MAINTENANCE AND OPERATION OF CENTRIFUGAL REFRIGERATION FOR AIR CONDITIONING SYSTEMS

CONTENTS PAGE

1. GENERAL 1
2. DESCRIPTION 1
3. COMPONENT PARTS 4
4. LUBRICATION 14
5. OPERATION 14
Dirt and Moisture 14
Leak Testing 15
Add Refrigerant 16
Acid Testing 17
Daily or Weekly Check 17
Monthly Operational Inspection and at Spring Start-up 17
Annual Shutdown Inspection 19
Clean-up After Motor Burnout 21
6. RECORDS 22
7. TROUBLE CHART FOR CENTRIFUGAL SYSTEM 24
8. REFERENCES 29

1. GENERAL

1.01 This section describes the operation and maintenance of centrifugal refrigeration compressors and associated equipment employed in air conditioning installations which use fluorinated hydrocarbons as the refrigerant.

1.02 This section is intended to provide basic information on centrifugal refrigeration systems so that the maintenance employee will be prepared to operate and maintain the many makes and variations of equipment he is likely to encounter in telephone buildings. When a system is taken over for operation and maintenance, a complete set of the manufacturer's operating instructions should be obtained. It is important that the people responsible for the equipment operation become familiar with the contents of these manufacturer's instructions. They should be kept in a place readily available to anyone who may have occasion to work on the equipment. For detailed information on any specific unit, the manufacturer's literature should be consulted. Prior to servicing any unit, the mechanic should establish the status of the manufacturer's warranty.

1.03 The illustrations used in this section have been selected to show typical examples of the equipment and are not intended to endorse or recommend any one manufacturer's product. Where special BSP sections have been written to cover certain installations, these sections shall be followed.

2. DESCRIPTION

2.01 The principle that governs the functioning of any hermetic centrifugal refrigeration system is the same principle that is basic to most refrigeration systems — the evaporating and condensing temperature of refrigerants can be varied by changing the pressure exerted upon them.

The refrigeration cycle, Fig. 1, starts at the evaporator or cooler. The cooling media flowing through the tubes is warmer than the refrigerant in the shell surrounding the tubes; consequently, heat is transferred from the cooling media to the refrigerant. This heat evaporates the refrigerant at a temperature corresponding to the low pressure in the evaporator, as maintained by the compressor.

The evaporated refrigerant vapor (gas) flows through the prewhirl vanes into the compressor where it is partially compressed by the first stage impeller. It then mixes with the stream of gas which has come from the economizer through a hermetic motor. The mixture of suction and economizer gas enters the second stage impeller where it is compressed and discharged into the condenser.

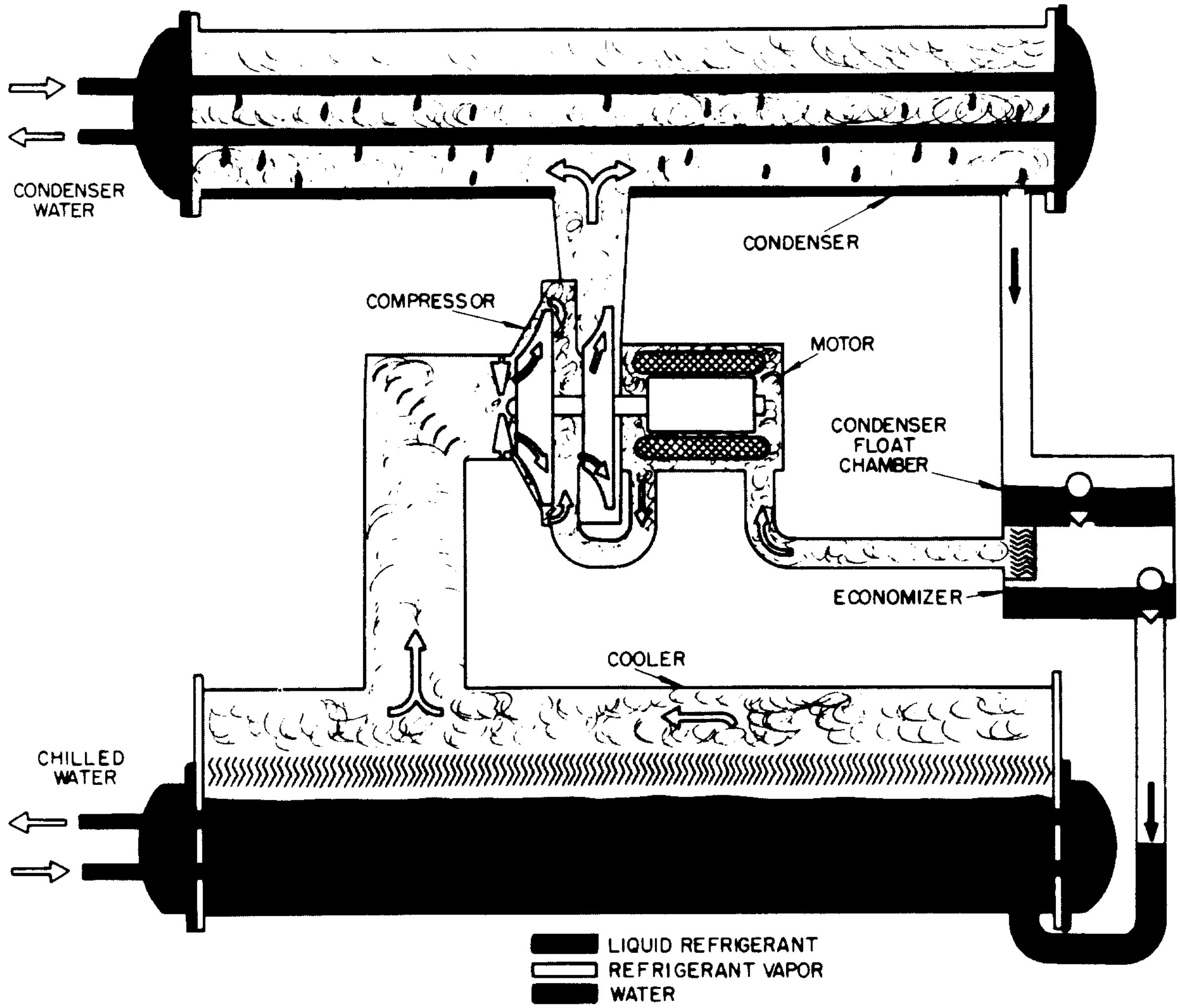
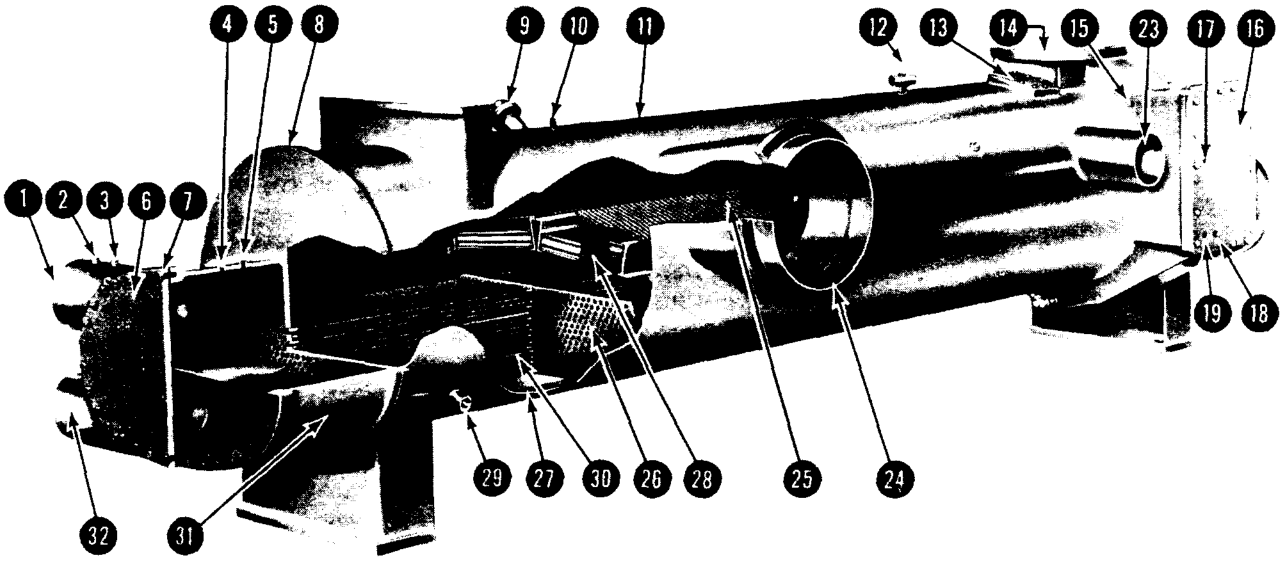


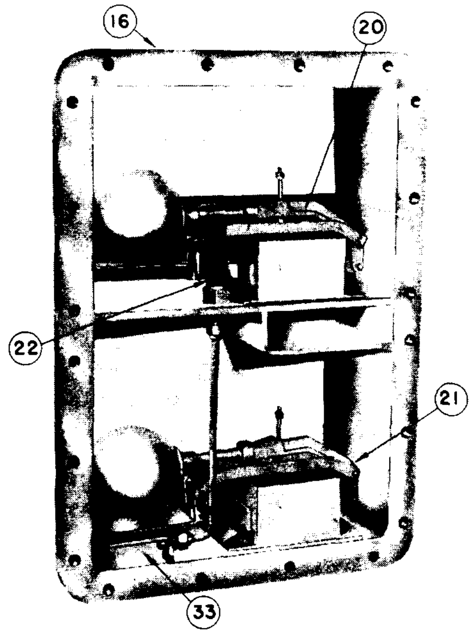
Fig. 1 – Refrigeration Cycle Diagram (Carrier Corp.)

The refrigerant discharged by the compressor condenses on the outside of the condenser tubes, at a temperature corresponding to the condenser pressure. This temperature is higher than that of the water in the tubes so the heat is transferred into the condenser water.

The liquefied refrigerant drains into the condenser float chamber. The rising refrigerant level in this chamber opens the float valve and allows liquid to pass into the economizer chamber, when so equipped. The cooled liquid collects in the economizer float valve sump. The rising level in this sump opens the economizer float valve and allows this liquid to pass into the cooler. As the cooler pressure is lower than the economizer pressure, some of the liquid is evaporated and thereby cools the remainder to the cooler temperature. The vapor thus formed passes to the compressor along with the vapor continuously formed by the cooling of the water. This completes the cycle.

2.02 Since compression of the refrigerant is accomplished by means of centrifugal force, this type of compressor is inherently suitable for large volumes of refrigerant at low pressure differentials. Two or more stages are usually required and high speeds are necessary to obtain good efficiency. The evaporator is usually constructed as an integral part of the centrifugal type condensing unit to chill water which is then circulated to the air conditioning system. This is done because it would not be economical to pipe these large volumes of refrigerant any distance. One important advantage of this type system is its flexibility under varying heat loads; in some cases, units can be designed to operate reasonably efficiently at capacities as low as 20 per cent of normal load.





