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GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

(For official use only)

MAINTENANCE HANDBOOK FOR CENTRALISED AC PLANTS

CAMTECH/99/E/CACP/1.0

☝entr*e*
for
✌dvanced
Maintenance
❄☜☝**H**nology

Excellence in Maintenance

Maharajpur, Gwalior - 474 020

CONTENTS

PREFACE

The proper upkeep and maintenance is necessary to ensure good reliability and availability of centralised air-conditioning plants. This handbook on maintenance of centralised air-conditioning plants 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:10.06.99 *Jt. Director*

FOREWORD

Centralised AC Plants in Indian Railways are installed at many important and key locations. Some of our vital installations like Computerised Reservation Centres, Electronic Test Rooms, Spectrograph etc. depend on these for properly discharging their functions. CAMTECH has prepared this handbook to assist the field personnel in proper upkeep and maintenance of these AC plants

A comprehensive troubleshooting chart is also given in the book for quick diagnosis of the problem. The book is written in a simple and easy to understand form so that even a grassroot level workman can benifit from reading it and can enhance his understanding of the system which will help in discharging his duties with excellence.

CAMTECH,
Gwalior
Date : 25.06.99

D. K. Saraf
Director

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

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

CORRECTION SLIPS ISSUED

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CHAPTER 1

GENERAL

A Central plant with full ducting is best suited for Air-Conditioning of large buildings, conference halls, PRS buildings etc. In the central system the Air-Conditioning plant comprising two or more heavy compressor units including the ancillary equipments like compressors and evaporators are located at a central point usually at the ground floor or basement. The conditioned air is delivered through a ducting system to all parts of the building. A duplicate ducting system is required to take the return air from inside, back to the central plant to be de-humidified cooled and recharged with fresh ventilating air to be circulated once again.

The ducts are usually bulky and cumbersome as they have to handle large quantity of air. To accommodate them and keep them out of sight is a problem which often poses structural difficulties. In a large hall, network of ducting would be required to distribute the air uniformly to all parts. Individual damper vanes are necessary to control the amount of air admitted at each outlet, as also at points where smaller ducts branch out. A considerable amount of adjustment and experimentation would be required to maintain the temperature variation within 2° F or 3° F over all parts.

One advantage of this system is that the processing of air is centrally controlled and therefore a high standard of efficiency can be maintained. The compressor plant itself being large is sturdy and robust and could operate for long periods with little attention. Normally there should be at least two complete independent units, one a working set and second a stand by.

Apart from the objection of the large ducting, the other attendant difficulties of the central plant system are

- Adjustment of individual room temperature as required from time to time is not possible. Therefore the system is definitely wrong from buildings which are split up into a number of small rooms, offices.
- It permits mixing of air, cigarette smoke, bacteria and odour between different areas of offices.
- The ducting occupies an appreciable space.

CHAPTER 2

REFRIGERATION CYCLE

2.1 Refrigerants are heat carrying medium which during their cycle in the refrigerant system absorb heat at a low temperature level and discard the heat so absorbed at a higher level. The refrigerants common used are R-12, R-22, R-11 etc.

The refrigerant have boiling points much below ordinary room temperature, so they exists as gas and are only held in the liquid state by keeping them under pressure.

Refrigeration can be produced by allowing a liquid refrigerant from high pressure vessel to pass and boil inside a coil or evaporator. The latent heat needed for the boiling is taken from the surrounding space of the evaporator, thereby cooling the space. After passing from evaporator, the refrigerant is reclaimed with the help of compressor. The compressor compressed the vapour to the pressure corresponding to a saturation temperature, higher than the temperature of naturally available air or water. The compressor also circulates the refrigerant through the system.

The refrigeration cycle thus comprise of :

- Absorption of heat by the evaporation of a liquid refrigerant in the evaporator at a controlled lower pressure.
- Raising the pressure of the low pressure vapour coming from the evaporator by the use of the compressor.
- Removal of heat from the high vapour in the condenser so as to liquidity or condense the vapour and
- By the use of the throttling device, reducing the pressure of high pressure liquid (from the condenser) to the level of pressure needed in the evaporator.

2.2 STATE OF REFRIGERANT

2.2.1 In Evaporator

As the liquid refrigerant flows through the evaporator, it absorbs heat and changes from liquid state to a saturated vapour. The vapour thus produced remains saturated as long as there is some liquid present. The vapour and liquid will be at saturated temperature and the corresponding pressure. Finally by the time refrigerant approaches the end of the evaporator, all the liquid is used up i.e. all the liquid is vaporised upto the point of saturation.

