Alfa compressors. Time to attain above specified pressure in the above reservoir shall vary accordingly to working speed of the compressor and atmospheric pressure also.

**Leak Back Test :** This test is in continuation of efficiency test. In this test immediately after attending pressure of 7 kg/cm<sup>2</sup> in the reservoir, the compressor shall be stopped and pressure drop due to leak back shall be noted. Pressure shall be recorded at the end of 5 minutes and take the drop in pressure shall not exceed 1.25 kg/cm<sup>2</sup>.

**Vacuum Test :** The compressor shall be run with suction valve closed and delivery valve open to atmosphere till a vacuum of 100 of Hg. Below atmospheric pressure is created. The drop in

vacuum level shall be recorded, after switching off the compressor.

**Sub-merge Test** : The compressor shall be charged with dry air at  $21 \text{ kg/cm}^2$  pressure and sun-merge in the water. Then check shall be conducted for any leakage, the same shall be attended and test repeated. However, no leakage through casing shall be permitted.

#### 4.2.7 **Condenser Unit (including Liquid Receiver cum Dehydrator)**

- Dismantle the M.S. Frame, Condenser coil, Liquid receiver-cum-dehydrator. Cover the inlet and outlet flanges of cooling coil with a strip of cover plate and gasket so that water may not enter into the cooling coil. Clean thoroughly the condenser coil, M.S. frame by dry air to remove the loose suspended particles in and around cooling fins.
- Immerse the heat exchanger in water tank for 24 hours. Wash the coil and fins thoroughly with compressed water jet at  $12 \text{ kg/cm}^2$  pressure. Remove all the suspended material from the fins. Clean the water spraying pipe and open the holes.
- The cleaning process shall be supplemented by scrubbing with brush and use of compressed water jet, where in hot mixture of diesel oil and water is applied at high pressure.

- After cleaning the cooling coil pressurise with air at 300 psi (21 kg/cm<sup>2</sup>) and immerse in water tank duly connecting a pressure gauge for 24 hours to detect any leakage by air bubble method. Also see if the pressure drops, leak in pipe is detected and brazed.
- After cleaning check the air flow of unit with anemometer.
- De-flange the liquid receiver by removing the outer cover and gasket packing. Clean thoroughly the inner walls of receiver to remove any oil/impurity. Clean the sight glass. Assemble the sight glass. Assemble the cleaned liquid receiver parts by providing suitable gasket and flanging the outer cover.
- Pressurise the liquid receiver at 300 psi (21 kg/cm<sup>2</sup>) and test it for leakage by immersing in water tank and notice air bubble in case of leakage.
- Replace the filter and drier and assemble after leak testing of the liquid receiver. Clean the condenser housing thoroughly and paint it before assembly of other equipments.
- Change the dehydrator-cum-filter (catch all filter) element. Also clean the conical filter (of brass wire mesh) thoroughly.

#### 4.2.8 Evaporator Unit

- Dismantle the housing assembly and take out the cooling coil. Attend the heating element in position by conducting continuity test. Also check the insulation value between positive terminal and negative terminals shortened and the earth. If the value is less than 2 meg. Ohms, replace the complete unit.
- Clean the cooling coil by blowing compressed air. Cover the inlet and outlet flanges of cooling coil with strip of cover plate and gasket so that water may not enter into cooling coil. Immerse in water tank for 24 hours and wash with compressed water jet at  $12 \text{ kg/cm}^2$  pressure. Remove all suspended material on fins and clean the cooling coil.
- The cleaning process shall be supplemented by scrubbing with brush and use of compressed water jet, where in hot mixture of diesel oil and water is applied at high pressure.
- After cleaning the cooling coil pressurise with compressed air at 300 psi ( $21 \text{ kg/cm}^2$ ) and immerse in water tank duly connecting a pressure gauge to detect any leakage by air bubble method. Also see, if the pressure drops, leaks in pipe is detected and brazed.
- Clean the Evaporator housing and paint it. Assemble the cleaned unit.



- Take out main auxiliary drip trays from the bottom of the evaporator unit, disconnecting the drain pipe connections. Check for free flow of water through drip drain pipe admitting water on the drip tray. Replace the hose pipes and hose clips by the new ones.

#### 4.2.9 **Motor for Compressor, Condenser and Evaporator**

- Dismantle the motor as per manufacturer's instructions.
- Test the insulation resistance of armature with 500 V megger. It should be more than 1 meg. Ohm.
- Check armature winding by voltage drop test method for open circuit and short circuit fault.
  - If the armature is burnt, over heated or short circuited, rewind it as per manufacturer's instructions.
  - If armature is in good condition apply a coat of air drying insulation on the winding.
- Check the commutator surface. If the surface is found improper, skim the commutator surface.
- Check the under cut between segments. If it is found shallow under cut the mica to the required depth. Chamfer the edges of the segments.
- Check the bearings with the help of shock pulse meter. If needed, in case of compressor and condenser motors, replace by new ones, otherwise

after cleaning and greasing reuse it. In case of evaporator motor 100%, bearing shall be changed.

- Check the field winding by resistance measurement method for open circuit and short circuit.
- Check the insulation of field system with the help of 500 V Megger. It shall be more than 1 meg. Ohm. Replace the field coil, if defective. If field winding is in good condition apply a coat of air drying insulation on the windings.
- Check the brush boxes and studs for rigidity, clean the rocker assembly.
- Replace the carbon brushes and finish the brushes using sand paper of size 400 grade or by using brush seating stone until the faces of brushes make perfect contact on commutator surface. Blow out the carbon dust using dry air jet.
- After assembly conduct the load test and insulation test. Current taken by motor should not more than the rated current. Conduct insulation test with 500 V megger. It should be more than 1 meg. Ohm.
- After the compressor/condenser motor is completely assembled connect a milli voltmeter across brushes of opposite polarity. Connect the shut field to 110 V mains through a switch. Switch on the mains and note the kick in the voltmeter. Rock the brush gear to the left or right and repeat the test as before. Clamp the rocker arm in a particular position at which the kick is zero or

minimum. Before this test, care should be taken to make sure that the brushes are bedded properly. If brushes are at neutral axis, the speed in both the directions of rotation will be same.

- After the evaporator is completely assembled the neutral axis can be selected by running the motor in both the directions on no load at approximately 25% of the rated voltage and measure the speed in both the directions. If brushes are at neutral axis, the speed in both the directions of rotation will be same.

#### 4.2.10 **Control Panel**

- Completely isolate the panel from the power supply and its loads. Contacts of the contactors (12,13,13A, 29 and 17) shall be removed and cleaned by means of clear rag soaked in petrol. Any contacts which are burnt should be replaced, after which they should be lightly covered with vaseline.
- 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.
- Check the flexible braided connections. If found damaged, replace the same.
- 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 pin removed. This should be examined for wear and if necessary, replace by a new pin lightly covered with vaseline.

- Measure the insulation resistance of each relay and contactor. If the insulation value is less than 2 meg. ohms, re-place the coil of the respective unit.
- Check whether all connections are tight. If found loose, tighten the same.
- Replace all the fuse links.
- Conduct the performance test

#### 4.2.11 **Gauges and Cut-outs**

- Clean the contacts with CTC/petrol and test for correct operation of settings. Calibrate with the standard gauges. Also test in series.
- Check the performance of the gauges. Calibrate with the standard gauges. Replace defective gauges.

#### 4.2.12 **Refrigeration Piping**

- Whenever the AC equipments are removed from the refrigeration system for the purpose of overhauling the pipe outlets should be closed immediately to prevent entry of any foreign material into the piping system.
- After reconnecting all the AC equipments, pressure test and vacuum test shall be performed before charging the refrigerant.

#### 4.2.13 **Pre-cooling Transformer Rectifier Unit**

- Open the canopy and clean externally with compressed air.
- Dismantle the unit as per manufacturer's instructions.
- 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.
- Clean the transformer, rectifier and rotary switch. Check for operation, if defective, change it.