1 WATER OUTLET NOZZLE
2 OPENING - CHILLED WATER FLOW SWITCH
3 OPENING - LOW TEMPERATURE AND RECYCLE SWITCH
4 OPENING - VENT
5 OPENING - CONTROL ELEMENT (ELECTRONIC) - IMMERSION ELEMENT (PNEUMATIC)
6 WATER BOX COVER
7 GASKET - WATER BOX COVER
8 TUBE SHEET AND END FLANGE
9 RUPTURE VALVE
10 OPENING - COOLER PRESSURE GAGE
11 SHELL
12 CHARGING VALVE
13 EQUALIZING DAMPER ACCESS COVER (R 11 AND R 114)
14 CONDENSER DRAIN
15 OPENING - CONDENSER PRESSURE GAGE
16 FLOAT VALVE CHAMBER *
17 THERMOMETER OPENING - CONDENSER
18 OPENING - REFRIGERANT LOW TEMPERATURE CUTOUT SWITCH
19 THERMOMETER OPENING - COOLER REFRIGERANT
20 CONDENSER FLOAT VALVE *
21 ECONOMIZER FLOAT VALVE
22 STRAINER
23 ECONOMIZER GAS OUTLET
24 COMPRESSOR SUCTION OPENING
25 GAS BAFFLE
26 TUBE SUPPORT SHEET
27 DISTRIBUTION BAFFLE
28 ELIMINATOR
29 STUBOUT - PURGE REFRIGERANT SUPPLY LINE
30 TUBES
31 WATER BOX
32 WATER INLET NOZZLE
33 THERMOMETER EXPANSION CHAMBER

* REFRIGERANT 114 CONDENSER FLOAT VALVE CHAMBER LOCATED ON BACK SIDE OF COOLER. ECONOMIZER FLOAT VALVE CHAMBER LOCATED AS SHOWN.

Fig. 2 — Typical Evaporator (Carrier Corp.)

3. COMPONENT PARTS

3.01 *Evaporator or Cooler* — Since the evaporator is on the suction side of the compressor, it is at a lower pressure and, therefore, a lower temperature than the condenser. Refrigerant entering the evaporator cools itself to the existing evaporator temperature by flashing. The flash gas passes up through the liquid refrigerant and is drawn off by the compressor. The remainder of the liquid, now cooled by the flashing, contacts the tubes of the evaporator containing the warm system water. Heat is transferred from the tubes to the refrigerant, causing the refrigerant to vaporize. This evaporative process chills the water within the tubes to some predetermined temperature. The refrigerant vapor passes upward through the eliminators where any droplets of entrained refrigerant are removed. See Fig. 2.

There are a number of evaporator arrangements, but basically they may be classed as either the dry-type or flood-type. The most common type used in Telephone Company buildings is a variation of the flood-type. In the flood-type evaporator, the refrigerant space is largely filled with liquid. The shell-and-tube evaporator is similar to the horizontal shell-and-tube condenser. It consists of a shell in which are placed a large number of tubes that are fastened to tube sheets at each end. Refrigerant liquid is fed through a float valve to the shell and surrounds the tubes. The water that is to be cooled flows through the tubes. Within the evaporator proper, there are no moving parts. The tubes are copper with external fins around the tube through its full length.

A rupture or relief valve is mounted on top of the evaporator shell. This valve prevents dangerous pressures from developing in the machine in case of fire or other failures. Some of these devices provide a threaded connection for an atmospheric vent line. See Fig. 3.

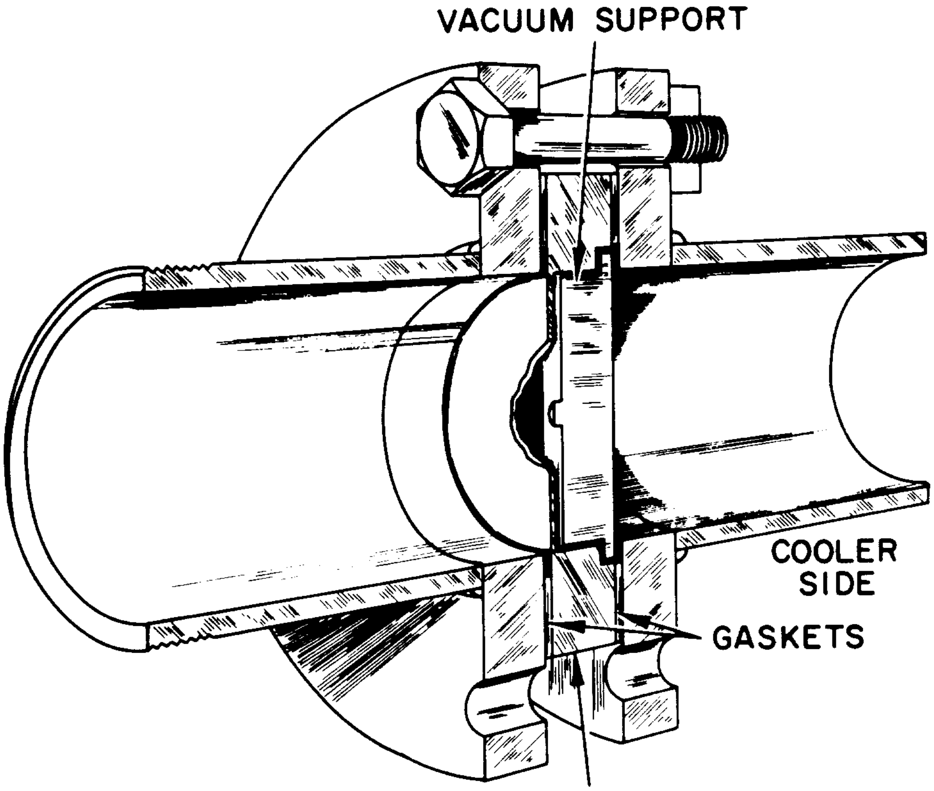


Fig. 3 – Rupture Valve Assembly (Carrier Corp.)

Associated with the evaporator is one or more float valves whose function is to permit only liquid refrigerant to enter the evaporator and to maintain a liquid refrigerant seal between the condenser and the economizer, and between the economizer and the cooler. See Fig. 2.

3.02 *Economizer (when installed)* — The economizer is a small flash chamber with float valves, eliminators and other equipment. Liquid refrigerant enters the chamber of the shell where it partially flashes sufficiently to cool itself to the temperature corresponding to the second stage suction pressure. The liquid then moves through the chamber and flows to the outlet. The flash vapor flows upward through the eliminator, where any entrained liquid refrigerant is removed. In some systems, this refrigerant is used at this stage to cool the compressor motor. This piece of equipment reduces the load on the compressor, thereby allowing a saving in power consumption. See Fig. 4 for an economizer.

3.03 *Compressor — Hermetic* — The low pressure, heat laden, refrigerant vapor is drawn from the evaporator into the compressor. Here the vapor is compressed, by centrifugal force, to the condensing conditions. Its purpose is to maintain an evaporator pressure corresponding to the desired cooler temperature and to raise the pressure of the refrigerant gas removed from the evaporator to a pressure which corresponds to a temperature well above that of the condenser water supply.

In most systems, two stages of compression are used. Vapor compressed in the first stage of the compressor is passed to the second stage,

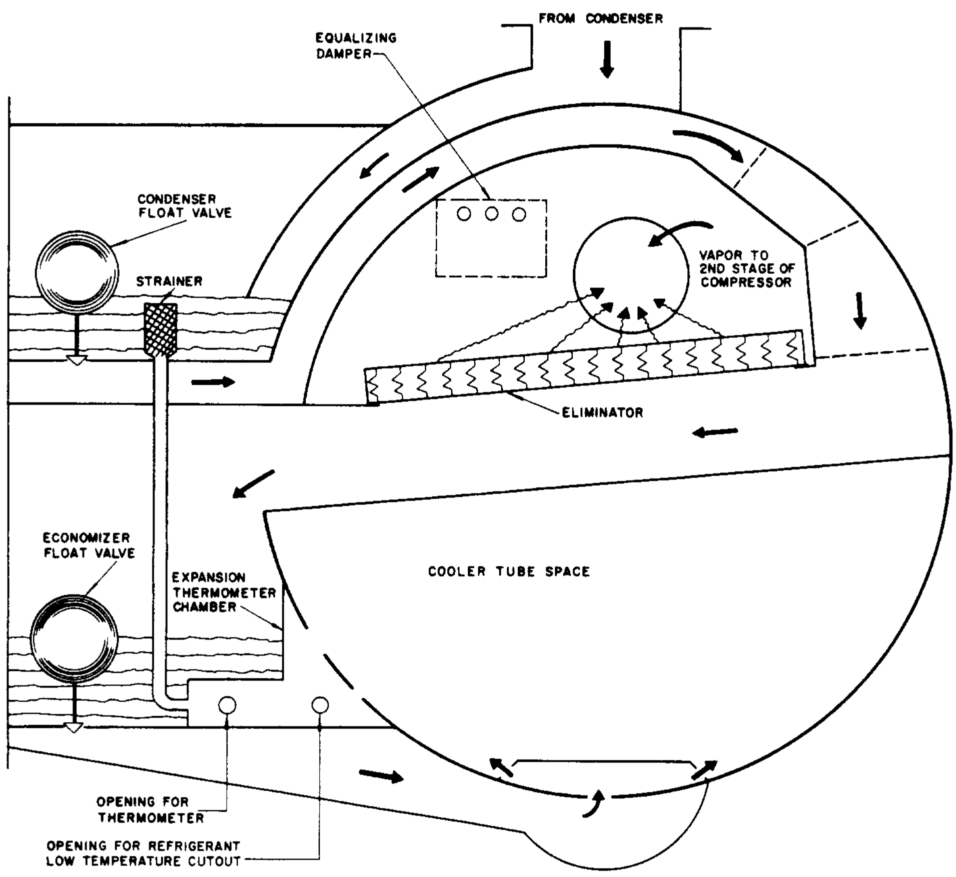


Fig. 4 – Economizer Schematic Diagram (Carrier Corp.)

where the compression process is repeated before it is discharged into the condenser. Centrifugal compressors create a gas velocity through centrifugal forces set up by the impeller and then by means of diffusers converts this velocity into pressure, with a minimum of energy loss.

The motors are hermetic and are positively cooled by circulating chilled water through a jacket surrounding the motor or refrigerant gas through the stator. The water-cooled motors are provided with drain plugs in the motor jacket so that the jacket may be drained in the event the unit is subjected to freezing temperature. The rotor assembly and the compressor impellers are supported by bearings. These two main bearings are lubricated by oil, under pressure, by an electrically driven oil pump. A bearing high temperature cutout is usually provided to sense the bearing temperature and to stop the machine if the bearing temperature increases. Also, a low oil pressure cutout is usually provided to protect the compressor motor due to oil failure. See Fig. 5 for a typical water-cooled compressor and Fig. 6 for a typical gas-cooled compressor.

3.04 ***Condenser*** — The condenser is a shell and tube heat exchanger. Refrigerant gas discharged from the compressor is condensed on the outside of the tubes by transfer of heat to the water which flows through the tubes. To provide efficient distribution of the gas within the condenser, a plate is located directly in front of the discharge inlet connection. This plate distributes refrigerant gas through the entire length of the condenser. A liquid sump at the bottom of the shell collects the condensed refrigerant which drains away from the tubes. Sometimes a pitch in the condenser assists the flow of liquid refrigerant to this sump.

Most condenser units are so designed as to allow the covers on the water boxes to be removed for checking and cleaning the condenser tubes, without disconnecting the water piping.

A baffle is installed in the condenser to trap the non-condensable gases, usually air, which must be purged from the machine.

