Why Compressor Fail

1 - Contamination

2 - High operating Temperatures

3 - Slugging

4 - Flooding

5 - Electrical Problems

6 - Transport Problems

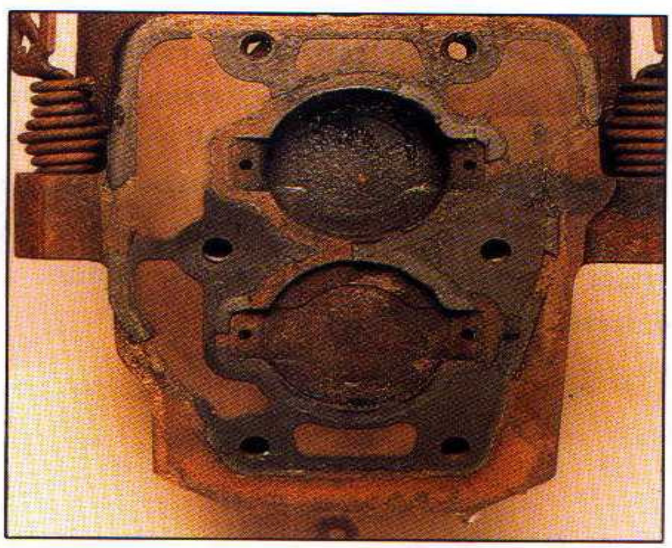
1.Contamination

Contaminants are the substances, if present in the Refrigeration system will play a harmful role in the functioning of the Refrigeration system. Contaminants can be broadly classified as :

- *Moisture*
- *Air and Other Non Condensable Gases*
- *Metallic Contaminants like Chips, dirt etc.,*
- *Copper Oxide / Copper Chloride*
- *Brazing or Soldering Flux*

The presence of the contaminants will lead to premature failure of the compressor which is a loss to the customer and manufacturers. Over 20% of the failed compressors received by our service centre are failed because of the contaminants in the system.

A typical example of jammed pump because of contaminants is demonstrated in the figure.



1a.MOISTURE :

The moisture can get entrapped in the system because of the following reasons:

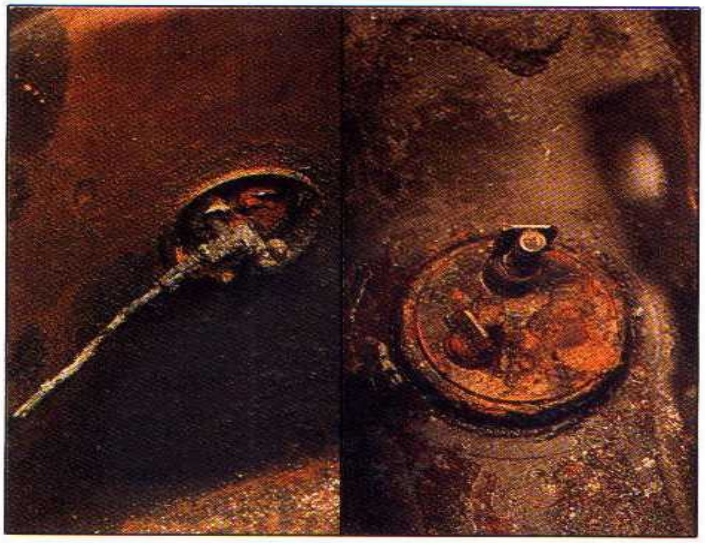
- *System tubing is opened for a long duration*
- *Water Entry during leak Testing*
- *Improper evacuation etc.,*

The presence of the moisture will affect the system in two ways. First, it will react with the refrigerant to form acid and secondly it will freeze at the capillary device especially in low temperature applications.

The other effects of moisture presence are Copper plating, Chemicals damaging motor insulation, Corrosion of components forming sludge, Flapper valve failure, Ageing of the oil. The most common problem is Copper Plating which will be discussed later.

The Maximum permissible moisture is 50 Mg per Sq. M of internal surface

Quite often we receive complaints of terminal bursting. It is a typical example of failure due to presence of moisture. Same can be seen in the figure as how the acids which are formed due to moisture has effected the cable inside the compressor.



Often there is a tendency to add antifreezing agents in refrigerant to overcome ice formation due to moisture content. Though these seems to solve the problem, but it has other side effects which ultimately enhances the chances of compressor failure.