As the vapour continuous to flow through the evaporator, after all the liquid has been evaporated, it continues to absorb heat. But as there is no liquid left to boil off, the temperature of the vapour rises higher than the saturation temperature and vapour become superheated.

The part of the evaporator in which the liquid boils, is called 'active' and the part of the evaporator, where there is no liquid present but only the superheating of the vapour takes place, is not very effective for refrigeration.

2.2.2 **In Compressor**

In the compressor, due to the work done on compression, the vapour gets further superheated. Therefore the temperature of the discharge vapour will be much higher than the temperature of the saturated vapour.

2.2.3 **In Condenser**

In the condenser, the temperature of the superheated vapour has to be brought down, before it can be condensed into a liquid. In the condenser, once the vapour has been cooled, it begins to condense.

2.2.4 **In Liquid Line**

A the refrigerant effect is obtained by the change of state of liquid to vapour in the evaporator, the expansion valve or throttling device should pass the maximum possible liquid refrigerant from the liquid line to the evaporator.

CHAPTER 3

REFRIGERATION SYSTEM COMPONENTS

Following figure shows the line diagram of the Centralised AC Plant alongwith the system components

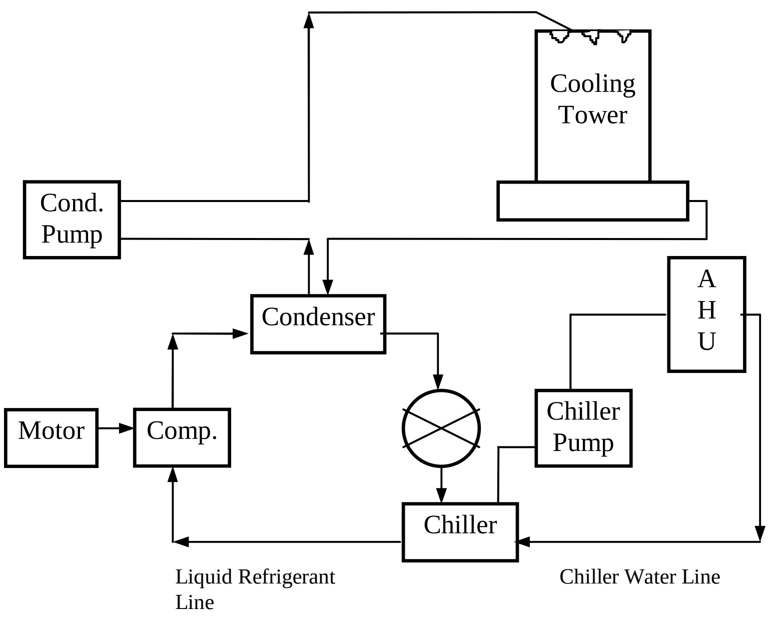

Fig. 3.1 CENTRAL PLANT AIR-CONDITIONING

3.1 COMPRESSOR

For reclaiming the refrigerant vapour leaving the evaporator, it must be compressed to the pressure corresponding to saturation temperature higher than the temperature of the naturally available air or water. A compressor also circulates the refrigerant through the system and its capacity determines the capacity of the refrigeration system as a whole.

Types of refrigeration compressor used are: reciprocating, rotary, screw, centrifugal and scroll.

Reciprocating compressor are used in central AC plants. These are available in sizes as small as 1/12 hp to 150 h.p. for large capacity installations.

3.2 CONDENSER

Condenser works as a heat exchange equipment. The functions of the condenser are to de-superheat the high pressure gas, condense it and also subsoil the system.

Heat from the hot refrigerant gas is rejected in the condenser to the condensing medium air or water. Air and water are chosen because they are naturally available. Their normal temperature range is satisfactory for condensing refrigerants.

There are three types condensers viz. i) Air-Cooled ii) Water-Cooled iii) Evaporative. Water cooled condensers are used in Central AC Plants.

3.3 COOLING TOWERS

The cooling towers is used in conjunction with the water cooled condenser. Water in passing through the condenser water tubes only gets warmed up but does not get contaminated. It can therefore be used again, after cooling. The cooling tower cools the warm water for recirculating it in the condenser. It is thus a water conservation equipment. The heat removed by the refrigeration system from the space or product to be cooled is ultimately thrown to the atmosphere through the cooling tower in a water-cooled condenser system. Thus the cooling tower should function efficiently for the refrigeration system to perform well.