In order to have low head pressures, the condenser cooling water should be as cold as possible and the heat-exchange surface, clean and effective. The condensing water circuit is usually an open system using a cooling tower and requiring make-up water to replace evaporation loss. For this reason, the condenser tubes are subject to contamination by foreign matter — scale, algae, etc. At the time a new system is turned over for operation, it is advisable to have the water analyzed to determine if water treatment is required. The operator should refer to Section 770-230-301 for the recommended practice and procedure covering water treatment. Fouled heat-transfer surfaces cause an increase in the condensing temperatures and, therefore, an increase in head pressure. The presence inside of the system of non-condensable gas (air) also increases head pressure, which in turn causes increased power consumption by the compressor. High head pressure also reduces the capacity of the compressor.

3.05 ***Purge System (See Fig. 8 and 9)*** — Most purge units are located either on the side of the condenser or adjacent to the compressor suction opening on the evaporator. The purpose of the purge system is to:

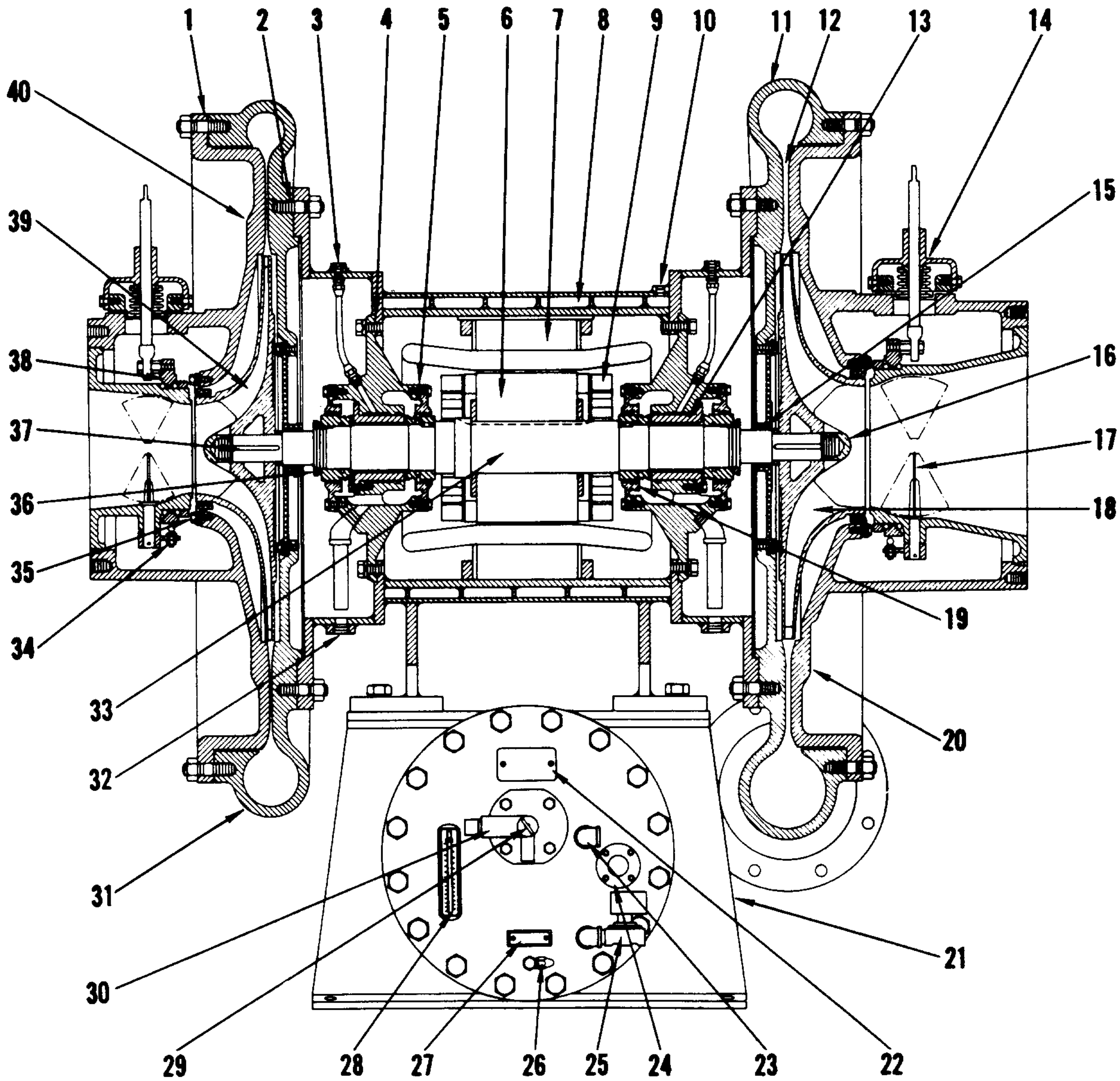
(1) Indicate air or water leakage and remove this water or non-condensable gases.

(2) Recover refrigerant.

(3) Evacuate the machine after repairs.

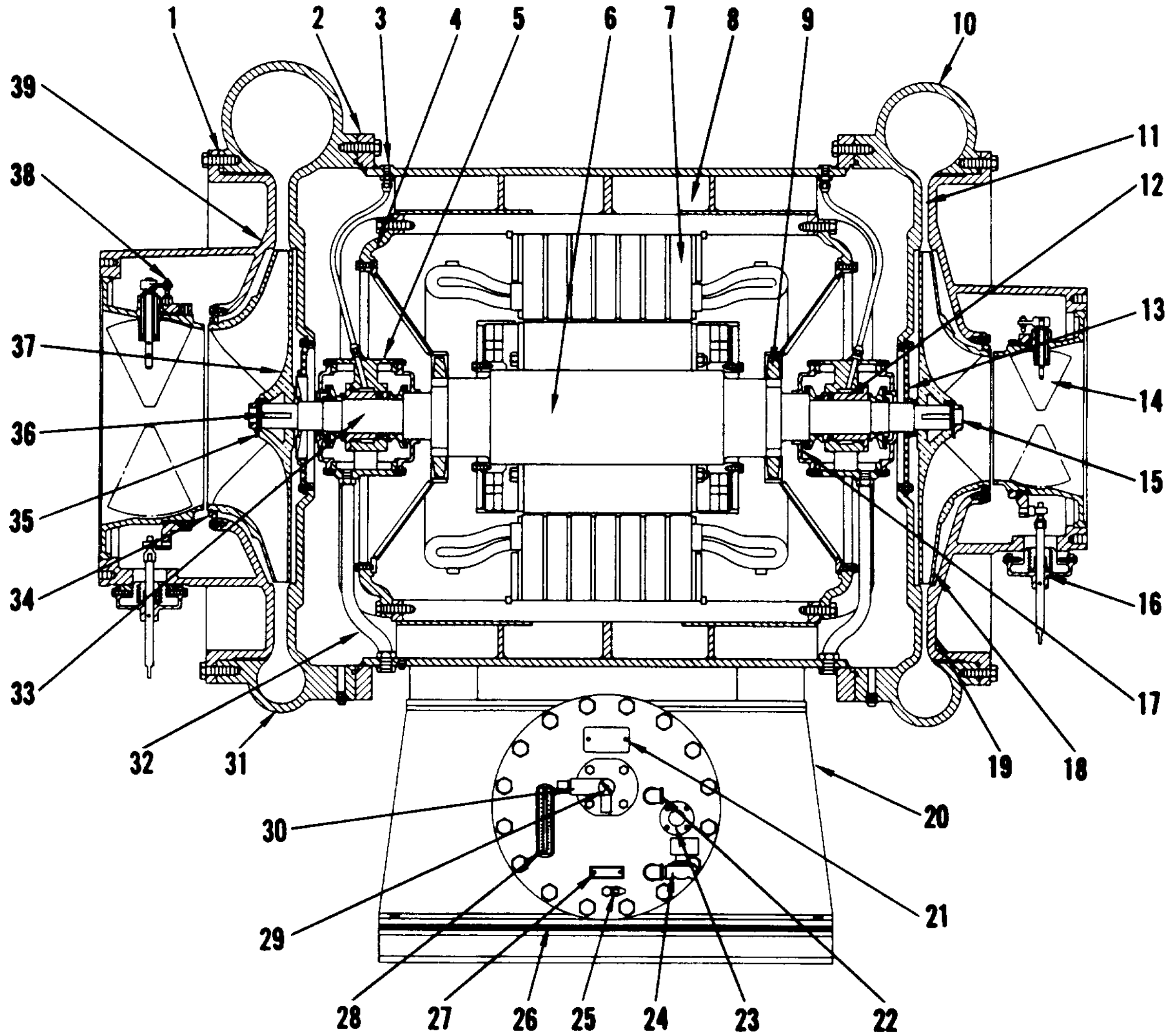
A manual blow-off valve is provided for water removal on many machines. A pressure differential switch operates the purge unit, removing air and any non-condensable gas automatically. Refrigerant that condenses in the purge chambers automatically returns through a float valve to the evaporator.

Although the purge unit does a very efficient job of removing refrigerant from the air being purged, it is physically impossible to remove all refrigerant. Some refrigerant will always be lost when discharging purged air. It is important, therefore, to locate and repair all leaks which cause the purge to continuously discharge air by frequent purge pump operation.



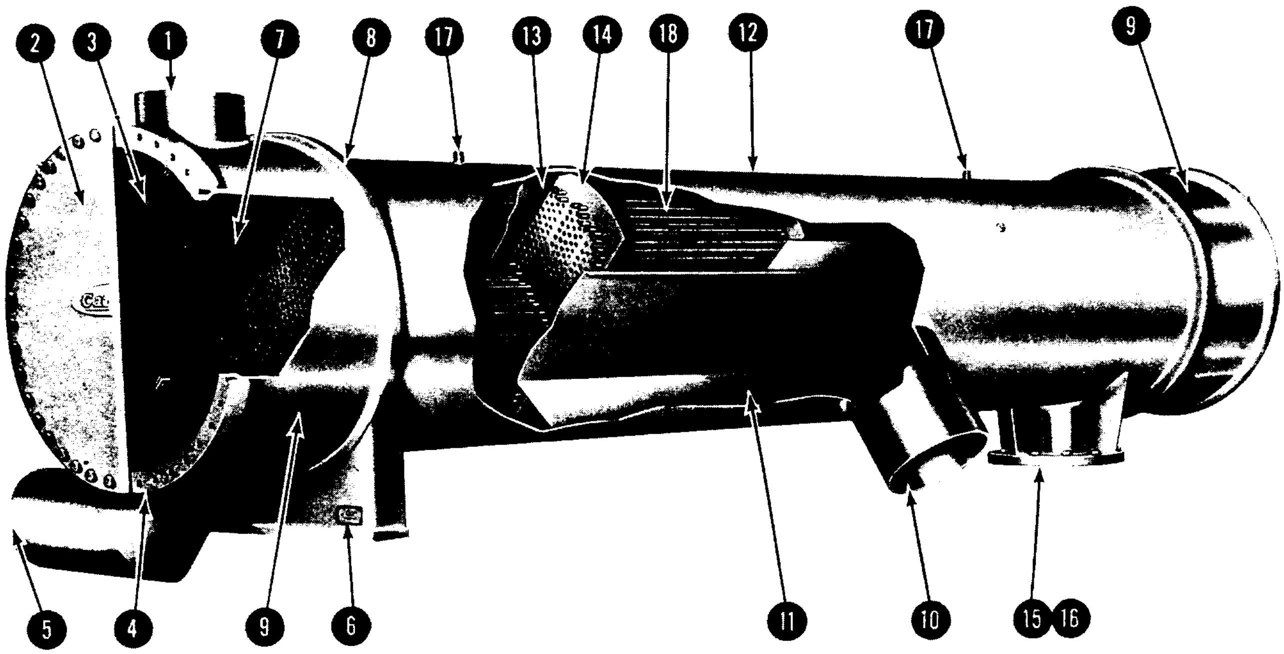
1. Gasket
2. Gasket
3. Oil inlet to bearing
4. Motor bearing bracket
5. Motor bearing end cover
6. Motor rotor
7. Motor stator winding
8. Motor water jacket
9. Motor fan blade
10. Motor jacket water connection
11. First stage volute
12. Diffuser passage
13. Sleeve bearing
14. Control linkage
15. Labyrinth seal
16. Shaft nut
17. Inlet vane assembly
18. First stage impeller
19. Fixed bearing collars
20. First stage suction cover
21. Base and oil tank assembly
22. Oil pump motor terminal box
23. Water outlet connection
24. Oil level sight glass
25. Solenoid valve, water inlet
26. Oil charging valve
27. Oil pump motor nameplate
28. Oil temperature thermometer
29. Oil filter handle
30. Pressure relief valve
31. Second stage volute casing
32. Oil outlet connection from bearing
33. Shaft
34. Ball joint linkage
35. Impeller labyrinth
36. Bearing collar locknut
37. Impeller key
38. Actuator ring
39. Second stage impeller
40. Second stage suction cover