#### 4.2.14 **Fans**

- Dismantle the lower guard, upper guard, blade and fan motor.
- Check the guard assembly, repair/replace if necessary.
- Check the blade angle with a measuring gauge. Correct the same, if necessary.
- 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.
- Check the armature winding and field coil, repair, replace, if necessary.

- Check the commutator for grooving, pitting marks, ovality, blackness etc. Skim or polish the commutator as required.
- Check the carbon brush and brush 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.
- Apply air drying insulating varnish if IR value of the armature and field coils is low, give impregnation treatment in an air circulating oven.
- Clean the ball bearing, check for noise, replace if necessary or grease it with recommended grade.
- **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 less than that specified in IS : 6680.

#### 4.2.15 **Wiring**

##### 4.2.15.1 **Light Fittings**

The light fittings, reflectors, clear acrylic 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/SK-7-6-079.

#### 4.2.15.2 **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 one meg. Ohm under highly humid/wet weather.

#### 4.2.15.3 **Cable Termination Joint**

- All cable joints shall be checked. Loose joints and cables having damaged insulation shall be replaced/repared. All cable 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 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.

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

4.2.15.5 The under frame wiring if running loose shall be provided in rigid steel conduit.

4.2.15.6 All inspection coves shall be opened to check the distribution boards and condition of wiring.

#### 4.2.16 **Air-Filter**

- For cleaning the ferrule type fresh air and return air filters remove them from frames which support them and after brushing or shaking off all loose dirt immerse them in a solution of hot water and soda (sodium carbonate) approximately 6 grams to one litre of water. When thoroughly cleaned, the filter units should be rinsed in clean hot water and allowed to dry. When properly dry, they should be completely kept immersed in the oil ( compressor lubricating oil) until air bubbles ceases to rise then remove and allow to drain for at least 8 hrs. Before being placed in service again.
- Replace the filter with new one in case of synthetic type filters.
- The manufacturer's instructions for any other specified type filter, shall be followed.

#### 4.2.17 **Cooling Test**

- Cooling capacity test should be carried out by providing electrical compensating loads for worst ambient conditions and full occupancy of the coach. The duration for pre cooling the coach should be between 3 to 4 hrs. After the stabilisation of the temperature of earth (20 mm from window and back rest panel and 100 mm above the berth)



should be recorded. The variation in temperature on different berths should not exceed 1 °C.

- The cycling duty of the plant shall be determined by recording ON and OFF time of the compressor. It should be between 10 to 15 cycles per hours.

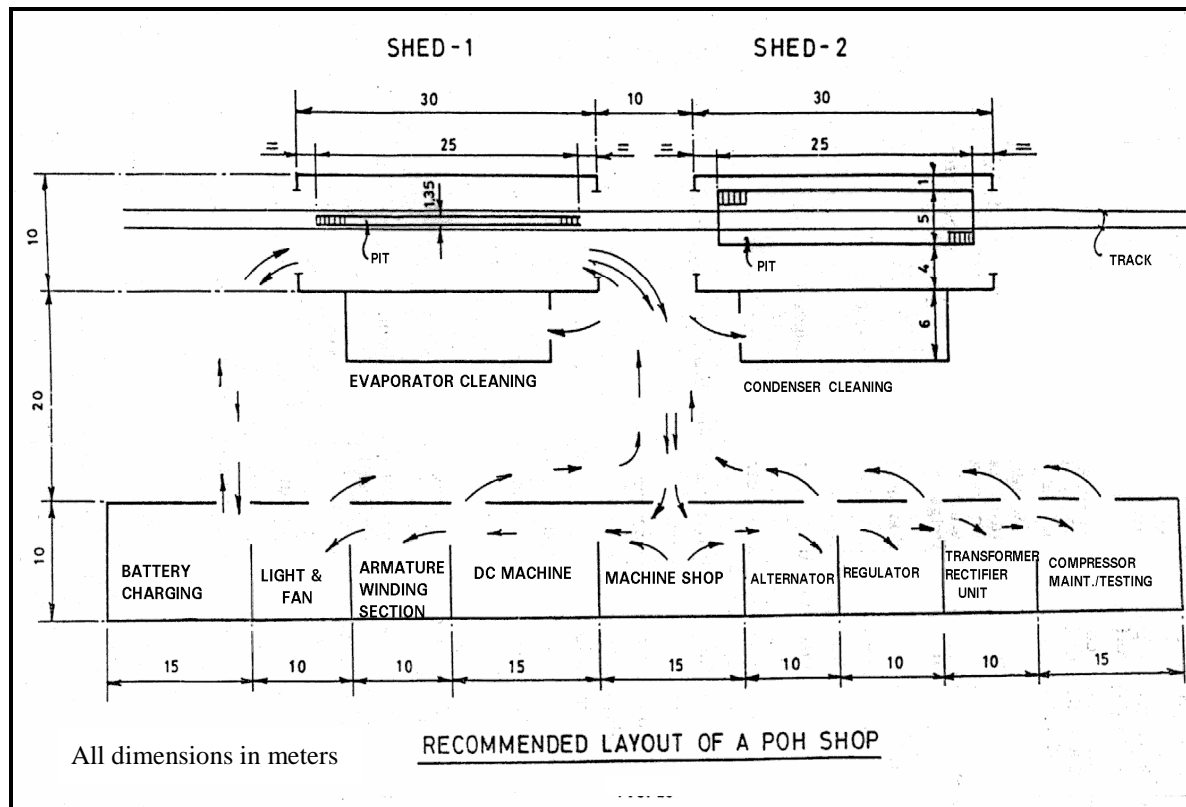
#### 4.3 **RECOMMENDED STANDARD FACILITIES FOR POH OF AC COACHES**

- Figure 4.1 shows a recommended layout of a POH shop with an outrun of 5 coaches per month.
- The layout incorporates a receiving shed with a pit of 1.35 M width, 1.3M depth and 30 M long to facilitate unloading/loading of equipment. Track and pit centre line are located 1 M off from the shed centre line.

Sr. No.	Type of coach	No. Of AC plant	Calculate d AC load of coach	Type of compressor in each Plant	Drive motor	Capacity of AC plant provided.	Conditions
1	BG AC First class	1	5.3 TR	ACCEL SMC-4-65	12.5 HP DC compound motor run at 1500 rpm at 110 V DC.	1 x 6.7 TR	5°C suction temperature and 55°C condensing saturation temperature
2	i) BG AC two tier and  ii) BG AC Compo site coach	2	i) 7.48 TR  ii) 7.97 TR	a) ACCEL SMC-4-65  b) Carrier 5F30 or c) KPC FK4	10 HP DC compound at 1160 rpm at 110 V DC. 8.5 HP DC compound motor at 1500 rpm at 110 V DC. 8.5 HP DC compound motor at 1500 rpm at 110 V DC.	2 x 5.2 TR  2 x 5.5 TR  2 x 5.4 TR	
3	BG AC chair car	2	11.1 TR	ACCEL SMC-4-65	12.5 HP DC compound motor run at 1500 rpm at 110 V DC.	2 x 6.6 TR	
4	MG AC sleeper	1	6.39 TR	ACCEL SMC-4-65 with suction manifold modified.	12.5 HP DC compound motor run at 1500 rpm at 110 V DC.	1 x 6.7 TR	

It is to be ensured that the combination of compressor and motor as mentioned above should be followed to obtain in balance in the whole system.

[illegible]



- The equipment unloaded from the coach may be moved to the respective sections off the shop by means of mechanised transport facilities.
- After completion of overhaul work, equipment may be loaded on the coach kept in the receiving line and then the coach shall be brought to the shed having wider line with a pit of 5 M width for final testing and detailed examination of under frame equipment.

#### 4.4 **REQUIREMENTS FOR THE PIT**

- For loading and unloading facilities, the pit width shall be 1.35 m (0.50 in M.G.), length 30 m and depth 1.3 m with steps on both side.
- For detailed examination/testing of under frame equipments, a pit having a width of 5 m shall be provided.
- The walls of the pit shall be watertight. The pit floor shall have slope of 1 in 300 towards one end with sump.
- Suitable pump shall be provided for pumping out water from the pit.
- Water tight fittings shall be provided in the sides of the pit at intervals of 6 mm.

