MANUAL 2100-052

AIR CONDITIONING AND HEAT PUMP TROUBLESHOOTING PROCEDURES

REFRIGERATION, HEATING AND AIR CONDITIONING

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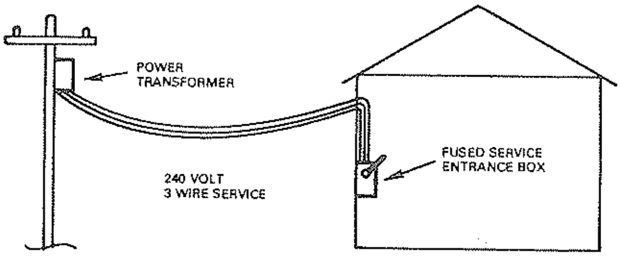
INTRODUCTION

This section will deal with the troubleshooting of cooling units. The technique used here, is the same as in troubleshooting heating units. A systematic and organized approach must be used by a service person, to isolate and correct the problem by the most direct route and in the least amount of time.

In order to troubleshoot a cooling unit, the service person must know how to troubleshoot specific component parts.

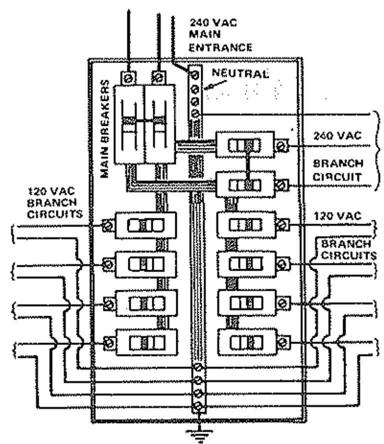
CHECKING POWER SUPPLY

Normally, the electrical service entering the house is 240 volt, single phase, three wire. With the heavy electrical load drawn by appliances such as an electric stove, electric clothes dryer, air conditioner, and other power equipment, the service to most modern houses is sized to carry 100 or 200 amperes and sometimes more. This service is connected to a main fused box or circuit breaker box located in the house as close to the electrical service entrance as possible. The two hot 240 volt legs are each fused to the total capacity of the service, which is determined by the size of the wire entering the house.

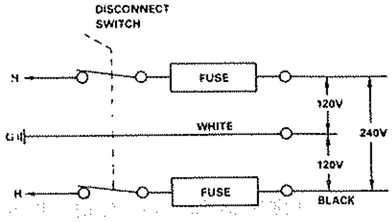


THREE-WIRE SERVICE FROM TRANSFORMER TO HOUSE

Within the main box, the circuits are broken down into numerous branch circuits. The branch 240 volt circuits serve major appliances such as an air conditioner, electric furnace, electric range and electric clothes dryer. These circuits are fused in each leg for the total current the appliance will draw. The wire connecting these circuits to the appliance must be large enough to carry the load determined by the size of the fuse.