Fig. 5 – Centrifugal Compressor With Water-cooled Motor (The Trane Co.)



1. Gasket
2. Gasket
3. Oil inlet to bearing
4. Motor bearing bracket
5. Motor bearing end cover
6. Motor rotor
7. Motor stator
8. Gas cooling passages
9. Gas circulating fan
10. Second stage volute casing
11. Diffuser passage
12. Sleeve bearing
13. Labyrinth seal
14. Inlet vane assembly
15. Shaft nut
16. Control linkage
17. Fixed bearing collar
18. Second stage impeller
19. Second stage suction cover
20. Base and oil tank assembly
21. Oil pump motor terminal box
22. Water outlet connection
23. Oil level sight glass
24. Solenoid valve, water inlet
25. Oil charging valve
26. Isomode pad
27. Oil pump motor nameplate
28. Oil temperature thermometer
29. Oil filter handle
30. Pressure relief valve
31. First stage volute casing
32. Oil outlet connection from bearings
33. Shaft
34. Impeller labyrinth seal
35. Shaft nut lock washer
36. Impeller key
37. First stage impeller
38. Ball joint linkage
39. First stage suction cover

Fig. 6 – Centrifugal Compressor With Gas-cooled Motor (The Trane Co.)



1 WATER INLET NOZZLE
2 WATER BOX COVER
3 GASKET - DIVISION PLATE
4 GASKET - WATER BOX
5 WATER OUTLET NOZZLE
6 MACHINE NAMEPLATE
7 DIVISION PLATE
8 TUBE SHEET
9 WATER BOX
10 REFRIGERANT GAS INLET
11 GAS DISTRIBUTION BAFFLE
12 CONDENSER SHELL
13 PURGE BAFFLE
14 TUBE SUPPORT SHEET
15 REFRIGERANT DRAIN OPENING
16 GASKET - DRAIN OPENING
17 PURGE CONNECTIONS
18 TUBES

Fig. 7 – Typical Condenser (Carrier Corp.)

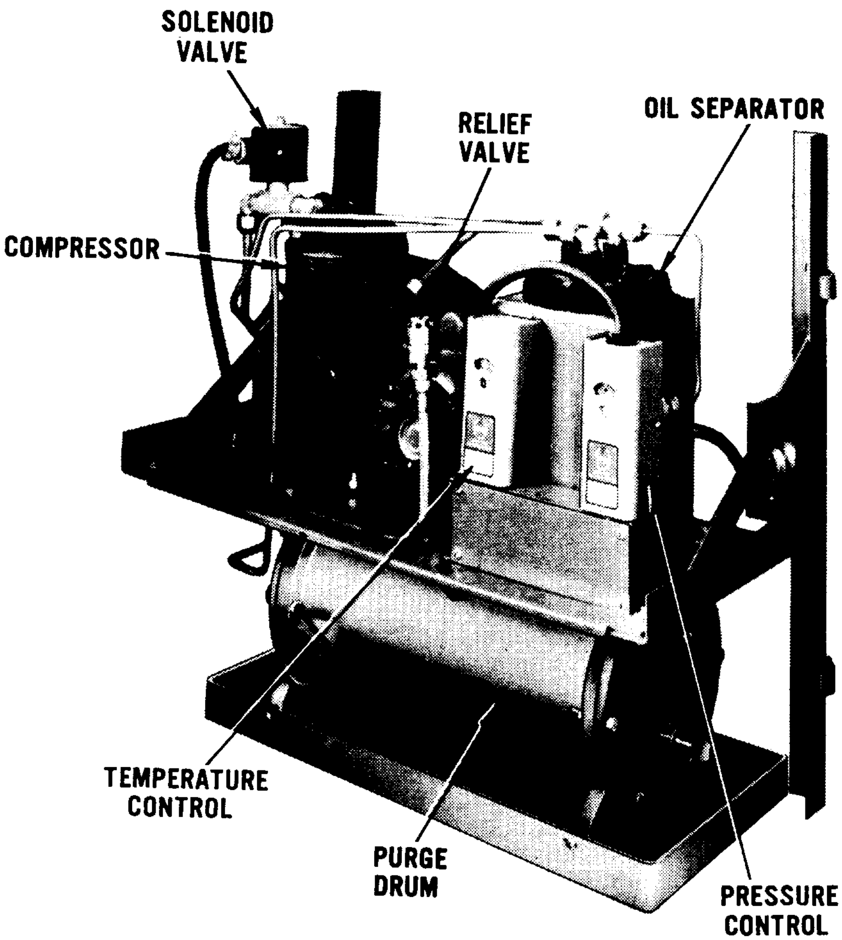


Fig. 8 – Typical Purge Unit (The Trane Co.)

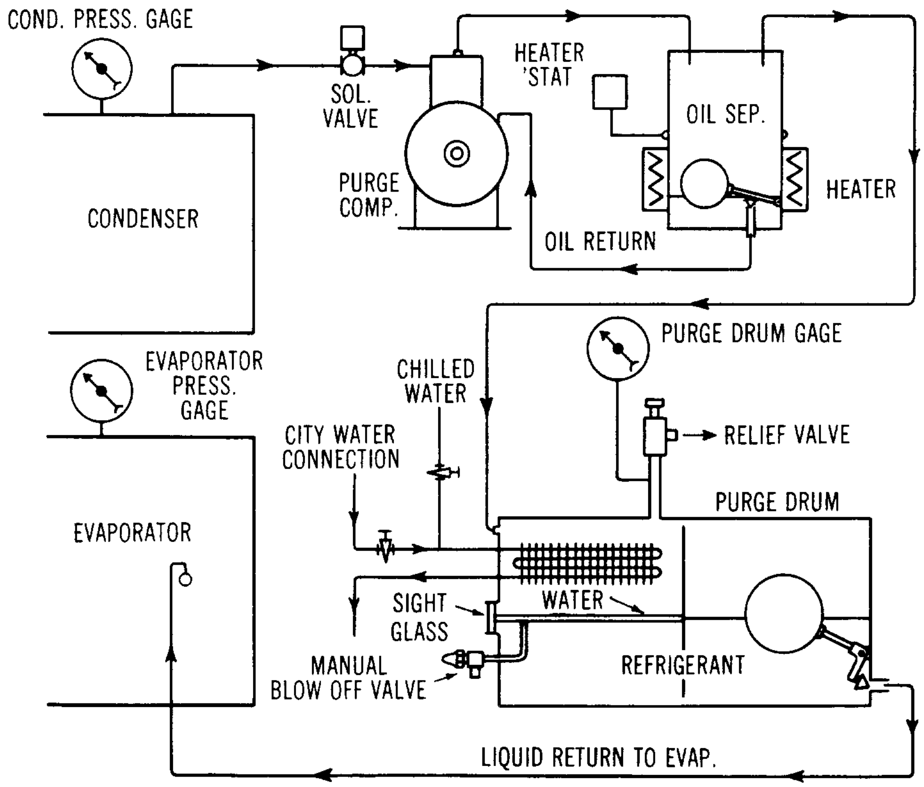


Fig. 9 – Typical Purge System (The Trane Co.)

An air leak in the centrifugal machine will be indicated by a high head pressure on the condenser gauge, and by cycling of the purge motor and/or solenoid valve. The leak should be found and repaired for two reasons: (1) air purged from the machine will carry some refrigerant vapor and will mean a continuous loss of refrigerant and (2) air which enters the machine will contain some water vapor which is harmful to the machine. Any accumulation of water can be seen floating on top of the refrigerant through the water sight glass and can be removed by opening the manual blow-off valve. It is recommended that the amount of water drawn off be recorded. ***Leak testing*** is covered in Paragraph 5.03 of this section.

3.06 ***Controls*** — Since there are many different types of controls manufactured, many variations will be found on each centrifugal system. This part will deal only with the most common types of controls. It is strongly recommended that a complete set of operating instructions and up-to-date drawings be made available for each air conditioning system.

Basically, there are two different types of controls in use on centrifugal refrigerant air conditioning systems.

(1) ***Electronic Control*** — The electronic control system regulates the chilled water temperature and prevents motor overload by positioning the prewhirl vanes through a hydraulic motor. Under normal conditions, the water leaving the evaporator is controlled by the chilled water temperature controller. A resistance element immersed in the chilled water reacts to temperature leaving the cooler. The element is part of a bridge circuit from which signals are strengthened by an electronic amplifier, which in turn activates relays. The relays open and close solenoid valves, which feed oil to, or bleed oil from, the hydraulic prewhirl vane motor. When the temperature of

the water leaving the evaporator increases, the vanes will move toward the open position. A decrease in temperature results in a movement toward the closed position.

(2) ***Pneumatic Control*** —The pneumatic control system regulates the chilled water temperature and prevents motor overload by positioning the prewhirl vanes through a pneumatic motor. The leaving chilled water temperature is sensed by a chilled water thermostat. This control sends a signal air pressure, proportioned to chilled water temperature, through the motor load control and then to the pilot positioner, which controls air pressure to the pneumatic vane operator. As the leaving chilled water temperature increases, the thermostat will increase the control air pressure to the motor load control. This pressure will then be transmitted to the pilot positioner. An increased control pressure on the pilot positioner allows more air to be fed to the pneumatic vane operator. As the vanes open, due to the increased air pressure, the chilled water temperature will gradually lower and, as the pneumatic motor moves, the spring acting on the lever arm will maintain a balance between the control pressure and the pneumatic motor to prevent "hunting" of the vanes.