- Two pin sockets 3 Nos. In each side of the pit for hand tamps.
- The wider pit shall be provided with 2 DC motor drives of capacity 25 KW each for testing of alternators.

#### 4.5 **FINAL TESTING OF A/C COACH AFTER POH**

- Visual inspection of coach for proper fitment of equipments.
- Ensure the refrigerant pipes are properly clamped.
- Suction pipe for proper lagging.
- Ensure all the modifications are completed.
- Check safety chain and tension rod of alternator for proper fitness.
- Under frame cables leading to alternator are properly cleaned.
- Check earth leakage by two lamp method.
- Check refrigeration system for any leakage before gas charging.
  - a. Vacuum test (for 12 Hours.)
  - b. Pressure test (by charging Freon 12 or CO<sub>2</sub> gas.

- Vacuum test for 15 minutes for dehydration of refrigeration system.
- Check control panel and ensure that proper fuses are provided.
- Check contactors, relay and switches for correct sequential operation.
- Ensure that time delay in operation of contactors No. 12,13,13A is 2.5 sec.
- Check heaters for correct operation.
- Check hooter for proper operation.
- Start the plant and check condenser motor, compressor motor, blower motor for any abnormality.
- Check leakage of air from doors.
- Check oil level in compressor, the level should be when operating - 1/2 bull's eyes.
- Check for proper working of capacity control solenoid valve.
- Run the plant for 4 Hrs. An equivalent heat load (convactor heater) should be kept for performance test of plant.
- If new expansion valve is provided during POH, it be set.

- Ensure that batteries are in fully charged condition.
- Take coach on trial run.
- Ensure that both the alternators are sharing load equally during run. If not set both the alternator panels.

#### 4.6 **GENERAL CHECKS**

- Suction pressure gauge reading should be 37-40 PSI.
- Oil pressure should be minimum 3 Kg/cm<sup>2</sup> above suction pressure.
- Delivery pressure gauge reading should be 150-170 PSI.
- Feel temperature - Suction should be cold and sweaty. Delivery should be very hot and liquid line should be warm.



## CHAPTER 5

### TEST FOR LEAKAGE IN COMPLETE REFRIGERANT SYSTEM

After completion of installation of all the refrigeration components and their interconnecting pipe work, the complete system must be thoroughly tested by means of a pressure test in order to ascertain that the system is absolutely gas tight. The pressure test is carried out in two stages i.e. a low pressure test followed by a high pressure test. The procedure is as follows :

#### 5.1 Low Pressure Test

- Open the compressor delivery stop valve within one turn of its back setting, open the two valves on the liquid receiver and leave the outlet valve to the dehydrator and the compressor suction valve closed.
- Connect the Freon charging pipe to Freon cylinder to the valve on the end of the suction manifold. Open the Freon cylinder valve and the manifold valve and allow 1 to 1.5 Kg. Weight of Freon to pass into the system. The amount of Freon can be determined by standing the cylinder on weighing scales while the gas is passing into the system. Place the cylinder in a bucket of warm water and apply the blow lamp to the bucket so that the heat developed by the hot water will raise the pressure in the cylinder and free the gas into the system.

- When the required amount of Freon gas has been introduced into the system, close the manifold valve and the cylinder valve and disconnect the charging pipe. Make up a length of 1/4" flare nuts. Also an adapter for connecting the end of the tube to the high pressure cylinder of Nitrogen, dry air or carbon dioxide, whichever the case may be.

**Note :** It is essential that the reducing valve with appropriate high and low pressure gauges be connected to the high pressure gas cylinder (approximately 150 Atmospheres).

- Connect the high pressure gas cylinder via the reducing valve and copper tube to the manifold valve. Open the gas cylinder valve and adjust the reducing valve to a pressure of 150 lbs/sq. inch (approximately 10 kg/cm<sup>2</sup>) then open the manifold valve and allow the pressure in the system to rise to 150 lbs/sq inch. By observing the pressure gauge, then close the suction manifold valve and gas cylinder valve.
- Light the Freon leakage detection lamp and pass the suction tube of the lamp carefully and slowly over every joint (soldered joints, flanged joints or union joints) liquid receiver, dehydrator and compressor, including its shaft seal. Test also the bellows casing of the high and low pressure cut-out switches.
- If any leakage are detected at the soldered joints of the pipe work, the exact location can be determined by an application of soap solution to the spot.
- Having determined the position of the leakage, it will then be necessary to isolate the particular section of

the system by closing the appropriate stop valve and releasing the pressure within if before isolating the defective joint.

- After re-soldering the defective joint, open the stop valves raise the pressure in the system to its original 150 lbs/sq. inch pressure by reconnecting the cylinder.
- Allow this pressure to remain in the system for at least four days. Checking from the suction gauge that it does not decrease more than 31 lbs/sq. Inch (approximately 2 kg/cm<sup>2</sup>).

## 5.2 High Pressure Test

- Fully close the liquid line stop valve adjacent to the expansion valve on the air-conditioning roof unit. Back seat the suction stop valve on the compressor, remove 1/4" copper pipe connected to the stop valve for the low pressure gauge and cut-out switch. Fit and tighten a sealing cap nut or blanked off flare nut on the flared union on the stop valve, then fully close the valve.
- Connect the high pressure gas cylinder (Nitrogen or carbon di-oxide or dry air) to the purge valve on the liquid receiver, open the cylinder valve and adjust the reducing valve until the gauge indicates 250 lbs/sq inch (approximately 17 kg/cm<sup>2</sup>), then open the purge valve and allow the pressure to increase in the system until the high pressure gauge in the coach indicates 250 lbs/sq inch. Close the purge valve and cylinder valve and disconnect the cylinder.

**Note :** Make sure that both, stop valve on the roof and the suction stop valve on the compressor, are firmly closed.

- Immediately after raising the pressure to 250 lbs/sq inch. In the high pressure section of the system, make a through test of all the joints in this sanction with the Freon leakage detection lamp i.e. from and including the stop valve on the roof unit to the condenser, liquid receiver dehydrator and the whole of the compressor.

**Note:** It is possible that a slight fall in pressure may be indicated on the pressure gauge after about half an hour or more. This may be due to equalisation of the pressure within the compressor.

- The most likely source of possible leakage which may occur under the high pressure test, are the flanged joints. Do not overlook testing the valve stem gland of the various stop valves for leakage and to tighten the gland sealing nut if any gland which may be found to be leaking.
- The system must be subjected to a vacuum test.

## CHAPTER 6

### DEHYDRATION OF REFRIGERATION SYSTEM (BY VACUUM PUMP)

- Connect vacuum pipe by means of copper tube with ends flared and fitted with 1/4" SAE flare nuts with purge valve on liquid receiver.
- See that all valves in the system except the purge valve are in their fully open position.

**Note :** The stop valves on the compressor must not be back-seated, otherwise the connections to the high and low pressure gauges and cut-out switches will be isolated.

- Close the air inlet valve and open the stop valve on the manifold connected to the moisture trap, then start the vacuum pump.
- Allow the vacuum pump to operate for 5 minutes. This will evacuate the air and moisture from the moisture trap, the piping connecting between the vacuum pump and the purge valve on the liquid receiver and the piping connected to the vacuum gauge. By checking this feature, the satisfactory working off the vacuum pump could be ensured.
- If there are no leakage in the piping and the vacuum pump is in good condition, it should create a vacuum

equivalent to 5 mm of Mercury, minimum within a period of 5 minutes.

- Open the purge valve on the liquid receiver to allow the pump to commence evacuating the air from the refrigeration system.
- Allow the vacuum pump to continue to run for nearly 330 minutes. The vacuum gauge will commence to indicate partial vacuum.
- Wait until the pressure gauge indicated a constant reading of 5 mm, for three successive reading taken at 10 minutes intervals.
- Meanwhile arrange all equipment for charging the Freon into the system. When all equipment are ready, close the stop valve on the manifold tightly on its seat, also close the purge valve. Then stop the vacuum pump and open the air inlet stop valve to admit air to the pump while it is stationary.