The anti freezing agents lead to:

- *Promotion of corrosion and copper plating*
- *Promotion of Alcholysis of Polyester foil*
- *Being absorbed in drier by which moisture is liberated*

Alcholysis make insulation brittle and breaks it at edges and folds. Hence anti freeze agents has negative effect and does not present a permanent solution to moisture problem. It is therefore essential to eliminate moisture from refrigeration system.

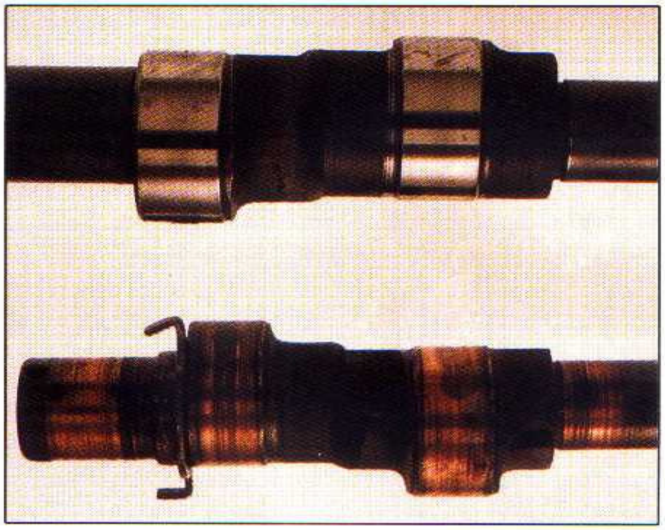
COPPER PLATING

The formation of a thin film of copper on the surface of components in the compressors is known as Copper Plating.

Copper plating on the compressor components takes place in two steps. First, copper components react with moisture in the system at high temperature and hence copper is dissolved. In a subsequent electrochemical reaction, dissolved copper is deposited on metallic surfaces.

A blush of copper is often discernible on compressor bearing, valve surfaces and piston outer surface when machines which have operated at high temperatures are first cut open. After several hours of exposure to air, this thin film becomes invisible, probably because metallic copper is converted to copper oxide, in some cases, however, the copper deposit can build up to substantial thickness and interfere with proper operation of the compressor. In such cases copper plating may be the primary cause of compressor failure.

The figure shows the copper plated Crank shaft in comparison with new crankshaft.



It is therefore, imperative that to avoid copper plating problems the amount of moisture in a refrigeration system must be kept below allowable maximum if not eliminated completely. Precautions must be taken to guard against entry of moisture into the system during manufacturing and service operations.

1b. AIR & OTHER NON - CONDENSABLE GASES:

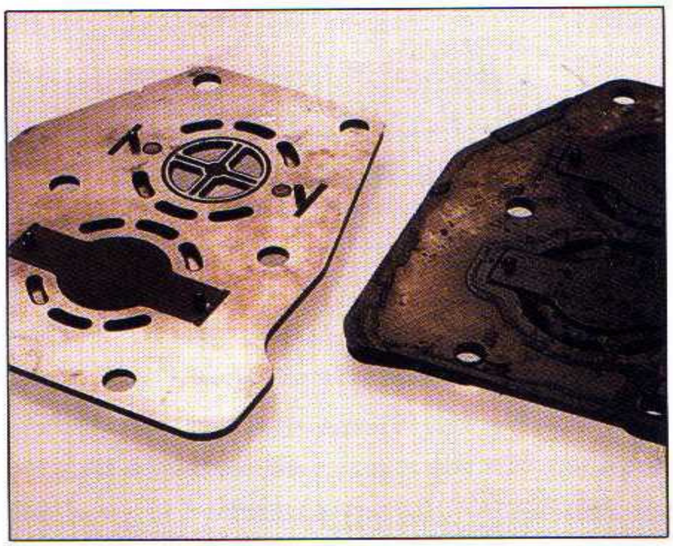
The gas which has extremely low Normal Boiling point and critical points remains as a Non-Condensable Gas if present in Refrigeration System.