3.4 THROTTLING DEVICE

The pressure of the liquid refrigerant from the condenser/receiver has to be reduced so that it can vaporise at the desired temperature in the evaporator. Also, sufficient liquid has to be fed into the evaporator to meet the refrigeration load. These functions are taken care of by the throttling device.

As the rate of flow of the liquid refrigerant to the evaporator has to be varied according to the load on the system. Further the pressure of the liquid refrigerant at the higher side has to be reduced to the evaporator pressure before it is fed to the evaporator.

These two functions are performed by the throttling device. The throttling device is fixed at the end of the liquid line and the outlet of the device is at the inlet of the evaporator.

3.5 **EVAPORATOR**

The pressure of heat removal from the substance to be cooled or refrigerated is done in the evaporator. The liquid refrigerant is vaporised inside the evaporator (coil or shell) in order to remove heat from a fluid such as air, water or brain. The fluid to be cooled can be made to pass over the evaporator surface inside which the refrigerant is boiling, such a system is called the direct expansion system.

In certain cases such as in big air conditioning system or in industrial processing water or brine is chilled in the evaporator. The chilled fluid is circulated through copper or steel coils over which the air to be cooled is pressed, such a system is called the indirect system. The coil (copper or steel) generally called cooling coils acts a heat exchanger.

CHAPTER 4

OPERATION AND MAINTENANCE

4.1 OPERATION

4.1.1 Starting Procedure

Before starting the plant ensure that all electrical controls, interlocking, safety controls are set correctly. Direction of rotation and greasing of bearing are correct. AC supply is available at 415 V, 3 phase.

- Ensure that the water in the cooling tower sump tank is upto the prescribed level and if not, fill the water upto the required level.

- Open all the valves at the suction and discharge of condenser water pump and condenser. Start the condenser water pump and ensure that the water flow across the condenser is adequate. Start the cooling tower fan (in case of induced draft). Ensure water in the make-up water tank during the operation of the plant.

- Open all the valves at the suction and discharge off chilled water pump and chillier. Start the chilled water pump and ensure that the water flow across the chillier is adequate. Also ensure that water level in expansion tank is adequate during the operation of the plant (in case of chilled water plants).

- Start the air handling units. Dampers on AHU should be kept open.

- Ensure that the oil in the compressor crankcase is upto the prescribed level.

- Ensure that both suction and discharge valves of the compressor (in case heater has been provided).

- Start the compressor on unload and put on load of 50% and 100% gradually. Observe the HP, LP and OP carefully.

  On full loaf : HP should be 14 - 18 Kg/cm^2
  LP should be 3.5 - 4.5 Kg/cm^2
  OP should be 1.5 - 2 Kg/cm^2

- Tank temperature readings every two hour alongwith currents and pressure readings of plants and enter properly in the log book.

4.1.2 **Stopping**

Stopping of the plant should be in following order:

- Stop the compressor unit.

- Close the discharge valve, Condenser inlet globe valve, liquid line valve and suction of compressors.

- Stop condenser water pump.
- Stop cooling tower unit.
- Stop Air handling unit.

4.2 INSPECTION AND ROUTINE MAINTENANCE

4.2.1 Daily

- Checking of lubrication.
- Check pump glands.
- Check water level in cooling towers.
- Do visual check and operate the plant and ensure the working of the plant.
- Check operating pressures.
- Check for unusual noise and vibration.

4.2.2 Weekly

- Clean water strainers.
- Check the earth connection and fuses.
- Clean the condenser and other equipments.
- Check for leakage of gas (exterior).
- Clean the controls.
- Clean all the air filters.

4.2.2 **Monthly**

- Check compressor oil for discoloration or contamination.
- Check starting and running current and voltage while running.
- Check the insulation resistance valve.
- Defrost cooling coil, close suction line slowly and note the efficiency.
- Check oil level.
- Check leak in the seal of shaft.
- Check leak LP and HP cut-outs i.e. 5 $lbs/inch^2$ for LP and 150 $lbs/inch^2$ for HP.
- Check expansion valves.
- Check for entire system with the help of water & soap.
- Clean the drip tray with water.
- Check the condition of blower fans, shafts and its direction of rotation.
- Check the ducting condition.