### **Precautions**

- Open the air inlet stop valve slowly to avoid damage to the vacuum gauge.
- Dehydration of system by vacuum pump should not be attempted if the ambient temperature is below 4.5°C.
- Make careful observation of low pressure gauge on the coach by sticking a piece off gummed paper on the glass cover of dial in line with pointer and the marking a line on the paper in line with one edge of the pointer.

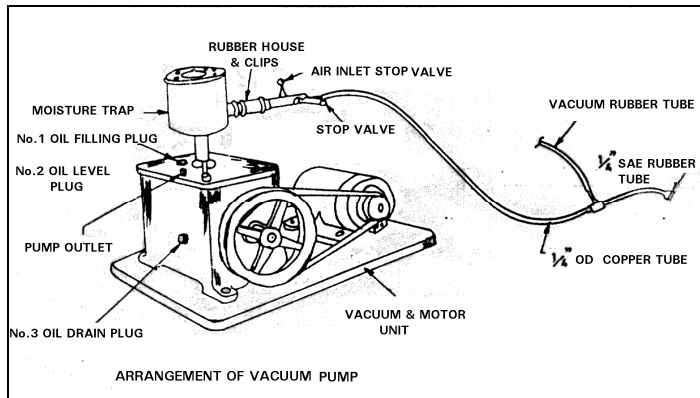


Figure 6.1

- Leave the system under vacuum for about 12 hours and observe the degree of vacuum indicated on the low pressure gauge has not changed during this period. If the vacuum has been maintained satisfactorily, the system can be charged with Freon , but before doing so, the vacuum pump must be out into operation again to obtain maximum vacuum on the system immediately before admitting the Freon into it.

## **CHAPTER 7**

### **PROCEDURE FOR CHARGING REFRIGERANT**

After having established a gas-tight and dehydrated system, charging with Freon may now be proceeded with as follows :

- 7.1 Remove the valve cover from the Freon cylinder. Remove the outlet and screw the charging pipe adapter of it. (Ensure that the fibre or lead washer is inside the adapter before it). Connect and , tighten the Freon charging pipe to the adapter on the cylinder.
- 7.2 Place the Freon cylinder in a bucket of water on platform scale or suspend it from a suitable spring balance and place it as near as possible to :
  - a. The compressor, if it is possible to run compressor, or
  - b. The liquid receiver on the condenser unit, if it is not possible to run the compressor.



<b>When the Freon cylinder is placed near the compressor</b>	<b>When the Freon cylinder is placed near the liquid receiver.</b>
7.2.1 Fully back seat the compressor suction stop valve and remove the low pressure gauge pipe from the union of the valve.	Having connected the charging pipe to the Freon cylinder, place the cylinder in an inclined position in the bucket of water on platform scales or suspend it from a suitable spring balance.
7.2.2 Connect the Freon charging pipe to the union on the valve but do not tighten the flare nut. Open the cylinder valve on the Freon cylinder for a second or two to expel the air from the charging pipe; then immediately tighten the flare nut on the charging pipe.	The outlet valve of the cylinder must not be the lowest point of cylinder, otherwise there is a risk of scale from the internal walls off the cylinder or other impurities being transferred into the system with the liquid Freon.
7.2.3 Make a note of the weight of the Freon cylinder, fully open the cylinder valve, then turn the stem of the compressor suction stop valve about three turns clockwise to admit the Freon gas into the system.	Connect the Freon charging pipe to the purge valve on the liquid receiver but do not tighten the Flare nut. Open the valve on the cylinder very slightly until gas escapes from the loose connected flare nut, then tighten the flare nut.

- 7.2.4 Allow the pressure of the Freon gas into the system build up to about 3 kg/cm<sup>2</sup> then start the compressor. Make a note of the weight off the Freon cylinder, then fully open the valve on the cylinder and the purge valve to admit Freon into the system. Observe the scale reading frequently.
- 7.2.5 Apply blow lamp to the bucket of water on which the cylinder is placed in order to heat the cylinder, when it is found that sufficient weight of Freon is transferred from the cylinder to the system, close cylinder valve, stop compressor suction stop valve, remove the charging pipe from it, reconnect the low pressure gauge pipe, then turn the stem of the compressor suction stop valve one turn clockwise. Should the flow of Freon become retarded or cease owing to equalisation of pressure in the cylinder and the system, heat should be applied by blowing the water bucket on which the cylinder is placed.

## CHAPTER 8

### CHECKING REFRIGERANT LEVEL

The refrigerant level should be checked about once every three months or whenever a shortage of refrigerant in the system is suspected, and it is to be noted that the level should be checked after the coach has returned from a journey in service and running under normal conditions. Proceed as follows :

- Short the Cooling Test studs on the control panel.
- Start the compressor and allows it to run until all foaming visible in the side glass.
- Then close the outlet stop valve situated on the liquid receiver.
- Allow the compressor to run until the suction pressure falls to 2 to 3 lbs/sq. inch. and compressor stops under control of low pressure cut-out switch. Some pressure due to Freon gas evaporating out of the oil in the crank case will accumulate in the low pressure section of the system. This will cause the low pressure switch to cut in and start the compressor again after an interval of few minutes. Allow the compressor to cycle once or twice, then close the inlet stop valve on the top of the liquid receiver and switch off the compressor.
- Open the inlet and outlet stop valves on the liquid receiver and remove the shorting on the C.T. terminal.

**Note:** Should the coach have been standing idle for some time without running the plant and it is considered necessary to check the refrigerant level, the compressor should be run normally for 15 minutes before proceeding to check the level.

**Note :**The liquid receiver is provided with two sight glasses. It is possible to observe the liquid refrigerant by directing the light of electric torch through the upper sight glass and looking through the lower one while the equipment is in operation.

**Note :** The minimum amount of Freon necessary in the system to enable the equipment to maintain its refrigeration function properly, is a level in the receiver of sufficient depth to ensure that outlet in the bottom of the receiver is just covered constantly while the equipment is in operation. The level of the Freon in the liquid receiver will fluctuate for a few minutes immediately after starting the compressor, but during steady operation of about 10 minutes after starting, the level will become normal at about the bottom of the lower sight glass of the receiver. The approximate quantity of refrigerant required for various types of coaches is given in table ( at Appendix-D).

## CHAPTER 9

### AREAS FOR IMPROVEMENT

Following are some areas, where there is a need for strict compliance of the maintenance practices :

- 9.1 Compressor shaft seals,
- 9.2 Refrigerant pipes, fittings and valves, flares, gauges, site-glass & ballows of cut-outs and gauges

#### 9.1 COMPRESSOR SHAFT SEAL

The refrigerant gas leaks due to failure of compressor shaft seal. Gas leakage through shaft seal can be minimised by taking the following steps :

##### 9.1.1 Misalignment

Proper alignment between compressor and motor is vital for satisfactory performance of shaft seals. Misalignment of more than 0.15 mm will lead to malfunctioning of the shaft seal. It is essential, therefore, that the shafts of compressor and motor are aligned with the help of dial gauge to an accuracy of 0.5 mm thereby providing margin for any degradation during service running continuously in vacuum, high speed.

##### 9.1.2 `O' rings bellows

*Maintenance Handbook for Conventional AC Coaches  
July'1999*

It has been observed that the bellows are tearing and the 'O' rings are getting deformed, due to inferior quality of materials. It is suggested that acceptance, sampling and destructive test be carried out on all rubber components to determine compression strength, influence of oil and, dimensional accuracy. These tests should be carried before and after heat ageing and oil immersion as specified.

### **9.1.3 Replacement during POH**

It should be ensured that shaft seals with rubber components which have undergone in service are not reused under any circumstances.

### **9.1.4 High discharge pressure**

High discharge pressure will result in high oil temperature. This is likely to affect the rubber components of the shaft seal. Hence, to prevent shaft seal failures, continuous high discharge pressure should be avoided. Periodical and through cleaning of the condenser with detergents and high pressure jet must be ensured.