Air and Non Condensable gases are the worst irritants in the Refrigeration System. The exact failure depend upon the type of Non Condensable present in the system. The presence of Non Condensables will increase the discharge pressure in the system for the following reasons

- *Air and other non condensables displace the refrigerant in the condensers.*
- *Non Condensables form a thin insulating layer on the inner surface of the condenser thus decreasing the overall heat transfer and hence building the discharge pressures in the system.*

The increase in the discharge pressure is the main reason for the higher consumption of power, higher system temperatures and decrease in efficiency of the compressor.

The consequence of the high temperatures and contaminants is the carbonisation of oil on the discharge valves, valve plates and cylinder heads. This can be observed in the figure.



The hottest parts in the compressor are the valves. The higher the buildup, more are the chances of compressor failure. The unavoidable solubles in the refrigeration system acts as a catalyst, promotes a chemical reaction between the refrigerant and oil soluble compounds.

Presence of Air and Non Condensables is avoided by proper evacuation.

1c. METALLIC CONTAMINANTS

Normally it has been observed that most of the refrigerating systems do have contaminants like dirt, metal chips, flux, brazing material etc., these contaminants do find their way into the system during assembly operations. The contaminants like metal chips, brazing flux etc., are solid particles and there is every possibility of their scoring the cylinder, valve plate and other important components of Compressor.

The consequence of metallic contaminants is seen from the figure where the copper bush in Out Bore Bearing has worn out when compared to new Bearing.

New Out Bore Bearing

Worn Out Bore Bearing

In addition, they are also responsible for the blockage of capillary, strainers and some times lubrication failure in the compressor by blocking its lubricating passage. The presence of iron and copper oxides, iron dust, rust or scales originating from brazing operation are also responsible in accelerating the decomposition of Refrigerant - 12 and 22 at elevated temperatures. We have also come across certain cases where lumps of brazing material have been found struck between the valves resulting in either no pumping or the breakage of valves. Therefore, in the interest of trouble free operation of the appliances and its reliability, best efforts will have to be made to keep the refrigeration system free from these contaminants, as far as possible.

As shown in the figure, the contaminants has blocked the passage for the lubrication oil in the piston ultimately leading to compressor jamming, of course with very high wear and heat. We had also observed that in most of the cases the solid contaminants will also lead to motor burnout because of the following reasons

- *Shorting of the windings to the stator*
- *Contaminants in the very narrow air gap between stator and rotor*
- *The failure of bearings because of plugging of contaminants in them*

Contaminants not only causes wear and tear of the components but also a chemical reaction in the system is initiated, thus changing the chemical composition of materials within the system.

2. High Operating Temperatures

Heat rejected by the condensor which is generated in the refrigeration system is because of the following reasons:

- *Heat due to compression*
- *Thermal losses from motor windings*
- *Heat due to friction at load bearings*

Generally the compressors design will take care of all the above sources of heat in the compressor.

In Air Conditioner applications the heat generated by the compressors is taken away by the air flowing over it. Any abnormality in the system or in installation, will generate more heat inside the compressors as the net load on the compressors increases.

It is always recommended to keep the load on the compressor nearer to the rated capacity. The compressor reliability will increase if the system is optimised slightly with lesser discharge pressure ie. with increasing the efficiency on the condenser side.

If the compressor is subjected to higher operating conditions, the chemical reaction between refrigerant and moisture, acid and oxides, acid and oil within a system increases. This chemical reaction very quickly begins the process of failure of the compressor. The harmful effects of the acids, however, does not just limit themselves to the compressor, but can cause harm to the whole system.

For the benefit of customers the following are the operating conditions given for the Air Conditioners at rated conditions.

PARAMETERS	CAPACITY RATING Room Side / Out Side in DBT/WBT in Deg.C 27/19 / 35/30	MAX. OPERATINGCONDITION Room Side / Out Side in DBT/WBT in Deg. C 35/24 / 46/27
Suction Pressure Kg/Sq.Cm(Psig)	4.9 - 5.3 (70 - 75)	5.8 - 6.2 (82 - 88)
Discharge Pressure kG/sQ. cM(P sig)	19 - 21.25 (270 - 310)	26 - 27 (370 - 385)
Discharge Gas Temp Deg. C(Deg.F)	70 - 85 (158 - 185)	90 - 105 (194 - 220)
Shell Temp Deg. C (Deg.F)	35 - 40 (95 - 104)	46 - 52 (115 - 125)