- Check the working of the plants and limits of vibration and noise.

- Carry out the capacity test.

4.2.3 **Yearly Schedule**

In addition to daily, weekly and monthly schedule, following checks should be done :

- Check suction and delivery of the compressor and its efficiency.

- Change the compressor oil.

- Clean the condenser with compressed air, brush and water carry out pressure test at 250 psi of CO2 for any leaks.

- Dismantle the weather make chamber by removing duct connections and opening the return air box, clean the evaporator coil, drip tray, ducting and repair the return air box (if required) , paint the system and re-install the same.

- Overhaul the blower motor including cleaning of runners.

- Check the service valves for wear.

- Overhaul the compressor motor and starter.

- Clean the contacts of LP/HP switches.
- Check and adjust the alignment of belts and their tension.
- Check the wiring and all the connections including meggering.
- Complete test for leaks.
- Check thermostatic switch and clean the contacts.

CHAPTER 5

SERVICE OPERATION

5.1 COMPRESSOR PUMP DOWN

Before opening the compressor or any other part of the system, the refrigerant has to be collected in the condenser and isolated to prevent it loss. This operation is known as the pump down and comprises of the following steps :

- Use a screwdriver to hold the spring loaded arm 'Up' inside the low pressure switch or put a temporary jumper wire across the terminals to keep the switch closed. This prevents the compressor from stopping before the refrigerant from it is emplied.

- While the compressor is running, slowly close the suction shut off valve.

- When the suction pressure drops top about 0.15 Kg/cm^2 (2 PSI) suction and stopping the compressor, a few minutes wait will be needed to permit the dissolved refrigerant to leave the oil in the crankcase. This will be accompanied by a rise in suction pressure.

- Additional refrigerant then be pumped to the condenser by again reducing suction pressure to 0.15 Kg/cm^2 (2 PSI) by operating the compressor.

- The above procedure should be repeated until there is no rise in pressure above 0.15 Kg/cm^2 after closing the service valves. If after the first such shut off, the suction pressure rises rapidly, this will indicate a leaking dis-charge service valve. No further attempt should be made to pump down. When it is evident that the discharge service. Valve is leaking., close the discharge shut-off valve as quickly as possible. It is recommended at this point that service valve be inspected.

- If normal results are obtained and the 0.15 Kg/cm^2 pressure to held, close the discharge shut-off valve.

- Do not forget to remove the screw driver or the jumper wire from the low pressure switch after the pump down has been completed.

5.2 REMOVING REFRIGERANT FROM THE SYSTEM

In case of an excess charge of refrigerant or in the event of a leak in the condenser, it will be necessary to remove the refrigerant from the system into the cylinder. This comprises of the following steps :

- Connect a suitable line between the angle valve provided for charging and an empty or partly empty refrigerant cylinder. The valve is located on the liquid line after the condenser and the main liquid outlet valve.

- Purge the air from the connection line before tightening the connection.

- Keep the cylinder cold by immersing it in ice cold water. This will ensure a faster refrigerant flow the system.

- Start the compressor and open the liquid line charging valve allowing the liquid to be removed into empty refrigerant cylinder. If suspected excess refrigerant is to be removed, hold the charging valve open only until the discharge pressure reaches the normal reading. After this operation is complete the charging line should be removed and charging valve carefully closed. Where the compressor is not operative, connect an auxiliary condensing unit to draw refrigerant from the system through the charging point and transfer it to the cylinder after condensing it. Use of condensing unit instead of an evacuating unit is advised to obtain faster removal.

- Weigh the cylinder after disconnecting it to see that its weigh does not exceed the original gross weight marked on it.

Caution : Do not overcharge the cylinder as excessive pressure is dangerous.

5.3 PREPARATION FOR A LONG SHUT-DOWN

It is necessary to shut down the system for a long time to perform preventive maintenance and annual overhaul. Besides the system may not be required in cold weather, particularly in Northern locations. It is desirable to pump down the refrigerant chances of refrigerant leak from the line joints and the compressor shaft seal. The following steps should be taken :

- In order to avoid freeze up in chillier during pump down make sure water is circulating through the chillier.

- Make sure that there are no refrigerant leaks on the condenser. Rule out leaks on the hit-gas inlet and liquid outlet joints and the valves. Make sure the valves are holding.

- Pump down the refrigerant as described under compressor pump-down. To ensure that there is no refrigerant left behind the lines, open the liquid solenoid valve.