### **9.1.5 Oil pressure cut-out**

This is provided to cut off power supply to the compressor in case of inadequate lubrication or failure of oil pump, to avoid oil starvation to the pistons and shaft

seal and to save the compressor and shaft seal from damage.

In some of the coaches the low oil pressure cut-out switches are by passed due to maintenance problems. This can be one of the reasons for the failure of shaft seals and compressors. Therefore low oil pressure cut-out switch should not be isolated for reasons of maintenance difficulties.

## **9.2 Refrigerant Pipes, Fittings and valves**

Leakage of refrigerant through pipes, fittings and valves can be reduced by taking the following steps :

### **9.2.1 Gaskets**

In coach air-conditioning system, gaskets are provided at several places such as receiver end plates, condenser unit inlet/outlet flanges and compressor suction/discharge pipe flanges. Gasket leaks occur due to shrinkage of gasket and relaxation of tension in the bolts. These bolts need periodical tightening. Whenever, a gasket is replaced, the mating surface of flanges should be thoroughly cleaned. For a leak proof joint, the surface should be clean and flat.

### **9.2.2 Gauge Line Flare Joints**

All the flare joints on gauge lines should be replaced by solder nipples to avoid leakage through flare joints. While tightening the nipples on the joints the threads should be provided with Teflon or neoprene tape.

## CHAPTER 10

### DETAILS OF FUSES USED IN A.C. CONTROL PANEL

FUSE No.	Capacity (in amp.) (HRC)	Circuit in which provided	Equivalent tinned copper fuse wire to be used in emergency.
F1+ F1-	100	Compressor Motor	14 SWG
F2+ F2-	10	Blower fan Motor	29 SWG
F3+ F3-	60	Air Heater	16 SWG
F4+ F4-	02	Control fuse for 12,13 and 13 A	39 SWG
F5A+ F5B -	15	Condenser Fan Motor 1 & 2	26 SWG
F6 +	2	Compressor motor pilot lamp & heater element of OP relay	39 SWG
F7+	2	Solenoid valve for ACCEL compressor	29 SWG
F8+	2	LV Relay	39 SWG
F9+	2	Air heater pilot lamp	39 SWG
F10	2	Blower fan pilot lamp	39 SWG
F36	2	Blower fan motor contractor	39 SWG
F37+	2	Blower fan motor contractor	39 SWG
F38+ F38-	2	HRC Pilot -Relay Air heater contractor coil	39 SWG
F39-	2	---- do-----	39 SWG



## OTHER FUSES

Fuse	Capacity (in amp.) ( HRC)	Circuit in which provided	Equivalent tinned copper fuse wire to be used in emergency.
Battery + & -	300	Battery Circuit	3 X 14 SWG
Alterna- tor Load + & -	250 (2 Nos.)	Alternator Load Circuit ( Fuses are in Power panel)	2 X 14 SWG
AC Control Panel Mains + & -	160 ( 2 Nos.)	Control panel PR & NPR ( Fuses are in power panel)	14 SWG
Regula- tor Fuse	5	Field Circuit of Alternator	33 SWG
Regula- tor Fuse	120	AC mains fuse of Alternator (Fuses are in Regulator)	145 SWG

## CHAPTER 11

### TOOLS AND INSTRUMENTS FOR AC COACH MAINTENANCE DEPOT

Following are the Plants, Tools and Instruments required for AC Coach maintenance :

- Battery Charger 200 A , 110/140 V
- Stationary compressor, 100 lt/min. At 12 Kg./sq.cm. Reservoir capacity 2000 lt.
- Portable high pressure water jet washing equipment (12 Kg./cm<sup>2</sup>.) with 3 mm jet nozzle and valve (for condenser).
- Variable speed motor.
- Gas welding equipment.
- Set of Spanners, screw drivers, pliers, knife etc.
- Set of special ring spanners, box spanners, ratchet heads.
- Torque wrenches, hand drill, files twist, drill bits.
- Gas cylinders with torches for welding and brazing.
- Small electric arc welding set.

- De-watering pump for pit line.
- Digital multimeter 5% accuracy (2 Nos.).
- Shunt for measurement of current.
- Vacuum and pressure gauge.
- Contact probe type electronic temperature indicator - (10 to 200 degree C) 2 Nos.
- Vibration Meter.
- Torque wrench calibrator - 1 No.
- Megger 2 Nos.
- Cell Tester (N/L & F/L voltage)
- Micrometer, Vernier Calliper, Filter gauge.
- Clip-on Ammeter
- Ductor Ohm-meter/Kelvin bridge Meter.

## CHAPTER 12

## TROUBLE SHOOTING

### 12.1 MECHANICAL SERVICE ANALYSIS

#### 12.1.1 Compressor will not start

CAUSE	SYMPTOMS	REMEDY
High head pressure	Starter overload cuts out.	Reset starter overload and determine cause of high head pressure.
Defective pressure switch	Pressure switch contacts remain open regardless of pressure.	Repair or replace pressure switch.
Loss of refrigerant charge	Pressure switch contact open.	Check systems for leaks; repair leaks and recharge system.
CAUSE	SYMPTOMS	REMEDY
Compressor is frozen	Liquid flooding, expansion valve chocking in suction strainer or excess gas.	Repair or replace compressor.

### 12.1.2 Compressor Short-cycles

Defective thermostat	Thermostat differential too close.	Replace thermostat.
Incorrect setting of low-pressure side of pressure switch.	Compressor cycling on low pressure switch.	Reset low pressure switch differential.
Low refrigerant charge	Compressor cycling on low pressure switch.	Check system for leaks, repair leaks and add refrigerant.
Defective overload.	Compressor cycling on overload.	Replace overload.
Evaporator blower and motor belts slipping.	Compressor cycling on low-pressure switch.	Tighten or replace belts.
Dirty or plugged air filters.	Less cooling frosting on cooling coil & suffocation in AC compartment.	Clean or replace air filters.

### 12.1.3 Compressor Runs Continuously

CAUSE	SYMPTOMS	REMEDY
Excessive load	High dry-bulb or wet-bulb temperature in conditioned area.	Check for excessive fresh air, infiltration.
Air or non condensable gases in the system.	Higher than normal head pressure.	Purge system, after drenching receiver with chilled water/

		Ice, then purge from purging valve, intermittently until visible gas is found escaping.
Thermostat setting too low.	Lower than normal temperature in conditioned area.	Reset thermostat.
Dirty condenser	Higher than normal head pressure.	Clean condenser.
Low refrigerant charge.	Lower than normal suction pressure.	Check system for leaks; repair and add refrigerant.
Overcharge of refrigerant.	Higher than normal head pressure.	Draw out excess refrigerant.
<b>CAUSE</b>	<b>SYMPTOMS</b>	<b>REMEDY</b>
Compressor valves leaking.	Pressure equalise rapidly when the system is turned off.	Replace valve plate assembly or the complete hermetic compressor.
Expansion or strainer plugged.	Lower than normal suction pressure.	Clean expansion valve or strainer.

#### 12.1.4 System Short of Capacity

Low refrigerant charge	Lower than normal head and suction pressures.	Check system for leaks; repair leaks and add refrigerant.
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Defective expansion valve.	Lower than normal suction pressure.	Replace expansion valve.
Air or non condensable gases in the system.	Higher than normal head pressure.	Purge system.
Dirty condenser.	Higher than normal head pressure.	Clean condenser.
Overcharge of refrigerant.	Higher than normal head pressure.	Draw out excess refrigerant in spare cylinder.

### 12.1.5 Head Pressure too High.

CAUSE	SYMPTOMS	REMEDY
Expansion valve or strainer plugged.	Lower than normal suction pressure.	Clean expansion valve or strainer.
Condenser air short circuiting/ cycling.	Higher than normal head pressure.	Remove obstructions or causes of short circuiting.
Overcharge of refrigerant.	Higher than normal head pressure.	Draw out excess refrigerant.
Air or non condensable gases in the system.	Higher than normal head pressure.	Purge system.
Dirty condenser.	Higher than normal head pressure.	Clean condenser.