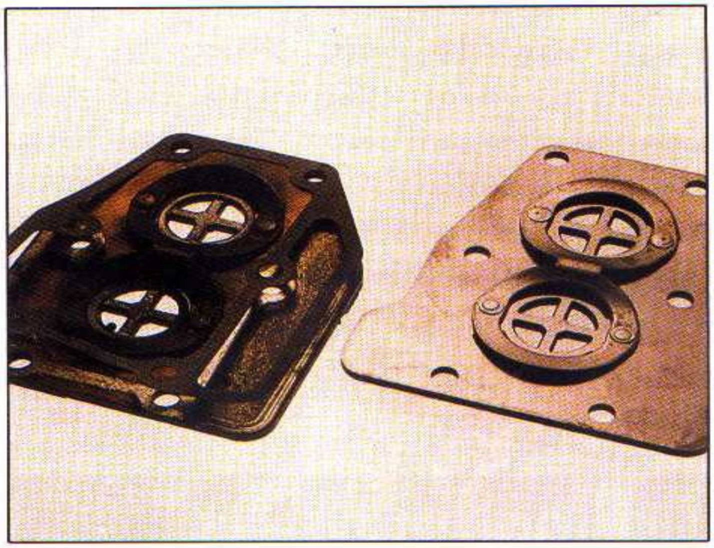
All the hermetic compressors are suction gas cooled. The statement doesn't mean that the refrigeration systems should be charged more with refrigerant to cool down the motor because in doing so, the motor will get overloaded and hot spots will be formed inside, even if the outside surface of the motor is cool enough to make the OLP inactive. Inner portion of the motor will be hot while outer will be cold and adding to that the OLP will not cut out thus leading to a disastrous failure of compressor. The over charging will also lead to Liquid slugging and flooding of the refrigerant which will be discussed later.

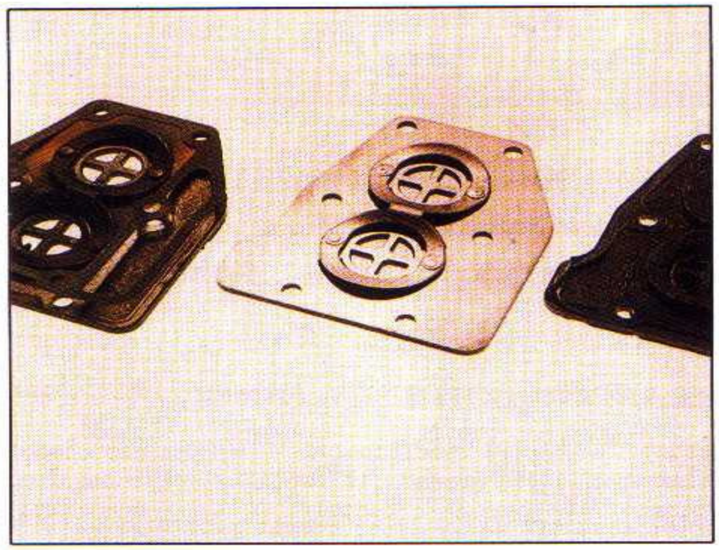
HIGH DISCHARGE PRESSURE & HIGH COMPRESSOR TEMPERATURE:

Undercharging of the compressor will also lead to failure of compressor as the motor will not have sufficient cooling.

The other reasons for compressor overheating are as follows:

- ***High Compression Ratios than rated***
- ***High Ambient Conditions than Considered for designing***
- ***Improper selection/ optimisation of Capillary or expansion device***
- ***High Load on the Evaporator than rated, leading to high return gas temperature***
- ***Suction line not insulated properly***
- ***Inefficiency at Condenser end***
- ***Oversized Evaporator etc.,***





During the high load operation, extra pressure forces the suction valve to flex more than its designed value. This extra flex combined with higher temperatures will exaggerate the wear pattern on the valve. Since this flexing is happening many times per minute and if compressor runs under this condition for prolonged period then this will cause the damage

The high discharge temperatures can also cause worn or seized pistons or scored cylinder walls.

Some contaminants are formed within the system because of excessive heat. This causes a reaction between the oil, and the refrigerant. In some cases heat will break down system ingredients, primarily oil, somewhere around 150 Deg. C to form a sludge and coat internal surfaces with carbon. This is shown in the figure Finally, since the high temperatures cause the oil to break down to form sludge, carbon, and other deposits closing the lubricating parts, thus proper lubrication would be nearly impossible.