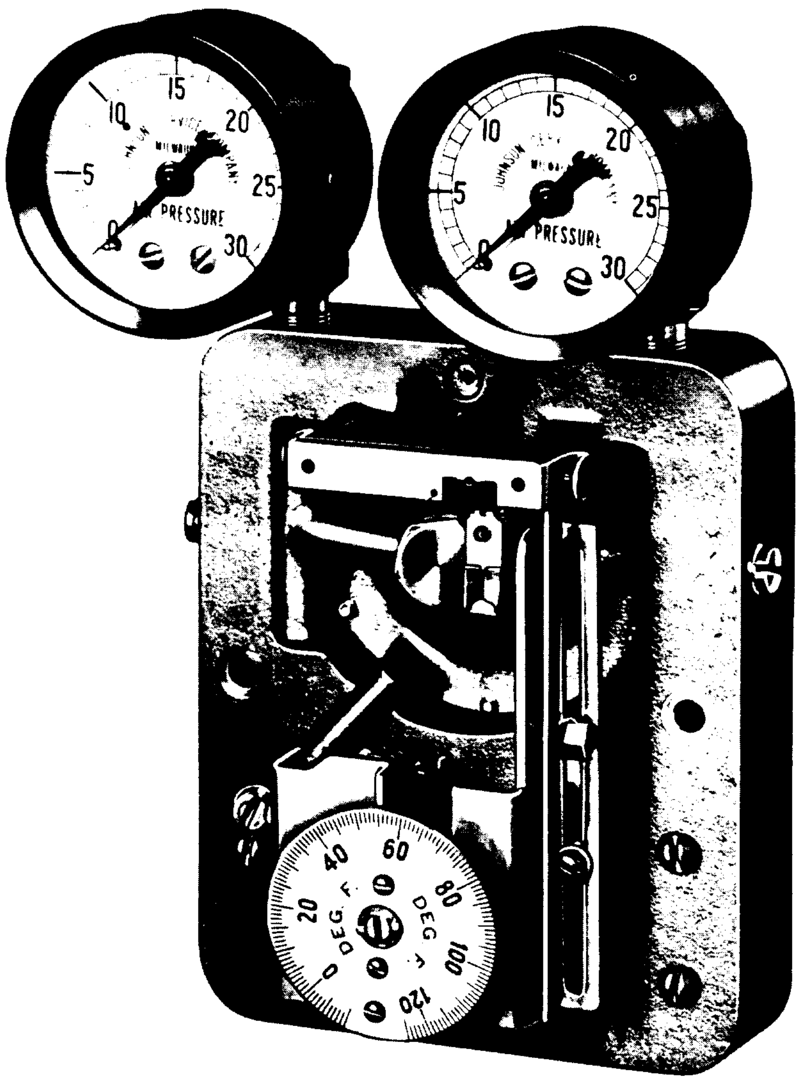


Fig. 10 – Chilled Water Thermostat (Carrier Corp.)

3.07 ***Others*** — Various other components of the air conditioning system such as the cooling tower and its associated water treatment, pumps, fans, coils and motors are not covered in this section. The operator should refer to the appropriate section of the BSPs covering the particular piece of equipment or to the manufacturer's data sheet for recommended maintenance procedures. The following is a list of BSPs pertaining to air conditioning equipment.

770-200-000 — Building Mechanical Equipment, Scheduling Routine Maintenance

770-220-301 — Air Filter Cell for Unit Ventilators

770-220-304 — Maintenance of Ventilating Fans

770-220-308 — Installation and Maintenance of V-Belts

770-230-300 — Fundamental Principles of Water Conditioning

770-230-301 — Water Treatment — Air Conditioning Systems

770-230-302 — Water Treatment Equipment — Open and Closed Heat Exchanger Systems

770-240-302 — Cooling Towers

770-510-150 — Piping Identification

760-560-150 — Guarding Moving Parts of Machines

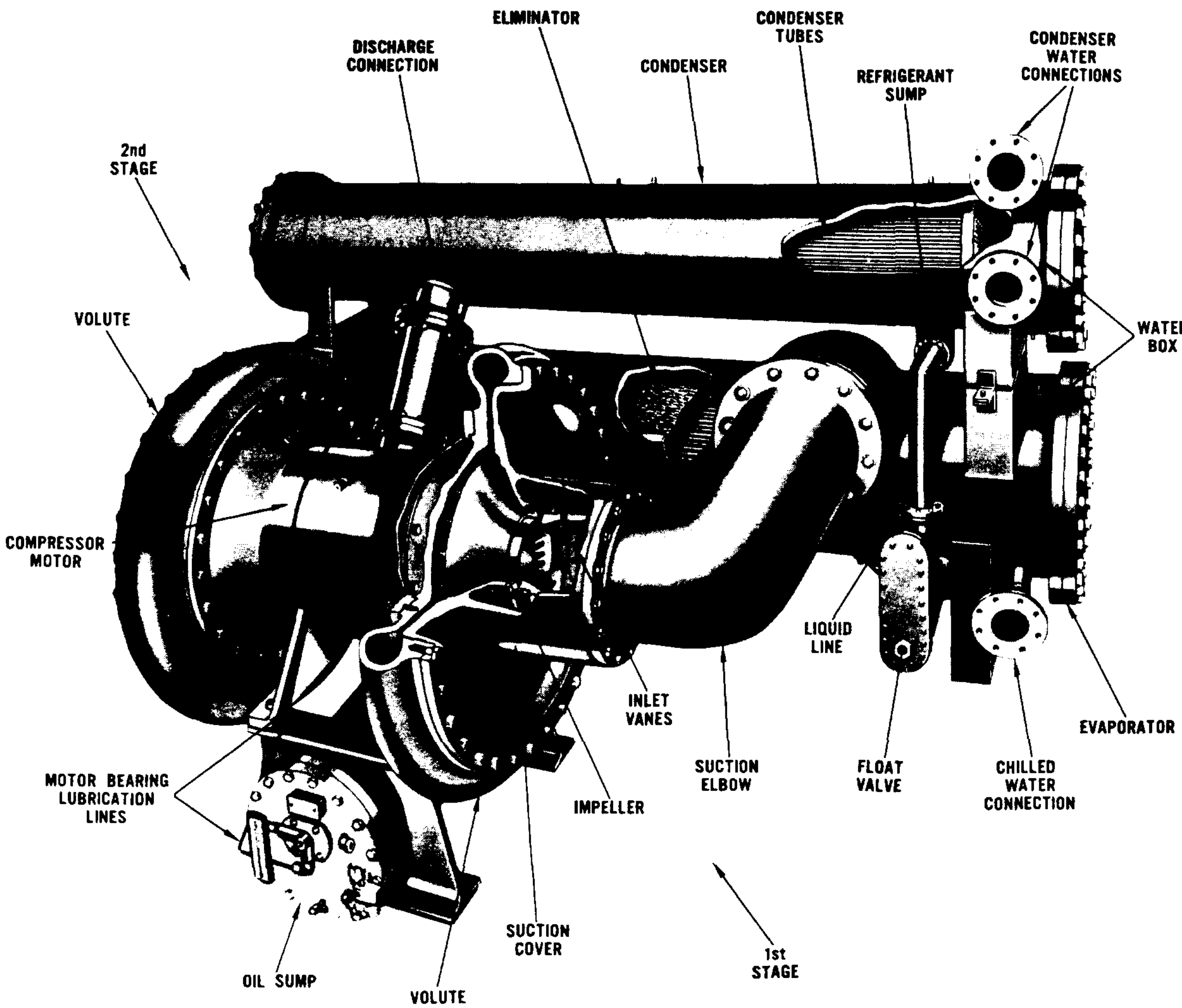


Fig. 11 – A Typical Centrifugal Refrigeration System (The Trane Co.)

4. LUBRICATION

4.01 For proper lubrication, use only high grade turbine oil such as that originally furnished by the manufacturer. Usually an additional supply can be ordered from the distributor of the brand of equipment that is installed. The operator should keep a record of all oil added or removed from the system as it can be an indicator in trouble analysis.

4.02 Usually the oil should be changed once a year unless the machine is opened for repairs. If the oil becomes contaminated during repairs, recharge with new oil. When changing the oil, the machine must be under vacuum. To add oil, attach a tube to the oil charging valve, place the other end in a container of oil and open the charging valve. Care should be taken to keep the end of the tube submerged in the oil to prevent air entering the machine. Do not break the oil container seal until the oil is ready to be placed into the machine. To drain small amounts of oil without breaking the vacuum, shut down the compressor, and with the oil pump running, loosen the drain nut on the oil cooler and bleed the oil.

4.03 Absorption of refrigerant by the oil may cause a rise in oil level. This can be checked by observing the oil level in oil sight glass usually located on the compressor. This could be caused by improper operation of the oil heater. If this has not progressed to a dangerous stage, the excessive refrigerant can be boiled out of the oil by raising the oil reservoir temperature. Prior to this, the cause should be corrected.

To minimize refrigerant absorption by the oil, some manufacturers incorporate a oil heater thermostat to maintain an oil reservoir temperature of approximately 140°F. The oil heater element is submerged in the oil reservoir. It keeps the oil hot during shutdown to minimize absorption. Usually a small pilot light on the oil reservoir cover is illuminated when the heater is on.

On extended shutdowns, the absorption of the refrigerant by the oil can be minimized by being sure the oil heater, when installed, is operating properly, operating the purge pump manually as required to keep the refrigerant vapor pressure down, and operating the oil pump occasionally to agitate the heater oil which permits the refrigerant to escape. If the machine is in an area subjected to below freezing temperatures, water must be removed from the oil cooler. To do this, open the inlet fitting and blow out the water coils.

4.04 The bearing maintenance consists primarily of maintaining clean oil in the lubricating system. Overheating can cause damage to the bearings. If bearing temperatures rise above normal, check the water supply to the oil cooler, the setting of the plug cock, and the operation of the solenoid valve. On machines equipped with a replaceable oil cooler-filter assembly, these cartridges should be changed annually. The machine should be at atmospheric pressure when this work is done. On most machines, a bearing high temperature cutout is installed in the compressor to shut down the machine if the bearing temperature becomes excessive. Where possible, the operator should refer to the manufacturer's data and determine the procedure for annually testing this switch.

5. OPERATION

5.01 The operation and maintenance of any air conditioning system should be handled by adequately trained and experienced personnel. Considerable repair cost will be incurred on any system when the day-to-day operation of the equipment is not thorough and complete. The manufacturer of a particular piece of equipment should be best qualified to furnish written guides and instructions on the equipment; therefore, the manufacturer's data should be obtained and used in conjunction with this section. Since this section is not intended to cover each manufacturer's equipment, the detailed procedures for doing the work will have to be obtained through experience.

Dirt and Moisture

5.02 Water removed from the centrifugal machine will accumulate in the water compartment of the purge condensing chamber. Any accumulation of water can be seen floating on top of the refrigerant through the water sight glass. If water is allowed to remain in the machine, serious damage will result.

There are several devices available to install on the liquid line of the system to indicate the presence and degree of moisture in the refrigerant. All moisture indicators change color on the basis of relative saturation of the refrigerant. Therefore, liquid line temperature must be considered if an accurate calibration is to be obtained. The sight glass should be observed and the color of the liquid should be compared against the safe standard color guide. Consideration should be given to installing a moisture-liquid indicator if the system does not have one.

In addition to the sight glass moisture indicator, it is recommended that each system have a filter-drier installed in the main liquid line. Moisture, acid and foreign matter are a constant threat to any system. These units are usually molded porous cone, consisting of a blend of highly effective desiccants. The units remove moisture from the refrigerant by adsorbing and retaining it on the surface of the desiccants. It is an accepted fact that moisture and heat accelerate refrigerant and refrigerant oil breakdown to form acids, sludges, and corrosive compounds which attack the internal metal parts of the system. This acid also attacks the motor insulation resulting in hermetic motor burnouts. The desiccant in the filter unit effectively removes acids by adsorbing and retaining them with the cone itself. Sludge is the result of oil decomposition and acid action. It hinders the normal operation of the system controls and reduces system capacity. The porous filter cone will filter out and hold this sludge.