Low refrigerant charge.	Sight glass indicates bubbles or liquid level indicator on receiver indicates shortage of refrigerant (after pump down).	Check system for leaks; repair leaks and add refrigerant.
Compressor valves leaking.	Lower than normal head pressures and pressures equalise rapidly when system is turned off.	Replace valve plate/ reeds assembly or the complete hermetic compressor.

#### 12.1.6 Suction Pressure too High.

CAUSE	SYMPTOMS	REMEDY
Excessive load on system.	Compressor runs continuously and capacity is low.	Remove conditions causing excessive load.
Expansion valve is stuck in open position.	Lower than normal head pressure. (LP $\leq$ HP)	Repair or replace expansion valve.

#### 12.1.7 Suction Pressure too Low.

Low refrigerant charge.	Sight glass indicates bubbles or liquid level valve on receiver indicates shortage of refrigerant.	Clean system for leaks; repair leaks and add refrigerant.
Expansion valve or strainer plugged.	Suction line is warm, expansion valve or strainer	Clean strainer expansion valve.



	may be showing frost, and system capacity is low.	
Evaporator air volume low.	Abnormally cold suction line and low suction pressure.	Increase air over the evaporator by proper RPM of BFM, Direction of fan blade and drum.
<b>CAUSE</b>	<b>SYMPTOMS</b>	<b>REMEDY</b>
Stratification of cool air in conditioned area.	System capacity is low and temperature of return air is low.	Increase air velocity through supply grills.

### 12.1.8 Compressor is Noisy.

Warm or scored compressor bearings.	Noticeable knock from compressor.	Replace/attend the compressor bearing.
Expansion valve is stuck in open position or is defective.	Abnormally cold suction line, high suction pressure, and lower than normal head pressure.	Repair or replace expansion valve.
Overcharge of refrigerant or air and non condensable in system.	Higher than normal head pressure.	Purge system by explained method or draw out excess gas.
Overcharge of oil.	Oil sight glass in compressor is completely filled during operation.	Drain excess oil.

Liquid refrigerant flooding back to compressor.	Abnormally cold suction line and high suction pressure.	Repair or replace expansion valve.
<b>CAUSE</b>	<b>SYMPTOMS</b>	<b>REMEDY</b>
Shipping or holddown bolts not loosened or removed.	Noticeable transmission of vibration from compressor to reset of unit compressor held firmly in mounting.	Loosen compressor holddown bolts so compressor is freely floating in mountings.
Lack of oil.	Oil level below midpoint of the oil sight glass in compressor during operation.	<ol style="list-style-type: none"> <li>1. Check weather cooling coil has been flooded with oil and then Pump down.</li> <li>2. Look for oil leakage and add oil if required.</li> <li>3. Check seal seepage.</li> <li>4.</li> </ol>
Broken compressor valves.	Rapid equalisation of the pressures when compressor stops.	Replace valve plate assembly or the complete hermetic compressor.

**12.1.9 Compressor Loses Oil.**

CAUSE	SYMPTOMS	REMEDY
Leaks in system	Presence of oil at piping joints or connections.	Repair leaks and add refrigerant and oil as required.
Shortage of refrigerant.	Lower than normal suction pressure. Sight glass indicated bubbles or liquid level valve on receiver indicates shortage of refrigerant.	Check system for leaks; repair leaks and add refrigerant.
Expansion valve or strainer plugged.	Lower than normal suction pressure.	Clean expansion valve/strainer.

## 12.2 ELECTRICAL SERVICE ANALYSIS

### 12.2.1 Compressor & Condenser Fan Motor will not start

CAUSE	SYMPTOMS	REMEDY
Power failure	Test lamp or voltmeter indicates no voltage at disconnect switch.	Ensure power supply.
Fuse blown.	Test lamp or voltmeter shows voltage on line side of disconnect switch but not on unit side.	Check the equipment or ageing of fuse and replace blown or defective fuse.
Thermostat setting too high.	Thermostat setting above the room temperature.	Reduce temperature setting of the thermostat.
Defective thermostat	Thermostat contacts or starter and fan proving relay do not become energised.	Check wiring and make necessary repairs.
Defective controls.	Compressor contactor or starter and fan relay do not become energised.	Detect the area of defect and location and allow accordingly.
Low voltage	LVR tripped.	Check for tripping (low voltage) & reset.

CAUSE	SYMPTOMS	REMEDY
Defective dual pressure control.	Dual control contacts remain in open position.	Replace the control.

### 12.2.2 Compressor will not start, but Condenser Fan runs

Faulty wiring to compressor motor.	Test lamp or voltmeter indicates no voltage at compressor.	Check compressor wiring and repair/attend
Defective compressor motor.	Voltage is available at compressor motor, but an open winding, ground or stuck compressor prevents operation.	Replace/attend the compressor or motor as applicable..
Defective compressor overload (single phase only)	Overload contacts remain in open position.	Replace overload.

### 12.2.3 Condenser Fan motor will not start, but Compressor runs

CAUSE	SYMPTOMS	REMEDY
Defective fan relay.	Relay contacts do not make when coil is energised.	Repair or replace relay (s).
Faulty wiring to fan motor.	Test lamp or voltmeter indicates no voltage at fan motor.	Check fan motor wiring and repair.
Defective fan motor.	Test or voltmeter indicates voltage available at motor.	Replace fan motor.

### 12.2.4 Condenser Fan Motor runs, But compressor Motor, Hums and will not start.

Low voltage	Test lamp or voltmeter indicates inadequate voltage at compressor.	Check line voltage; determine the location of the voltage drop.
Faulty wiring	Test lamp or voltmeter indicates inadequate voltage at compressor.	Check wiring and make necessary repairs.
Defective compressor	Test lamp or voltmeter indicates adequate voltage available at compressor.	Replace compressor.
CAUSE	SYMPTOMS	REMEDY
High head pressure.	Higher than normal head pressure for	Check head pressure and complete

	existing conditions.	operation of system to remove the cause of high-pressure condition.
Failure of one phase (three phase only).	Test lamp or voltmeter indicates no voltage from one phase to ground.	Check fuse and wiring.
Defective potential relay (single phase only).	Potential relay contacts do not close for starting.	Replace potential relay.

### 12.2.5 Compressor start, but Cycles on Overload.

Low voltage	Test lamp or voltmeter indicates inadequate voltage at compressor.	Check line voltage; determine the location of the voltage drop.
Faulty wiring	Test lamp or voltmeter indicates inadequate voltage at compressor.	Check wiring and make necessary repairs.
Defective overload.	Overload is breaking contact under normal operating conditions.	Replace overload.
<b>CAUSE</b>	<b>SYMPTOMS</b>	<b>REMEDY</b>
Unbalanced line (three phase AC motor only)	Test lamp or voltmeter indicates unequal phase voltages.	Check wiring.

### 12.2.6 Evaporator Fan Motor will not start.

Power failure	Test lamp or voltmeter indicates no voltage at disconnect switch.	Check and attend from source of power.
Fuse blown	Test lamp or voltmeter shows voltage on line side of disconnect switch but not on unit side.	Replace blown or defective fuse.
Faulty wiring	Evaporator fan relay(s) do not become energised.	Check wiring and make necessary repairs.
Defective fan motor	Test lamp or voltmeter indicates voltage available at motor.	Replace fan motor.
Defective fan relay	Relay contacts do not make when coil is energised.	Repair or replace relay(s).



## CHAPTER 13

### DO'S AND DON'TS

#### 13.1 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.

#### 13.2 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 the pressure of 250 PSI to the entire system since the expansion valve and compressor valve may get damaged.
- Don't use old gaskets again, while assembling. Teflon taping without cleaning the threaded portion is not to be done be avoided.
- Don't remove 'Catch all' filter into open air at any and all weather condition and replace if exposed to the atmosphere at once.