3. Slugging

Slugging can be defined as a short term return of a mass of liquid refrigerant, oil, or both to the compressors cylinders instead of a super-heated gas.

REASONS FOR SLUGGING

Always the refrigerant will try to settle in the coldest part of its cycle when the system is in Off condition. Take the example of the Water Cooler or Bottle cooler, when the thermostat cuts off, almost 70% of the refrigerant will store in the evaporator which is at lowest temperature in the cycle in the liquid form. Once the thermostat cuts in, Slugging will occur.

If slugging occurs, it will occur at start-up or during a rapid change in system operating conditions. The quality of the noise will change during slugging operation due to hydraulic compression, which is when the compressor is trying to do what it wasn't designed to do, compress a liquid. This phenomenon of compressing the liquid refrigerant or oil will add tremendous load on the compressor

The design of the suction line in the Refrigeration systems is very critical. If the diameter of the Suction line tube is higher, there will not be enough velocity to return oil to the compressors. If lesser, there will be an excessive pressure drop resulting in a loss of capacity and an increase in superheat at the compressor. The piping that is selected is based on the capacity of the system and on the refrigerant used. Pressure drop is based on length and size of tubing used and on the number of fittings. Operating conditions at full load and partial load are taken into consideration.

4. Flooding

Flooding is the continuous return of liquid refrigerant or liquid droplets in the suction vapour to the compressor.

REASONS FOR FLOODING:

Insufficient expansion or too low a superheat setting would allow more refrigerant to flow to the low side of the system than the loading requires. The refrigerant may flow back to the compressors in a saturated state with entrained liquid droplets in the vapour. This would gradually wash the oil off the lubricated surfaces. In the case of a thermostatic expansion device, check to see if the sensingbulb is in the proper location, in good contact with the suction line, and insulated.

The consequence of flooding is usually oil dilution. This will result in crankcase foaming and over heating of bearing surfaces. If the flood back is severe enough, it can result in damage to the pistons, rings, and valves because the refrigerant washes the oil off the bearing surfaces.

In compressors oil and refrigerant mix continuously, Refrigeration oils are soluble in liquid refrigerant and at normal room temperature they will mix completely. Since oil must pass through the compressor cylinders and various other components to provide lubrication, a small amount of oil is always circulating with the refrigerant. Oil and refrigerant vapors don't mix readily and the oil can be properly circulated through the system only if the gas velocity is high enough to sweep the oil along, which calls for proper design of the piping.

One of the basic characteristics of the refrigerant and oil mixture in a sealed system is the fact that the refrigerant is attracted by the oil and will vaporise and migrate through the system to the compressor crankcase even though no pressure differential exist to cause the movement. On reaching the crankcase the refrigerant will condense into liquid and this migration will continue until the oil is saturated with liquid refrigerant. When the pressure on the saturated mixture of the refrigerant and oil is suddenly reduced as it happens in the compressor crank case on start up. The amount of liquid refrigerant required to saturate the oil is drastically reduced and the reminder of liquid refrigerant flashes into causing violent boiling of the refrigerant and oil mixture. This causes the typical foaming in the compressor crankcase at start up which can drive all the oil out of the crank case in a minute or so.

It may be noted that not all foaming is the result of refrigerant in the crankcase agitation of the oil will also cause some foaming.

Damage from a flooded start may be an immediate scramble, broken valves, or blown gaskets.

The failure may come on gradually if there is a partial loss of lubrication because of migration of the oil for some period of time after start-up or if a major portion of the oil is pumped out of the crankcase during a flooded start. In these cases, the compressor failure is due to a lack of lubrication.

The usual result of inadequate lubrication as occurs on a flooded start, is that the bearing surfaces are overheated and scored. Because of the hydraulic slugging effect of flooding, the compressor may blow the gasket.

During normal operation some oil will leave the crank case of reciprocating compressors. The successful operation of the system requires that this oil returns at the same rate at which it leaves the compressor. Causes of oil leaving at an excessive rate are those usually associated with oil foaming. These include flooding, overcharge of oil, and use of non-approved oil.

Reasons for oil not returning at a satisfactory rate include low refrigerant velocity, low load, short cycling, traps, and piping errors. The Results of lack of lubrication are overheating and scored bearing surfaces, usually uniform thoughout the compressor.