It is recommended that such a device be installed on the main refrigerant liquid line.

Leak Testing

5.03 To leak test machines which are normally under vacuum, it is necessary to shut down and pressurize the machine by using dry nitrogen. The refrigerant vapor within the unit serves as a tracer gas for leak detection purposes.

> ***WARNING:*** ***Do not use oxygen or acetylene in place of nitrogen for leak testing. A violent explosion may result. Always install a pressure regulating valve in the hookup to prevent the unit from being subject to excessive pressures. Never apply full drum pressure, and always disconnect the line from the nitrogen source after obtaining required test pressure.***

(1) Connect the cylinder of nitrogen with pressure regulator to the evaporator.

(2) Open the connection valve and charge enough nitrogen into the unit to develop between 5 to 10 psig test pressure. TEST PRESSURE MUST NOT EXCEED 10 PSIG AS DAMAGE TO THE DISC OF THE EVAPORATOR RELIEF VALVE WILL RESULT.

(3) Close the connection to the evaporator and remove the nitrogen charging unit.

(4) Using a halide torch, check the entire unit for leaks, paying particular attention to:

- (a) gasket joints
- (b) bolt heads and nuts
- (c) sight glasses
- (d) motor terminals
- (e) welded joints
- (f) putty lines on castings
- (g) gauges and gauge connections
- (h) purge relief valve
- (i) evaporator and condenser boxes

Inserting the exploring tube of the halide torch into the water boxes, through the drain openings, will reveal tube or tube to sheet leaks.

(5) Repair any leaks, purge the nitrogen from the system by putting the purge unit into operation. Allow the purge to operate until the nitrogen ceases to be discharged through the purge relief valve.

A halide leak detector can be obtained from any refrigeration supply house. To use the detector, attach it to a "Prestolite" tank, light it, and adjust the flame so it is very low, yet hot enough to cause a red glow on the copper reaction ring. Too large a flame will melt the copper ring and the detector will be ineffective. In checking for leaks, place the end of the feeler tube at the point of test and observe the flame. The feeler tube pulls a sample of air into the burner. Any refrigerant present will decompose into free acids which will react with the copper ring, and change the flame color. Small leaks give a greenish tint while larger leaks color the flame a vivid blue.

A heavy concentration of refrigerant in the room will decrease the efficiency of the test. It is best to ventilate the room before attempting to test.

Add Refrigerant

5.04 A refrigerant level indicator is provided on the system to indicate the proper level of refrigerant. The manufacturer's data will give the exact location of this piece of equipment as well as indicate the proper operating levels. Too much refrigerant in the evaporator will cause liquid droplets to be pulled into the compressor suction, resulting in too much power consumption for the tonnage of refrigeration produced. Too little refrigerant causes inadequate water cooling in the upper tubes. The refrigerant temperature will drop to compensate for this and in extreme cases the machine will shut down.

To charge the evaporator with refrigerant (R 113 and R 11), use a drum valve and fittings as shown in Fig. 12.

With the valve closed, screw the fitting into the drum containing the refrigerant. Connect the drum to the evaporator charging valve, using soft copper tubing.

With the connection at the evaporator valve loose, open the drum charging valve slightly to force the air out of the line with the refrigerant. Then tighten the connection and open both valves wide. The ends of the drum will usually pull in when all the refrigerant is removed since the drum is subjected to the vacuum in the evaporator. ***Protective goggles should be worn during this entire operation.*** Caution should be taken to assure the operator that too great a vacuum is not drawn by the evaporator on the drum, as an implosion may result. The evaporator should be under a vacuum when adding refrigerant.

Drums of refrigerant should always be stored in a cool place. If the temperature of the drum of refrigerant is allowed to rise above the boiling point of the refrigerant, there will be

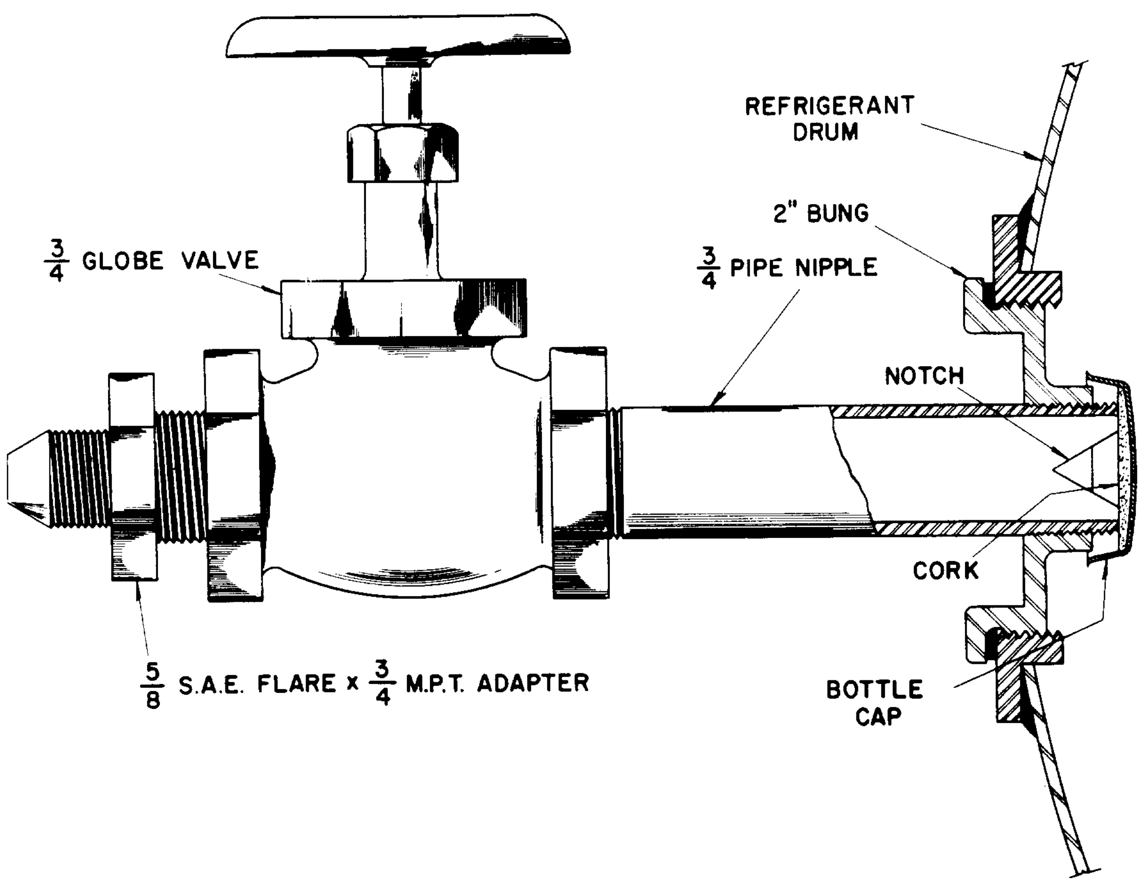


Fig. 12 — Drum Charging Valve

pressure in the drum. Opening a drum which contains pressure in any way other than that described above could result in serious loss of refrigerant and possible injury to the operator.

The evaporator can be charged with the refrigerant drum at a lower level by turning the drum valve ***down*** and maintaining a pressure difference between the evaporator and the drum great enough to force the refrigerant into the evaporator. This may require slight heating of the drum with hot water. ***Do not use a torch.*** A pressure gauge should be placed in the charge line as a safety precaution to the operator.

5.05 Most refrigeration installations come equipped with controls and safety devices to enable the equipment to operate on a fully automatic basis. This does not mean that the only time the equipment needs attention is following a shutdown on safety controls or the annual start-up or shutdown. Automatic operation does not preclude the need for qualified mechanics to make periodic inspections and to record pertinent operating data. When a system is taken over for operation and maintenance, a complete set of the manufacturer's operating and maintenance instructions should be placed in a location accessible to anyone who may have the occasion to work on the equipment.

Acid Testing

5.06 The formation of acids within the refrigerating cycle have long been recognized as one of the major causes of hermetic compressor and other component failures. Much literature has been published about the effects of contaminants on the oil-refrigerant mixture in refrigeration systems. The chemical stability of this mixture is affected by many possible system ingredients — air, moisture, acid, metals, heat, etc. In general, refrigerants do not have much chemical reactivity. Reactions of most interest in refrigeration probably include hydrolysis, oxidation and reduction, thermal decomposition, reaction with oil and direct reaction with metals. In most of the reactions, inorganic acids and reactive organic compounds such as organic acids are either present or formed and eventually cause serious trouble.

The continuous free circulation of a refrigerant-oil mixture serves a dual role in that the refrigerant acts as a solvent, but the oil becomes a scavenger. It collects the acids formed and if their concentration is excessive, and not brought under control, internal damage is inevitable. Paragraph 5.02 recommended that a filter be installed to prevent some of the above problems. However, it is advisable to ***once a year*** test the refrigerant-oil to determine its safe acid concentration limits. There are available on the market several Acid Test Kits that can be used to accurately and reliably detect the presence of acid in the system. Usually very little oil is drained from the machine and it normally takes less than five minutes. Simple step-by-step procedures for testing and making color comparisons are supplied with the kit.

This oil sampling service can also be done by outside contractors who specialize in this work. In addition to acid content, most outside firms will provide additional information such as dilution of oil by refrigerant, metal particles in oil, and the probable remaining useful life of the oil. It is recommended that the oil be tested at least once a year.

Daily or Weekly Check

5.07 It is desirable to record operating data daily; however, where this is not feasible, the minimum check should be weekly. In addition to the daily log (Fig. 13) on the compressor, the attendant should observe any unusual noise, odors, oil or water spots, and any sudden change in temperatures and pressures.

Since each machine establishes a normal operating pattern of pressures and temperatures for given conditions, deviations from the patterns can be warnings of developing trouble. A typical example of an operating log is illustrated in Part 6, Fig. 13.

Monthly Operational Inspection and at Spring Start-up

5.08 The following guide should be used in conjunction with the manufacturer's operating instructions for the exact procedures to be followed, the limits of the particular system and other information.

COMPRESSOR

1. Check compressor oil pressure and adjust if necessary.

2. Check oil level in oil reservoir.

3. Check operation of oil heater, oil heater thermostat and valves associated with this component.
4. Check main bearing temperature.
5. Check motor end bearing temperature.
6. Check compressor for excessive noise and vibration, determine cause and take necessary corrective action.
7. Check oil pump for noise, vibration or excessive amperage.

CONDENSER

1. Check condenser gas pressure gauge and temperatures.
2. Check temperature of entering and leaving condenser water.
3. Check difference between condensing temperature and temperature of leaving condenser water for indications of air in system, or dirty tubes.
4. Check condenser water pressures in and out for indication of scale buildup.

EVAPORATOR

1. Check suction pressure and refrigerant temperature.
2. Check temperature of entering and leaving chilled water.
3. Check difference between suction temperature, refrigerant temperature and leaving chilled water temperature for indications of excessive oil in refrigerant, or dirty tubes.