## **CHAPTER 14**

### **MODIFICATIONS DONE ON SELF GENERATING A.C. COACHES**

- Shifting of roof mounted evaporator unit away from the lavatory to the linen room. Drawing No. W GFSCZAC-6-4-004.
- Provision of drip sheet on canvass ducting - Drawing No. ICF/SK-4-4-067.
- Tapping of connection for condenser water cooling from the bottom of the tank and for wash basin at a height of 75 mm from the bottom. Drawing Nos. (A) W GSCWAC-6-3-011 Alt. `C`, (B) WGSC WAC-6-3-012 Alt. `Nil`.
- Modification to duct and air inlet to compartment with a new type of diffuser. Drawing No. WGFAC3-4-4-309.
- Provision of hooter for heater circuit. Drawing No. WGSCWAC-7-0-007.
- Provision of separators in the middle, between the rows of the batteries. Drawing No. WSFAC-7-1-030.
- Introduction to belt tensioning indicator in place of limit pipes in tensioning device.

- Modification of air inlet arrangement in the Attendant and First 4 Berth compartment. Drawing No. WGFAC3-7-3-305.
- Guide bush over the tension rod. Drawing No. ICF/SK-9-0-498.
- Modification to fresh air filter inlet adjustable with butterfly valve. Drawing No. MG/WGSCWAC-4-4-008.
- Introduction of new fresh air and return air filter. Drawing No. MG/WGSCWAC-4-4-005.
- Shifting of alternator- Junction box at the bogies over the alternator to the other side of the bolster frame as shown in Drawing No. WGFAC3-7-1-303.
- Transformer/Rectifier - Precooling location - mounting position interchanged. Drawing No. WGFAC3-9-0-303.
- Shifting of the precooling plugs from the underframe to the end wall diagonally opposite. Drawing No. WGFAC-7-1-308.
- Relocation of the cubicle from behind luggage compartment to lavatory partition in AC 2 -tier to avoid obstruction to the passage. Drawing No. WGSCWAC-9-0-001 Alt. 'C'.
- Provision of berth reading light for longitudinal berth s. Drawing No. (1) ICF/SK-7-6-063, (2) WGSC WAC-7-0-015.

- Compressor guard frame fixing hardware altered from M6 to M10. Drawing No. (1) WGGFSCZAC-9-0-010 (2) WGFSCZAC-9-0-011.
- The middle big panel of the flap door for attending to the blower motor has been made small for easy maintenance. Drawing No. WGSCWAC-4-3-020.
- Regulation of water flow rate to bare requirement for cooling of condensers used on Air-conditioned coaches as per Modification Sheet No. RDSO/AC/MS/10 dated 25.1.83.
- To prevent the jamming of suspension pin into the suspension bush used for hanging 18 KW brushless alternator M/s KEL Ltd., Kindara, as per Modification Sheet No. RDSO/AC/MS/4 dated November 1981.
- Protection covering to the packless vibration observer pipe used on suction line ahead of compressor as per modification Sheet No. ICF/MOD/ACC/83/2 dated 31.10.83 and 3.11.83.
- Modified suspension arrangement for 18 KW Brushless Alternator in self generating Air conditioned Coaches as per modification Sheet No. ICF/Mod/ACC/85/1 dated November'85.
- Modification to prevent rotation of the suspension pin of bogie mounted 18 KW Brushless Alternator as per Modification Sheet No. ICF/MOD/ACC/86/1 dated 29.11.85/14.12.85.

## **APPENDIX - A**

### **DESCRIPTION OF POWER SUPPLY FOR COACH A/C SYSTEM**

The Electrical power for the self generating type coaches is derived from the alternator mounted on bogie transform of the coach and driven by the axle through 'V' belt drive as long as the coach is in motion at the minimum full load output (MFO) speed of the alternator. During stationary or when the coach is running at less than MFO speed the entire coach load is met by the battery of 800 AH capacity. Provision for charging and precooling the coach from external supply has been made by means of battery charger, 200 A rating mounted on the coach under frame. Two numbers of 415 V, 3 Phase AC precooling socket have been provided diagonally on the end walls. The alternator working on association with rectifier cum regulator gives output of 18 KW at 130 V DC. One alternator set per A/C plant has been fitted in the self generating type A/C coaches. ( The power circuit diagram is shown at next page)

## APPENDIX - B

### TEMPERATURE SETTING

The temperature inside the air conditioned compartment is controlled by mercury in glass thermostat with different settings. Operation of cooling or heating take place in accordance with ambient conditions.

TYPE OF COACH	MODE	LOW ( ° C)	MEDIUM (° C)	HIGH ( ° C)
I st AC	Cooling	22	24	25
I st AC	Heating	17	19	20.5
II nd AC Sleeper & Others	Cooling	--	24	25.5
II nd AC Sleeper & Others	Heating	--	19	20.5

The temperature control thermostat are fitted in the return air passage. Two types of thermostat are used, one for controlling the cooling and the other for controlling the heating. Both these thermostat are alike. each consisting of a sealed glass tube containing a column of mercury. In all there are 6 thermostats, 3 for cooling and 3 for heating.

## APPENDIX - C

*Maintenance Handbook for Conventional AC Coaches*  
July'1999

## HEAT LOAD CALCULATION OF AC 2T SLEEPER COACH

AC air-conditioned coach has to work under widely varying conditions of ambient temperature, latitude, passenger load etc. In deciding the capacity of the plant, certain assumption regarding number of adverse conditions of the working are to be made and based on these assumptions the plant capacity required is worked out.

RDSO specification No. TRC-1-72 stipulates certain standard comfort conditions, volume of fresh air required per passenger per minute, coefficient of heat transfer for various parts of the coach etc.

Data and constants used and the assumptions made are,

### ABBREVIATIONS :

T.D.	=	Amb. Temp. Diff.
T.D.S.	=	Solar Temp. Diff.
K	=	Coefficient of heat transfer = $\text{K cal/Hr/m}^2/\text{°C}$
U	=	Coefficient of heat for window due to solar heat gain.
G.D.	=	Grains difference



COEFFICIENT OF HEAT TRANSFER (k) IN K cal/Hr/m<sup>2</sup>/°C for,

Wall and end partitions	= 0.615
Roof	= 0.65
Floor	= 0.72
Window (conduction)	= 1.94
`U' for window	= 5.34

The internal temperature in relation to the outside temperature and relative humidity to be maintained when operated with full compliment of 46 passengers, lighting and fan load etc.

	DBT ° C	WBT ° C	RH %	Moisture grains
Outside conditions	45	25	-	82
Inside conditions	25	--	40	56
T.D. =		20		G.D. = 26

T.D. for end portion is always considered to be 3° C less than T.D. for other parts of the coach, since non-air-conditioned space adjacent to the air-conditioned compartments is considered to have a temperature of 3° C less than the ambient temperature.

Solar Temp. Difference (TDS)	Side wall - 90° C
	Roof - 10.55 ° C
	Windows - 95.55 ° C

Requirement of fresh air  
for non-smoking compartments

= 0.35 m<sup>3</sup>/passenger/minute

Quantity of ventilating air  
for 46 passengers (Q)

= 0.35 x 46 = 16.1 m<sup>3</sup>/minute  
= 16.1 x 35.3 = 568.33 ft<sup>3</sup>/minute

The following are the wattage’s considered for various electrical appliances. 2’ Fluorescent tube light - 24 W.

Even though the wattage of the tube is 20 W, the choke also consumes energy. Hence, 1.2 times the wattage i.e. 1+2 x 20 = 24 W has been considered for the purpose of heat load calculations.