5.Electrical

Reasons for failure of Single phase motors:

In a single phase motor, one of the reasons for failure is the accessories used. It could be the start or run capacitors or any of the contactor - relay devices used. Without the proper voltage and micro fared rating, the compressor would not operate within the design tolerance or possibly fail to start, it could cause a locked rotor situation which brings on over heating of the start windings and rapid failure.

Another cause of compressor failure, is rapid cycling. The start stop cycling on controls and safety devices can result in shorted motor windings. This is because:

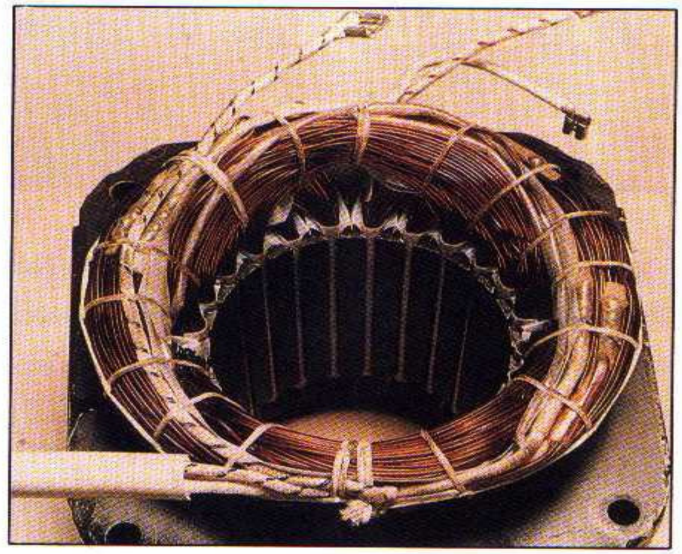
Each time the motor starts, the compressor draws locked rotor amps. It takes a few minutes of running to get rid of the heat caused by locked rotor current. Frequent cycling causes a buildup of heat because the heat from the previous start has not been removed ultimately leading to failure.

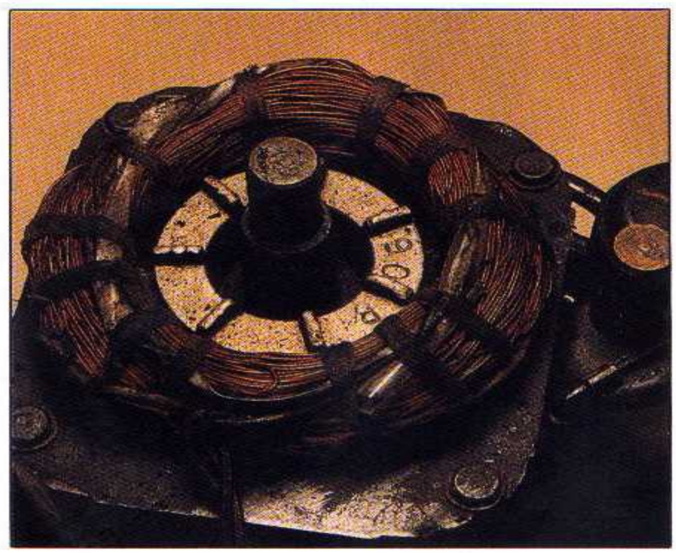
A totally burnt out motor is shown in the figure

Customers do try to repair the burnt out compressor by rewinding the same stator. It would be difficult to repair the compressors by customers on their own.

It is not advisable to rewind the motor as wires may not be of specified quality and guage. The quality of winding and processing will not be feasible out side manufacturers factory. Ultimately this will lead to motor failure.

For the information of our customers the photograph shows a cut opened compressor by customer for repairing. Since he has not succeeded in doing so the same has been sent to us. Customers motor winding is compared with a new motor.