- Open the main electric dis-connection switch, sealing it in that position with a warning tag against possible unauthorised attempts of operating the system.

5.4 STARTING THE SYSTEM AFTER LONG SHUT-DOWN

After the system shut-down for a long time, observe the following sequence in starting the system:

- Close all water drain, inspect all lines and auxiliary equipments such as cooling tower and water pump.
- Manually rotate the shafts of all auxiliary equipments to make sure, they are free.
- Fillip the condenser water and chilled water circuits.
- Open the compressor discharge shut-off valve and make sure that the suction shut-off valve is open.
- Close the system's main electric dis-connection switches.
- Open the liquid line valve and let out some refrigerant to fill up system by energising the solenoid valve for a short while.
- Leak test the entire system.
- Start the system.

CHAPTER 6

TROUBLE SHOOTING

Before attempting any repairs, the cause of trouble should be determined as accurately as possible. Correct identification of fault will result in an efficient service operation. To help identify the fault ask yourself the following questions :

- Is the system sufficiently charged with refrigerant ? It is overcharged ?
- Is the evaporator functioning correctly ? Are temperature being maintained ? What is the condition of the cooling coil ?
- In the voltage within the tolerance allowed ?
- Does the condenser have sufficiently water supply? Are the temperature satisfactory? Is the auxiliary equipment (pump and fans) in good working order ?
- Is the expansion valve working properly ?
- Are the safety controls set too close to the operating conditions " Are they defective?
- Is there any additional load on the system other than originally provided for ?

Definite symptoms will accompany a faulty operation in the system. The condition which cause these symptoms must be corrected to restore proper operation. The trouble shooting chart help to determine the sources of the trouble and correct them promptly.

Trouble 1 : Compressor fails to start

Possible Cause	Corrective Steps
1.Main disconnect switch open.	1. Close switch
2. Fuse blown	2. Check electrical circuits and motor winding for shorts or grounds. Investigate for possible overloading. Replace fuse after fault is corrected.
3. Defective contractor	3. Repair or replace.
4. System shut down by safety device.	4. Determine type and cause of shut-down and correct it before resetting safety switch.
5. Thermostat setting too high.	5. Check evaporator temperature. Lower thermostat setting,, if possible without freeze-up.
6. Liquid line solenoid will not open.	6. Repair or replace.
7. Motor (electrical) trouble.	7. Check motor for open/short circuits, or burnt-out.
Possible Cause	**Corrective Steps**

8. Loose wiring.	8. Check all wire junctions. Tighten all terminal screw.

Trouble 2 : Compressor Noisy or Vibrating

1. Improper isolation.	1.Check isolator operation.
2.Improper piping support.	2. Relocate, add or remove hangers.
3. Improper clearances.	3. Excessive wear of moving parts. Overhaul compressor and replace defective parts.
4. Flooding of refrigerant into crankcase.	4. Check rating and setting of expansion valve.
5. Belts/Coupling loose of aligned.	5. Tighten/Re-align.

Trouble 3 : High Discharge Pressure

1. Discharge shut-off valve partially closed.	1. Open valve.
2. Condenser water flow insufficient or temperature too high.	2. Check water shut-off valve. Investigate ways to increase water supply.

Possible Cause	Corrective Steps
3. System overcharged with refrigerant. 4.Choked/Clogged condenser tubes. 5. Non-condensable in system.	3. Remove excess. 4. Clean. 5. Purge the non-condensable.

Trouble 4 : Low discharge pressure.

1.Low water temperature	1. Adjust water shut-off valve to reduce water quantity.
2. Suction shut-off valve partially closed.	2. Open valve.
3. Insufficient refrigerant in system.	3. Check for leaks. Repair and add charge.
4. Low suction pressure.	4. See corrective steps for low pressure.
5. Compressor operating unloaded.	5. See corrective steps for failure of compressor to take load.
6. Condenser too large.	6. Check condenser rating table against the operation.

Possible Cause	Corrective Steps
7. Worn piston rings. Worn discharge valve.	7. Overhaul compressor.

Trouble 5 : High Suction Pressure

1. Excessive load.	1. Reduce load or add equipment.
2. Expansion valve over feeding.	2. Check remote bulb. Regulate superheat. Check valve operation. Repair or replace of necessary.
3. Compressor operating unloaded.	3. See corrective steps for failure of compressor to load up.