- Incandescent lamps

- 15 W
- Carriage Fan

- 29 W

**DATA COLLECTED FROM TRAIN’S A.C. MANUAL**

- Heat transfer from equipments and fans

- 2545 BTU/HP/Hr
- Heat Transfer from fluorescent lights  
and incandescent lamps

-3.4 BTU/Watt/Hr.
- Sensible heat per passenger

- 205 BTU  
(51.6 K.Cal/Hr)
- Latent heat per passenger

- 195 BTU/Hr  
(49.12 K.Cal/Hr)
- 1 Ton of refrigeration

- 12000 BTU/Hr  
(3024 K.Cal/Hr)

1 k-calories

- 3.97 BTU/Hr

**DIMENSIONS OF AC PORTION OF COACH**

Length OF AC portion (a)	=	15.2 M
Width of roof (B)	=	3.245 M
Width of floor (C)	=	3.04 M
Height of AC portion (D)	=	2.03 M
Area of side wall (A x D)	=	30.856 m <sup>2</sup>
Area of roof ( A x B )	=	49.324 M <sup>2</sup>
Area of floor ( A x C)	=	46.208 M <sup>2</sup>
Area of end portions	=	6.17 M <sup>2</sup>
Height of window	=	0.56 M
Width of window	=	0.61 M
Area of window 0.56 x 0.61	=	0.3416 M <sup>2</sup>
No. Of windows per side wall	=	16
Total area of windows per side wall	=	0.56x0.61x16=5.466M <sup>2</sup>
Area of side wall excluding windows	=	30.856 - 5.466 = 25.239M <sup>2</sup>

**CONNECTED ELECTRICAL LOADS INSIDE A.C. COMPARTMENT**

Fluorescent lights 2 feet long	=	30 Nos.
Incandescent lamps	=	16 Nos.
Fans	=	8 Nos.
Blower Fan Motors (0.65 HP)=	=	2 Nos.

1. Heat gain due to conduction= $A \times K \times TD \times 3.97$  BTU/Hr

$$\begin{aligned}
 \text{Side wall} &= 50.78 \times 0.615 \times 20 \times 3.97 \\
 &= 2479.64 \text{ BTU/Hr} \\
 &\quad (624.59 \text{ K.Cal/Hr}) \\
 \text{Roof} &= 49.324 \times 0.65 \times 20 \times 3.97 \\
 &= 2545.61 \text{ BTU/Hr} \\
 &\quad (641.21 \text{ K.Cal/Hr}) \\
 \text{Floor} &= 46.208 \times 0.72 \times 20 \times 3.97 \\
 &= 2641.62 \text{ BTU/Hr} \\
 &\quad = 665.4 \text{ K.Cal/Hr} \\
 \text{End partision} &= 2 \times 6.17 \times 0.615 \times (20-3) \times 17 \times 3.97 \\
 &= 512.288 \text{ BTU/Hr} \\
 \text{Window} &= 5.466 \times 2 \times 1.94 \times 20 \times 3.97 \\
 &= 1683.8 \text{ BTU/Hr} \\
 \text{Total} &= 2479.64 + 2545.61 + 2641.62 + 512.288 + 1683.8 \\
 &= 9862.954 \text{ BTU/Hr} \quad \text{--- (I)}
 \end{aligned}$$

$$\begin{aligned}
 2. \quad \text{Solar Heat Gain} &= A_x K_x \text{TDS} \times 3.97 \\
 \text{Side wall} &= 25.39 \times 0.615 \times 9 \times 3.97 \\
 &= 557.92 \text{ BTU/Hr} \\
 &= 140.53 \text{ K.Cal/Hr} \\
 \text{Roof} &= 49.324 \times 0.65 \times 10.53 \times 3.97 \\
 &= 1342.81 \text{ BTU/Hr} \\
 &= 338.24 \text{ K.Cal/Hr} \\
 \text{Window} &= 5.466 \times 5.34 \times 95.55 \times 3.97 \\
 &= 11071.34 \text{ BTU/Hr} \\
 &= 2788.75 \text{ K.Cal/Hr} \\
 \text{Total} &= 557.92 + 1342.81 + 11071.34 \\
 &= 12972.069 \text{ BTU/Hr} \quad \text{---- (II)} \\
 &= 3267.52 \text{ K.Cal/Hr}
 \end{aligned}$$

### 3. Heat gain due to passengers (BTU/Hr.)

$$\begin{aligned}
 \text{S.H.} &= 205 \times \text{No. of passengers} \\
 \text{L.H.} &= 195 \times \text{No. of passengers.} \\
 \text{S.H.} + \text{L.H.} &= 400 \times \text{No. of passengers.} \\
 &= 400 \times 46 = 18400 \text{ BTU/Hr} \\
 &= 4634.76 \text{ K.Cal/Hr} \text{ -----(III)}
 \end{aligned}$$

4. Heat gain due to ventilation (BTU/Hr) =

$$\begin{aligned}
 \text{S.H.} &= 1.08 \times Q \times \text{TD} \times 9/5 \\
 &= 1.08 \times 568.33 \times 20 \times 9/5 \\
 &= 22096.67 \text{ BTU/Hr} \\
 &= 5565.91 \text{ K.Cal/Hr} \\
 \text{L.H.} &= 0.68 \times Q \times \text{Gd} \\
 &= 0.68 \times 568.33 \times 26 \\
 &= 10048.07 \\
 &= (2531 \text{ K.Cal/Hr})
 \end{aligned}$$

$$\begin{aligned}
 \text{Total} &= 22096.67 + 10048.07 \\
 &= 32144.7 \text{ BTU/Hr} \\
 &= 8096.91 \text{ K.Cal/Hr}
 \end{aligned}$$

5. Heat gain due to elect. Appliances = wattage  $\times$  3.4  
BTU/Hr or H.P.  $\times$  3600 BTU/Hr

$$\begin{aligned}
 \text{Fluorescent Light 20 W} &= 20 \times 1.2 \text{ W} \\
 &= 1.2 \times 20 \times 3.40 \times 30 \\
 &= 2448 \text{ BTU/Hr} \\
 &= 616.62 \text{ K.Cal/Hr}
 \end{aligned}$$

$$\begin{aligned}
 \text{Incandescent lamps} &= 15 \times 16 \times 3.40 \\
 &= 816 \text{ BTU/Hr}
 \end{aligned}$$

$$= 205.54 \text{ K.Cal/Hr}$$

$$\begin{aligned} \text{Fan} &= 29\text{W} \times 8 \times 3.4 &= 788.8 \text{ BTU/Hr} \\ & &= 198.69 \text{ K.Cal/Hr} \end{aligned}$$

$$\begin{aligned} \text{Blower fan} &= 0.65 \text{ HP} \times 2 \times 2545 \\ &= 3308.5 \text{ BTU/Hr} \end{aligned}$$

$$\begin{aligned} \text{Total} &= 2448 + 816 + 788.8 + 3308.5 \\ &= 7361.3 \text{ BTU/Hr} \quad \text{--- (V)} \\ &= 1854.22 \text{ K.Cal/Hr} \end{aligned}$$

$$\begin{aligned} \text{Total of I + II + III + IV + V} &= 80741.023 \text{ BTU/H} \\ &= (20337.78 \text{ K.Cal/Hr}) \end{aligned}$$

$$\begin{aligned} \text{Heat gain due to infiltration @ 10\%} &= 8074.1 \text{ BTU/Hr} \\ &= (2033.78 \text{ K.Cal/Hr}) \end{aligned}$$

$$\begin{aligned} \text{Gross Total Heat gain} &= 81003.07 + 8100.3 \\ &= 88815 \text{ BTU/Hr} \\ &= 22371.56 \text{ K.Cal/Hr} \end{aligned}$$

$$\begin{aligned} \text{Refrigeration capacity (TR)} &= \frac{88815}{12000} = 7.4 \text{ TR} \end{aligned}$$

$$\begin{aligned} &= \frac{2237.56}{300} = 7.4 \text{ TR} \end{aligned}$$

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The following table shows the capacity of AC plants for various types of AC coaches :

Sr.	Type of coach	No.of AC Plants	Calculated AC Load of coach	Capacity of AC Plants provided
01	B.G. AC Ist class.	01	5.30 TR	6.7 TR x 1
02	a) B.G. AC 2 Tier.	02	7.48 TR	5.2 TR x 2
	b) B.G. AC composite coach.	02	7.97 TR	54 TR x 2
03	B.G. Chair car	02	11.10 TR	6.7 TR x 2
04	B.G. AC 3 Tier	02	--	6.6 TR x 2
05	M.G. AC 2 Tier	01	6.39 TR	6.7 TR x 1



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