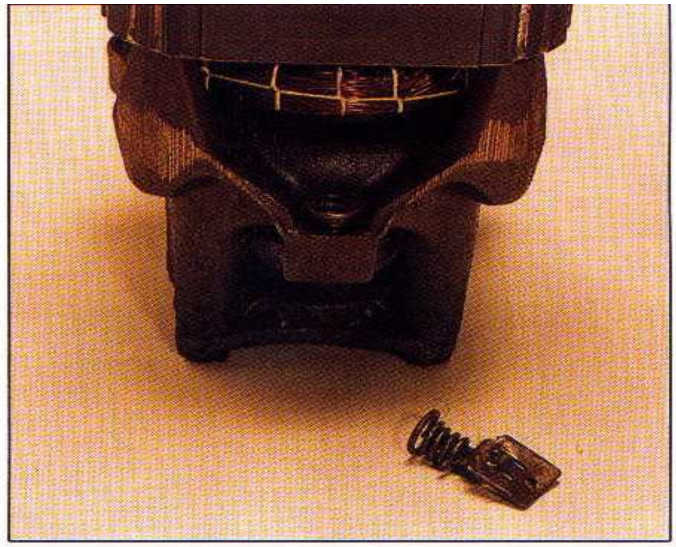




6. Transport Problems

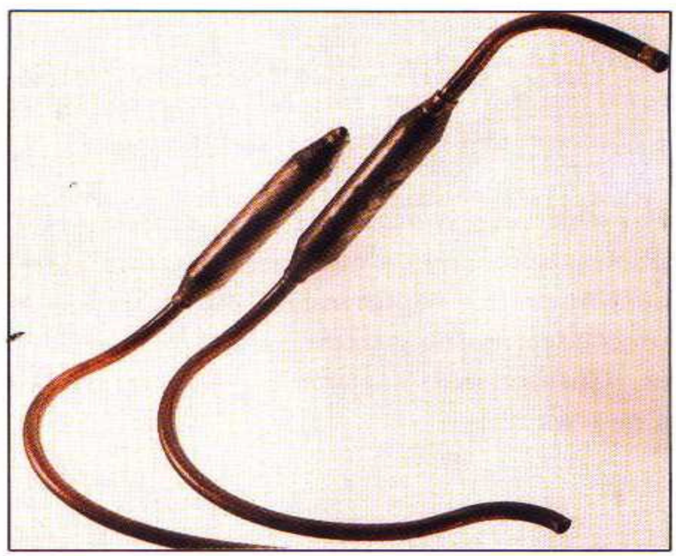
Very often bad transportation will lead to Noise Problems. One of the basic reason is the breakage of suspension spring used for pump mounting

inside the shell. If the alignment of the pump is lost, the crankshaft will get inclined and touch the locating cup leading to heavy noise. For the benefit of the customers photographs of locating cup and a pump with broken suspension spring is presented.



The other major problem of bad transportation is breakage of shock loop which will lead to poor pumping in the compressor.

Very high percentage of compressors coming to our Service centre are found to be OK as far as performance of compressors is concerned.



Following are some of the attributes for customer coming to the conclusion that compressor has failed.

- Compressor must have tripped - In this case allow the compressor to cool down to permit the internal overload to close.
- Noisy - In this case please evacuate system once and recharge with fresh gas .
- Startability - before rejecting the compressor, please check the standing pressures and terminal Voltage.
- After checking all the parameters in establishing the compressor failure, and it must be replaced by following proper method which is given.

METHOD TO BE FOLLOWED WHILE REPLACING THE COMPRESSOR :

- Remove the capillary and strainer etc., and scrap them as these are non repairable
- Wash thoroughly each component i.e. Condenser, Evaporator connecting tubes etc., by using CTC. It is recommended a tank and filter cloth to circulate the cleaning agent through the above components. The time of circulation would depend upon the severity of the Burnout and can vary from 1 - 2 hrs. At the end of the cleaning remove the circulating liquid which has been used for carrying out cleaning and use fresh cleaning solvent. Clean again for few minutes for fresh liquid and ensure that the liquid coming out from the cleaned components is absolutely free from contamination. If contamination still exists, clean it further.
- After the liquid wash, flush each of the above components by blowing dry Nitrogen or Dry Air under low pressure.
- Dehydrate each component by heating them in an oven at around 100 Deg. C by flushing little quantity of Dry Nitrogen. One can adopt vacuum dehydration also. Charge with 5psig dry Nitrogen and seal the ends of the above with rubber plugs / caps to avoid entry of atmospheric pressure air to contaminate the above parts.
- Assemble again the system using dehydrated condenser, evaporator and new capillary / Strainer. Complete the brazing of the tubes, leak testing, Dehydration and charging of the system.
- When expansion devices like capillary tubes, refrigerant charge is critical. For a given load, a certain refrigerant charge is required to maintain an established flowrate. Since this type of metering device does not react to load change, an overcharge of refrigerant can raise the head, which in turn increases the "flowrate" to a point where there is more flow than available heat trasfer. The lack of load in the evaporator prevents all the liquid from boiling off causing liquid floodback to the compressor.
- Low load on the evaporator can cause a flooding condition. The low load can be caused by low air quantity, There are many reasons for low air flow such as dirty filters, air restriction, air bypass, and dirty fan wheels. Under these conditions the coil tends to frost which just adds to the problems. And even a properly sized expansion valve will tend to hunt.