Trouble 6 : Low Suction Pressure

1. Chilled water pump not operating (Applicable to indirect expansion systems only)	1. Check and start pump.
2. Lack of refrigerant.	2. Check for leaks. Repair and add charge.
3. Evaporator dirty or iced up.	3. Clean or defrost.

Possible Cause	Corrective Steps
4. Clogged liquid line filter-drier.	4. Replace cartridge (s).
5. Clogged liquid line or compressor suction gas strainers.	5. Clean strainers.
6. Expansion valve malfunctioning.	6. Check and reset for proper superheat. Repair or replace if necessary.
7. Condensing temperature too low.	7. Check means for regulating condensing temperature.
8. Compressor will not unload.	8. See corrective steps for failure of compressor to unload.
9. Evaporator fan not operating.	9. Check and start fan. If interlocked check the circuit.

Trouble 7 : Compressor will not unload

1. Sol. Valve in the oil line stuck closed, not relieving oil pressure on the unloader mechanism.	1. Repair or replace the valve after ruling out physical block due to foreign matter.
2. Faulty unloader mechanism.	2. Repair or replace after ruling out other possibilities.

Possible Cause	Corrective Steps
3. Reduction in the compressor capacity not called for.	3. No action.
4. Defective automatic control.	4. Check setting and verify operation.

Trouble 8 : Compressor will not load

1. Inadequate oil pressure.	1. Rule out a clogged oil strainer and foam in the oil, failing which check the oil relief valve and as a last resort verify oil pump and moving parts clearance after disassembly.
2. Solenoid Valve in the oil line not opening for oil flow.	2. Check whether Solenoid Coil getting energised properly.
3. Faulty unloader mechanism.	3. Repair or replace after ruling out the possibilities.
4. Defective automatic control.	4. Check setting and verify operation.

Trouble 9 : Compressor indicate little or no oil pressure.

1. Low oil pressure.	1. See corrective steps for loss of oil. Add oil.

Possible Cause	Corrective Steps
2. Excessive liquid refrigerant in crankcase.	2. Energise crankcase heater. Reset expansion valve for higher super heat. Check liquid line solenoid valve operation.
3. Leaky oil line.	3. Locate the leak and repair the leak.
4. Oil pressure gauge defective.	3. Repair or replace. Keep valve closed except when taking readings.
5. Defective oil pump relief valve.	5. Repair or replace.
6. Oil-failure safety switch defective.	6. Repair or replace.
7. Worn out oil pump.	7. Replace.
8. Broken oil pump tang.	8. Replace pump assembly.
9. Clogged suction oil strainer.	9. Replace pump assembly.
10. Worn out bearings.	10. Overhaul compressor.

Trouble 10 : Compressor Short Cycles.

1.Thermostat differential set too close.	1. Reset differential.

Possible Cause	**Corrective Steps**
2. Leaky liquid-line solenoid valve.	2. Replace solenoid valve, if a non-recycling relay has been provided in the circuit, cycling will not occur.
3. Overcharge of refrigerant.	3. Remove excess to bring down the discharge pressure. If the high pressure switch has a manual reset, cycling will not occur.
4. Inadequate refrigerant.	4. Check for leaks. Repair and add make up charge. If the low-pressure switch has a manual reset cycling will not occur.

CHAPTER 7

DO'S AND DON'TS

7.1 DO'S

- Do evaluate the Compressor before carrying out maintenance.
- Do understand the problem while carrying out the repairs.
- Do keep all the tools, gauges and instrumentation in working condition.
- Do work with full confidence.
- Do keep plant room clean.
- Do ensure that in three phase supply, the neutral is available.

6.2 DON'TS

- Don'ts use the compressor to build up pressure. If used to compress air, overloading and damage may result.
- Don'ts use Oxygen to build up pressure. when using dry Nitrogen, guard against building up dangerous pressure in the system.

- Don’ts use system compressor to evaluate the system.
- Don’ts pump the compressor below 0-15 kg/cm^2 (2 PSI). Negative pressure pulls moisture and dirt into crankcase.
- Don’ts overcharge the cylinder while removing refrigerant from system as it is dangerous.
- Don’ts use a metallic wire brush to clean fins of coils.
- Don’ts wear loose clothes and chappals.

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ADRA - 723 121

45. D.E.E.(G)
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MUMBAI - 400 008

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58. Principal ,
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