SAFETY CONTROLS

Check each of the following safety controls for proper operation. When possible, record the cutoff point in a log record.

1. Chilled water safety switch and recycle control.
2. Low refrigerant temperature safety switch.
3. Condenser high pressure safety switch.
4. Low oil pressure safety switch.
5. Evaporator differential pressure safety switch.
6. Vane closed switch.
7. Chilled water pump interlock.
8. Condenser water pump interlock.

OPERATING CONTROLS

Depending upon the manufacturer of the equipment, the various operations will vary. Therefore, it is recommended that each system be surveyed and a set of guides for the operating controls be prepared and followed. The following items are usually provided and should be checked.

1. Check operation of motor overloads.
2. Check operation of capacity indicator.
3. Inspect for moisture and clean the resistance elements. Apply grease if applicable.
4. Check operation of chilled water control for both thermostatic and manual operation.
5. Check operation and setting of starter time delay relay.
6. Check operation of main switch and red and green indicating lights.

PURGE UNIT

1. Remove excessive water in purge unit.
2. Check for leaks by noting amount of water discharged from purge relief valve.
3. Maintain purge compressor oil level. Check heater elements.
4. Check operation of float valve in purge separation chamber.
5. Check operation and setting of purge relief valve.
6. Check purge suction pressure.
7. Check purge V-belt and adjust for proper tension.
8. Clean purge condenser and fan.
9. Lubricate purge motor bearings when necessary.

10. Check shaft seals of purge compressor for leaks.

11. Note any excessive noise or vibration.

Annual Shutdown Inspection

5.09 Some makes of hermetic centrifugal machines have inspection plates on the compressor motor, evaporator and condenser. These openings are provided to allow the operator access into the machine without removing piping, heads and large pieces of castings. In a short period of time, the operator is able to remove the inspection plate and make many checks on the main internal ports without exposing the system to the detrimental elements of the atmosphere. Once the plates are replaced, the purge unit can be operated for several minutes to remove the air. This is considerably less trouble and expense than having to use the normal means of opening up the compressor.

On machines equipped with such inspection plates, the following items should be checked at the shutdown period.

> *Note:* It is ***not*** recommended that the operator open up a system in which it is necessary to remove large piping and heavy castings in order to make an annual inspection unless other trouble indicators suggest that it is necessary.

COMPRESSOR

1. With the inspection plate removed, inspect the following items for damage, wear and proper clearances.
   (a) Main Bearing or Thrust Bearing
   (b) Motor End Bearings
   (c) Shaft Journal
   (d) Carbon Ring
   (e) Felt Ring Seals
2. Inspect the motor winding insulation for defects, cracks and discoloration.
3. Inspect economizer damper for proper operation and clearances.
4. Remove oil, clean or replace oil filter and add new oil charge.
5. Check oil heater, oil heater thermostat, oil pressure regulating valve, water regulating valve or plug cock, and solenoid valve for proper operation, calibration and any signs of leaks.
6. Check operation and calibration of main bearing thermometer, motor end bearing thermometer, oil reservoir temperature thermometer and oil pressure gauge.
7. Leak Test vane shaft seal.
8. Acid Test — See Paragraph 5.06.

INSULATION RESISTANCE TEST (Once a Year) — With the constant expansion and contraction from alternate heating and cooling of the motor windings, it is possible for minute cracks to develop in the winding insulation. Acid in oil or refrigerant collects on the windings, causing short-circuiting that could lead to motor burnout. To help reduce this, a properly installed and maintained drier in the system will be of great benefit.

To detect a failure in motor insulation prior to a burnout, an insulation resistance test should be made annually. The test set for this is called a megohmmeter. Its purpose is to test the insulation resistance between motor windings and motor frames.

An ohmmeter will also measure resistance, but it applies only 1.5 to 6.0 V DC. A megohmmeter applies from 250 V to 10,000 V DC depending upon the type of instrument. In order to assure the adequacy of the insulation, it is necessary to test the insulation at the higher voltages.

It is recommended that the test be performed at 500 V DC for motors operating on 208/220 V AC. For machines operating at higher voltages, above 220 V, consult the manufacturer for the correct test voltage. The Institute of Electrical and Electronics Engineers (IEEE) have a bulletin, No. 43, Recommended Practice for Testing Insulation Resistance of Rotating Machinery. This bulletin covers the subject in detail. This can be obtained from IEEE, 345 E. 47th St., N. Y., N. Y.

There are many makes of megger test sets on the market and the cost varies with the DC output. It is recommended that for most of our testing needs a machine capable of 1000 V DC output is sufficient. Along with each test set, the manufacturer will furnish detail testing procedures. These instructions should be followed. There are several points to be remembered in interpreting and using the results of insulation testing.

1. Always make sure the motor to be tested has been properly de-energized and removed from the electrical distribution system to protect personnel doing the testing and also the test equipment.

2. A 60-second application of 500 V DC is recommended where short-time single readings are to be made on windings and where comparisons with earlier and later data are to be made.

3. Very little has been written on the minimum test value that is safe for hermetic motors. When the test results indicate readings less than 5 megohms at 500 V DC test current, consideration should be given to the need for further inspection.

4. In using the megger test set, always take the readings after the compressor has operated for about 30 minutes. This will give a uniform temperature for comparison of readings. On a cold machine a lower reading can usually be expected.

5. To megger test a hermetic motor it is not recommended that the system be opened up in order to attach the test leads to the motor terminals. It is recommended that the starter wiring leads be disconnected on the load side of the switch and the test leads of the megger test set be attached according to the manufacturer's instructions. With this set-up the operator must remember he is meggering the wiring to the motor as well as the motor windings. If this reading is less than satisfactory, (see Step 3) then it will be necessary to remove the starter wiring and connect the test leads of the megger to the terminal blocks on the motor. A low megger reading at this point will mean that the compressor will have to be opened in order to attach the megger test leads directly to the motor windings. In most cases unless the starter winding or terminal blocks are bad, the first test is all that will be necessary.

6. The value of megger readings comes from establishing a continuing history on a particular motor. Therefore, it is necessary to establish a benchmark value for the motor at the time it is new. The megohm value at this time should be recorded and subsequently each annual reading plotted on a graph to determine the remaining life of the insulation. On existing motors in operation you can start such records and can expect the initial readings to be lower, in most cases, than on a new motor.

7. For testing motor starters and contactors, refer to Section 770-280-602.

CONDENSER

1. Inspect condenser tubes for algae, sediment, mud and scale and if tubes are dirty, follow recommendations of the manufacturer.

2. Check operation and calibration of condenser pressure gauge and recalibrate if needed.

EVAPORATOR

1. Check sight glass for proper refrigerant charge and indications of oil contamination.

2. Check pressure gauge for proper operation and calibration and recalibrate if needed.

3. If machine has been in operation only one season or if maintenance log and previous operating conditions indicate possible tube fouling, inspect cooler tubes and if tubes are dirty, follow manufacturer's recommendation.

SAFETY CONTROLS

Note: For a detailed description on the step-by-step method to follow on performing the following test, the operator should refer to the manufacturer's data for the correct test procedure as this will vary between different makes of equipment.

1. Check operation and set point or calibration of each of the following controls:

   (a) Condenser high pressure switch.

(b) Chilled water temperature safety switch and recycle control.

(c) Refrigerant temperature safety switch.

(d) Cooler differential flow switch.

(e) Vane closed switch.

2. Check electrical contacts and operation of following controls:

(a) Condenser high pressure cutout reset relay.

(b) Refrigerant low temperature reset relay.

(c) Condenser water pump electrical interlocks.

(d) Chilled water pump electrical interlocks.

OPERATING CONTROLS

If conditions are such that machine may be placed in operation for a short period of time, check operation and calibration of each of the following controls:

1. Electronic motor overload control module.
2. Electronic chilled water temperature control module.
3. Capacity indicator.
4. Water regulating valve or solenoid valve and plug cock.

PURGE UNIT

The complete purge unit should be carefully inspected, cleaned and checked for normal appearance and operation. Specific steps included in the inspection are:

1. Remove, clean, inspect and adjust purge separation chamber float valve.
2. Clean and inspect separation chamber.
3. Remove, clean and inspect oil separator float valve and screen.
4. Clean and inspect purge condenser.
5. Clean, inspect and lubricate purge motor.
6. Inspect purge V-belt and adjust belt tension if required.
7. Check operation of oil separator and oil reservoir heater elements.
8. Check purge relief valve for normal operation.
9. Check purge compressor for excessive noise while purge system is in operation.
10. Change oil in purge compressor.

Clean-up After Motor Burnout

5.10 Servicing of a system after a severe hermetic motor burnout is a time-consuming and expensive operation. Not only must the stator be replaced or rewired, but the entire system must be thoroughly cleaned of all harmful contaminants — moisture, acid and sludges — left by the burnout.

The first step is to determine that a burnout has actually occurred. This can be done by electrical testing with the megger. Also, another means of determining this is analyzing an oil sample. If a burnout has occurred, the oil will indicate a high acid content. Flushing the system with Refrigerant 11 to remove contaminants after a hermetic burnout has been one of the recommended clean-up procedures. However, the flushing method is a complicated operation and has several limitations. Commercial refrigerant cleaning devices, similar to the Sporlan Cleaner, are available to do the job in less time and do a more thorough job of cleaning. The refrigerant cleaner uses the refrigerant and oil in the system as a solvent to bring the contaminants to a porous filter, eliminating the difficulties inherent with the flushing technique. One benefit of using a system cleaner device is the cost savings made by reusing the original refrigerant charge.

If a burnout has definitely occurred, the equipment manufacturer's recommended procedure should be followed. If this is not available, the following procedure may be used.

1. Remove oil refrigerant and store in drums. (Have test made on oil.)
2. Remove oil from reservoir, hydraulic motor, oil cooler, oil lines.
3. Remove motor stator.
4. Clean inside of motor shell.
5. Clean inside of oil reservoir.
6. Dismantle bearings and clean all parts including the shaft and rotor.
7. Add new charge of oil to oil reservoir.
8. Change oil filter.
9. Flush lubricating system with new oil by operating the pump and running the vanes, open and closed, a number of times to flush out the lines and the hydraulic motor.
10. Drain all oil again and put in new charge of oil.
11. Change oil filter.
12. Remove float chamber covers and clean float chambers and floats.
13. Dehydrate machine.
14. Break dehydration vacuum with dry nitrogen.
15. Install new stator.
16. Make insulation resistance test on new stator and record readings.
17. Dehydrate machine again.
18. Again make insulation resistance test on motor and record readings.
19. Charge oil refrigerant into machine through system cleaning device. Change cartridges after each drum of refrigerant.
20. Operate machine one-half to one hour.
21. Remove refrigerant into drums.
22. Take a sample of refrigerant and have it analyzed for acid content.
23. Distill refrigerant into machine, passing the gas vapors through a freshly charged drier, as described in Step 19.
24. Operate one hour.
25. Remove sample of refrigerant and have tested for acid content.
26. If refrigerant still shows acid, again remove refrigerant into drums and charge back into machine through drier.
27. Install drier between condenser and cooler. This drier should be checked after operating 2 days, 15 days, and 30 days for evidence of acid being removed. If, after this period, there are no indications of acid, the drier installation can be removed. Install between opening in condenser float chamber and cooler charging valve, where possible.
28. The purge compressor should be operated continuously for the first 30 days after repairs.
29. After 30 days' operation, the oil and oil filter should again be changed. The machine can then be considered cleaned up.