Trouble Shooting Chart

Symptom	Possible Cause	Remedial Actions
Compressor does	- No incoming supply (fuse blown) - Thermostat in Off position - Improper Wiring - Thermostat defective - Supply Voltage Low - Compressor terminal Voltage Low - Terminal Clip of the comp., came out or loose contacts in internal wiring - No continuity in the wiring - Overload Protector Tripped	- Check the supply - Keep thermostat in normal position - Check wiring against Wiring Diag - Replace thermostat - Correct the supply Voltage - Determine reason and correct - Check wiring and put the clips on terminals - Check the continuity with multimeter - Wait for OLP to cut - in
Compressor does not start - Hums and trips on Over load Protector - Higher Supply Voltage - Compressor defective	- Improper Wiring - Compressor not able to start due to low terminal Voltage - Start relay not functioning - Start capacitor Defective - Higher Supply Voltage - Compressor defective	- Check against wiring diagram Check whether Run and Start terminals are interchanged - Determine reason and correct - Replace the relay - Replace the capacitor - Determine Reason and Correct - Determine the reasons and replace
Compressors Starts, draws high current	- Improper wiring - Wrong Capacitor - Fan Motor taking high current - High Supply Voltage - Check for the pinch or Choke in entire System - Clogged condenser (Inside) - Capillary Tube Partial Choke - Refrgerant Over Charged - Compressor defective	- Check wiring against wiring diag. - Check and replace run capacitor - Check and replace Fan Motor - Determine the reason and correct - Change the Tubing or Delete - Clean the Condenser with TCE and flush with Nitrogen till the clogging is removed - Flush the Capillary or Replace - Ensure correct charge - Determine the reasons and replace

Compressor trips after thermostat cuts in	- Low Voltage - Temperature Differential of Thermo-stat too low - Compressor startability with imbalanced pressure is Poor	- Check for the reason - Set the correct temperature differential so that compressor is in after minimum 3 minutes - Check the relay - Replace the compressor
Compressor Sweating Heavily	- High Refrigerant Charge - Lesser Expansion	- Purge the refrigerant to correct Wt - Put Proper Expansion Device
No Cooling/ Less Cooling	- Choked Air Filter - Blocked Condenser Coil - Fan Motor speed low - Compressor Poor Pumping	- Clean the Filter - Clean the coil - Check, if necessary Replace - Check and replace the comp.
No Cooling / Less Cooling ultimately leading to Compressor Tripping	- Gas Leak - Gas Under Charged	- Trace the Leak and Correct - Correct the Charge
More Cooling	- Thermostat not cutting off	- Checkand replace the stat
Start Capacitor (if any) - Open / Blown	- Relay Contacts not operating properly - Excessive short cycling - improper Capacitor	- Clean contacts. Replace Relay if necessary - Determine reason and correct - Check and Replace
Run Capacitor - Open / Blown	- Improper Capacitor - Excessively High Voltage	- Replace with Correct Rating - Determine Reason and correct
Start Relay (if any) - Defective - Burn out	- Incorrect Relay - Incorrect Mounting - Line Voltage Too high/low - Excessive short cycling - Loose relay mounting - Incorrect Run Capacitor	- Check and Replace - Remount in correct position - Determine Reason and Correct - Determine Reason and correct - Remount rigidly - Check, if necessary Replace
Unit Noisy	- Loose parts or Mountings - System tube rattling - Fan Blades Bent - Fan Loose on the Shaft - Fan Motor Bearings worn out - Compressor Noisy - Presence of Non Condensables	- Check and tighten the same - Adjust to avoid the contacts - Replace Fan Blade - Tighten Grub Screw - Check and Replace - Check and Replace - Evacuate and recharge with fresh Refrigerant