6. RECORDS

6.01 Temperature, pressures, refrigerant and oil leaks are a good indication of the condition of the machine and can be a valuable help to the repair personnel. If no records are kept of replacements, the operator may not be aware of the repeated failures being experienced. Similarly, records should be kept of suction and discharge pressures and condensing temperature. These can be used as trouble indicators in the compressor system and when noting any abnormal changes in the readings, this will aid in preventing breakdowns or loss of compressor efficiency. A typical log record form is included as Fig. 13.

REFRIGERATION LOG
HERMETIC CENTRIFUGAL REFRIGERATING MACHINE

PLANT________________________________ MACHINE SERIAL NO. ______________________________ SIZE ________________

	COOLER					CONDENSER				COMPRESSOR							THERMAL PURGE			
	GPM ______________					GPM ______________					BEARING TEMP.		OIL				Purge Pressure for Pump Operation		Time Between Pump Starts	Refrig. Level
				WATER TEMP.				WATER TEMP.									Starts	Stops		
																	COMPRESSION PURGE			
Time	Vacuum	Liquid Temp.	Liquid Level	In	Out	Vacuum or Press.	Cond. Temp.	In	Out	Position Cap. Indicator	Main	Motor End	Level	Temp.	Pressure	Motor Amps	Suct. Press.	Disch. Press.	Oil Level	Refrig. Level
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21

REMARKS: List repairs made, oil or refrigerant added or removed, oil added to purge (if compression type), and water drained from purge. Give amounts.

DATE____________________

Fig. 13 – Refrigeration Log for Centrifugal Refrigeration System (Carrier Corp.)

7. TROUBLE CHART FOR CENTRIFUGAL SYSTEM

SYMPTOM	TROUBLE FOUND	POSSIBLE CAUSE	RECOMMENDED ACTION
Compressor fails to start.	1. Electric circuit test shows no current on line side of motor starter.	1a Power failure. 1b Disconnect switch open.	1a Contact Power Co. 1b Determine why switch was opened. If everything is normal, close switch.
	2. Inoperative motor starter.	2. Burned-out coil or faulty contacts.	2. Determine cause, and repair.
	3. Motor starter will not operate.	3. Open control circuit. a. High pressure control. b. Motor temperature control (water-cooled units only). c. Low temperature control. d. Low oil pressure. e. Oil pump not operating. f. Motor starter overloads. g. Chilled water temperature control not set correctly or not calling for cooling. h. Open circuit from "interlocking" relays.	3. Locate open control. Determine and correct cause. See individual control instructions. If there has been a power failure or control circuit has been de-energized, RESET on panel must be depressed.
Compressor "short-cycles."	1. Air pressure varying in branch line.	1. Chilled water temperature control not functioning properly.	1. Repair or replace control.
	2. Air pressure on supply line between air compressor and pneumatic control circuit varying.	2. Air compressor not supplying proper air pressure to pneumatic control circuit.	2. Repair compressor and air lines, as required.
	3. Contacts of pneumatic-electric switch opening and closing rapidly or contacts not closing properly.	3. Pneumatic-electric switch not functioning properly.	3. Check switch and determine cause of trouble. Repair or replace.
	4. Oil pressure fluctuating. Unit cycling on oil pressure control.	4. Dirty oil filter malfunctioning regulating valve.	4. Clean filter or repair regulating valve.

SYMPTOM	TROUBLE FOUND	POSSIBLE CAUSE	RECOMMENDED ACTION
Compressor runs continuously but does not reduce chilled water temperature.	1. High temperature in conditioned area.	1. Excessive load.	1. Stop excessive infiltration of outdoor air.
	2. Branch line pressure from control too low.	2. Chilled water temperature control controlling at too high a temperature.	2. Reset or repair control.
	3. Inlet vanes not operating properly.	3. Pilot positioner, vane operator or load limit relay not functioning properly.	3. Repair or reset pilot positioner, vane operator or load limit relay.
	4. Refrigerant level too low.	4. Shortage of refrigerant.	4. Determine cause of loss. Repair, as required. Add refrigerant.
	5. Everything normal but lack of capacity.	5. Impeller rotation incorrect.	5. Correct rotation.
Discharge pressure too high.	1. Excessively warm water leaving condenser.	1a Too little or too warm condenser water.	1a Provide adequate cool water. Correct operation of cooling tower or setting of cooling tower thermostat.
		1b Air in water circuit.	1b Vent air from circuit.
	2. Water temperature rise through condenser too low.	2. Fouled tubes in condenser.	2. Clean tubes.
	3. Water temperature leaving tower too high.	3. Improper operation cooling tower.	3. Check operation of cooling tower fan and setting of cooling tower thermostat. Clean sprays in cooling tower. Clean strainer in cooling tower piping.
	4. Insufficient water circulating through condenser.	4a Restriction in water line strainer.	4a Clean strainer.
		4b Condenser water pump worn.	4b Repair or replace water pump.
	5. Exceptionally hot condenser and excessive discharge temperature.	5. Air or noncondensable gas in system.	5. Purge system.

SYMPTOM	TROUBLE FOUND	POSSIBLE CAUSE	RECOMMENDED ACTION
Discharge pressure too low.	1. Excessively cold water leaving condenser.	1a Too much condenser water.	1a Adjust flow.
		1b Cooling tower thermostat set too low.	1b Raise thermostat setting.
Suction pressure too high.	1. Compressor runs continuously without reducing water temperature.	1. Excessive load on evaporator.	1. Look for excessive infiltration of warm air into conditioned space, and correct.
Suction pressure too low.	1. Refrigerant level low.	1a Lack of refrigerant.	1a Correct cause of refrigerant loss. Add refrigerant.
		1b Liquid line float valve stuck or obstructed.	1b Check action of float. Repair as required.
	2. Light load on evaporator.	2. Water in chilled water circuit being bypassed around evaporator or insufficient flow of water through evaporator.	2. Adjust chilled water circuit valves.
	3. Temperature of water leaving evaporator below design setting.	3. Chilled water temperature control set too low or not functioning properly.	3. Check action of temperature control. Repair or replace.
	4. Vanes do not close. Temperature of water leaving evaporator below design setting.	4. Pilot positioner and vane operator not set correctly.	4. Reset pilot positioner and vane operator.
Compressor motor starter cuts out on overloads.	1. Voltmeter shows low voltage reading.	1. Low voltage.	1. Contact Power Co. Regulate voltage.
	2. Overloads trip below 105% of motor full load amperage.	2. Starter overloads incorrectly set.	2. Correct setting of overloads.
	3. Motor overloading and vanes not closing in response to load limit relay.	3. Load limit relay not properly set.	3. Correct setting of load limit relay.

SYMPTOM	TROUBLE FOUND	POSSIBLE CAUSE	RECOMMENDED ACTION
Compressor cuts out on low temperature control.	1. Refrigerant level low.	1. Lack of refrigerant.	1. Correct cause of refrigerant loss. Add refrigerant.
	2. Water in chilled water circuit being bypassed around evaporator or insufficient flow of water through evaporator.	2. Light load on evaporator.	2. Adjust chilled water circuit valves.
	3. Temperature of water leaving evaporator below design setting.	3. Chilled water temperature control set too low or not functioning properly.	3. Check action of temperature control. Repair or replace.
	4. Vanes do not close. Temperature of water leaving evaporator below design setting.	4. Pilot positioner and vane operator not set correctly.	4. Reset pilot positioner and vane operator.
	5. Low temperature control cuts out above correct set point.	5. Low temperature control not functioning properly.	5. Readjust, repair or replace low temperature control.
Compressor cuts out on high condenser pressure.	1. High pressure control cuts out below correct set point.	1. High pressure control not functioning properly.	1. Readjust, repair or replace high pressure control.
Purge unit will not build up pressure.	1. Air in system but purge unit will not build up enough pressure to vent through relief valve.	1a Purge condenser float valve stuck in open position.	1a Remove purge condenser head and clean or repair float valve mechanism.
		1b Purge compressor valves worn.	1b Repair or replace valve plate assembly.
		1c Valves between condenser and purge compressor closed.	1c Open valves.
		1d Solenoid valve to purge unit not opening.	1d Repair or replace solenoid valve.
Purge unit relieves at too low a pressure.	1. Relief valve opens below correct set point.	1. Relief valve stuck or set too low.	1. Repair, clean, adjust or replace relief valve.

SYMPTOM	TROUBLE FOUND	POSSIBLE CAUSE	RECOMMENDED ACTION
Purge unit relieves liquid from condenser relief valve.	1. Liquid refrigerant coming out of relief valve. Liquid level in purge condenser too high.	1a Float valve stuck shut or float assembly rotated out of proper position in purge drum head.	1a Remove purge condenser head and clean or repair float valve mechanism.
		1b Manual valve on purge return line at evaporator closed.	1b Open valve.
Purge compressor loses oil.	1. Excessive loss of oil from purge compressor.	1a Oil separator heater not functioning.	1a Replace burned-out heater. Check setting and action of purge temperature control. Readjust, repair or replace.
		1b Oil separator float valve stuck shut.	1b Remove purge unit oil separator. Clean or repair float assembly.
Mixture in purge condenser dark in color and sight glass etched.	1. Oil separator too hot to touch. Sight glass dark.	1. Oil separator heater set too high.	1. Reset purge temperature control. Replace oil in purge unit. Clean compressor, oil separator and purge condenser. Check for damaged compressor.
Compressor cuts out or will not operate due to action of oil pressure control.	1. Oil level low in oil sump.	1. Insufficient oil charge.	1. Locate and correct cause of oil loss. Add oil.
	2. Oil temperature in sump too low.	2a Oil heater not functioning or control set too low.	2a Check for burned-out oil heater or improper action of setting of oil temperature control.
		2b Water valve does not shut off.	2b Check for obstruction in water valve or improper action of setting of oil temperature control.
	3. Insufficient oil pressure.	3a Failure of oil pump.	3a Check for burned-out pump motor or broken pump drive coupling. Repair or replace.

SYMPTOM	TROUBLE FOUND	POSSIBLE CAUSE	RECOMMENDED ACTION
		3b Improper setting of oil pressure regulating valve.	3b Reset oil pressure regulating valve.
		3c Dirt in oil pressure regulating valve.	3c Flush out valve, and reset.
		3d Oil pump running in reverse direction of rotation.	3d Check rotation of oil pump. Correct rotation.
		3e Oil filter restricting flow of oil.	3e Rotate handle on oil filter. If oil pressure does not come up, clean oil filter.
Oil temperature in sump too low.	1. Oil temperature too low.	1a Oil temperature control not functioning correctly.	1a Check action of temperature control. Adjust, repair or replace.
		1b Water valve stuck open.	1b Clean water valve.
		1c Oil heater burned out.	1c Replace heater.
Oil temperature in sump too high.	1. Oil temperature too high.	1a Oil temperature control not functioning correctly.	1a Check action of temperature control. Adjust, repair or replace.
		1b Water valve not opening.	1b Replace coil. Clean water valve.
		1c Manual valve in water line closed.	1c Open valve.
		1d Cooling coil fouled.	1d Clean cooling coil.

8. REFERENCES

8.01 The following references were used in preparing this section.

The Trane Co., Service Manual Section 1B1B, July 1963, Operation and Maintenance.

Carrier Corporation, Operation and Maintenance, Section 19C-12, Chapter 1 through 7, 1962.