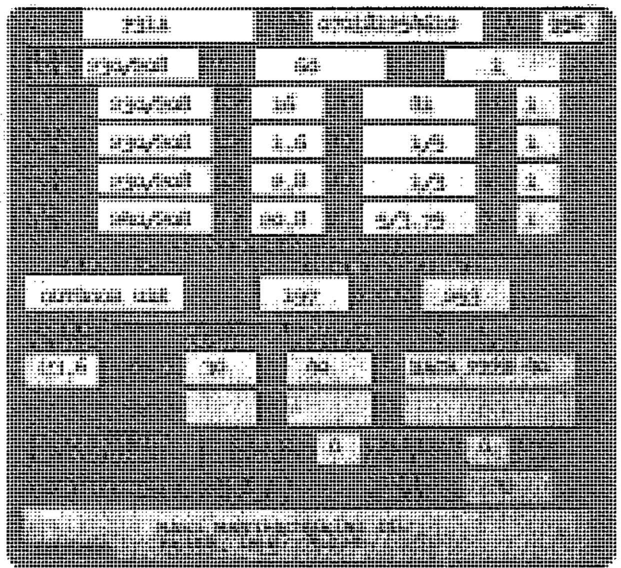


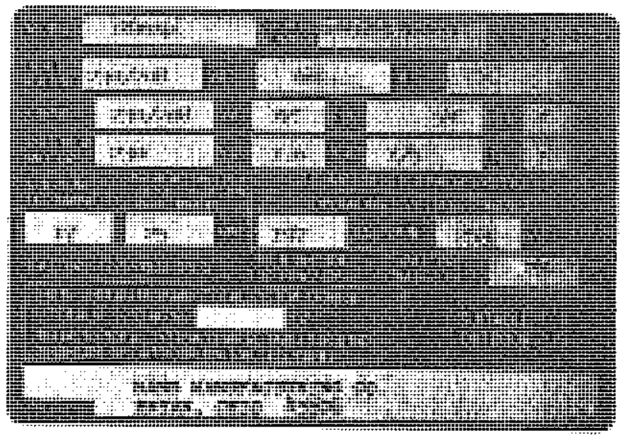
MAIN FUSE BOX



240V THREE-WIRE SERVICE

Refer to the unit nameplate or engineering data sheet for maximum fuse size and minimum circuit ampacity rating in accordance with the National Electrical Code (NEC). The main box may either be a fused box or be equipped with circuit breakers which can be reset.

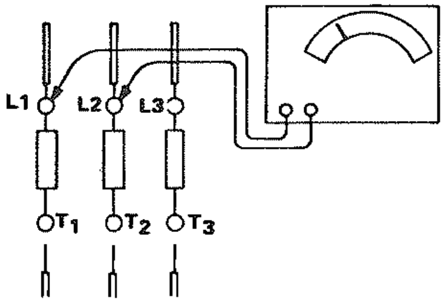




Use a voltmeter or the voltage taps of a clamp-on ammeter. The voltage read between the two power leads of a single-phase unit and the voltage read between each pair of the three power leads on the three-phase units should be within ten per cent of the voltage which appears on the nameplate. If there is a *continuous high or low voltage* , a check should be made with the power company. These conditions can be harmful to the equipment.

TO CHECK POWER SUPPLY

1. Disconnect the load wires from the load terminals of disconnect switch T1, T2 (T3—if 3 phase), so that the equipment will not operate while making the following checks.



Checking power supply with voltmeter.

2. Use voltmeter and check across:

   L1 to L2
   L1 to L3
   L2 to L3 (3 phase)

3. Check to see if there are any other switches or problems at main panel.

4. If no voltage, call the power company.

5. If 3 phase unit shows different values, call the power company.

CHECKING UNIT VOLTAGE

If there is a problem with a unit starting, or the compressor is cycling on its overload, the trouble may be due to improper electric service being supplied to the unit. It will be necessary to check the voltage at the unit power connections.

1. Shut off current by throwing the disconnect switch.

2. Connect voltmeter to L1 and L2 terminals on contactor (single phase). For three phase unit, check L1-L2, L2-L3 and L1-L3 independently.

3. Turn on the disconnect switch after turning the thermostat so it does not call for cooling.

4. Read the voltage. This is called "idle" voltage.

5. Turn the thermostat to call for cooling. With unit running, read the voltmeter. This is called "running" voltage.

6. To accurately determine the voltage at the instant of start ("locked rotor" voltage), it is necessary to stall the compressor (single phase units only). Proceed as in step 5 above, but stop the unit by turning the thermostat up or by opening the main switch. Then try to restart it at once. If the unit is operating as a PSC unit, it will fail to restart. The locked rotor voltage can be read in the few seconds prior to the time the overload trips off the compressor. It should not dip more than 15 volts. If it does, check at the distribution panel for voltage dip. If it is still too great, consult the power company and ask for proper service for the unit.

   Some common causes of voltage drop include electric meters that are too small, service transformers that are overloaded, and service wiring that is too small.

7. Some models include a starting capacitor and accelerating relay. These models will not be bothered as much by low voltage, since they have higher starting torque. However, they should still not be subject to low voltage, since they can result in damage to the accelerating relay and compressor. Even with these models, it is wise to limit the starting dip to 15 volts or less. To check the dip of these models, disconnect one of the starting capacitor leads to remove it from the circuit, and let it start PSC, as in step 6 above.

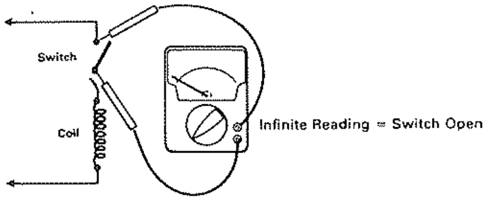
VOLTAGE CHECKS OF ELECTRICALLY ACTUATED SWITCHES

A voltage measurement can also determine whether a switch or contacts are opened or closed. If the switch is open, a potential difference exists across the switch, and the voltmeter will have a voltage deflection. If the switch is closed, the same potential difference exists at each terminal of the switch; consequently, there is no potential difference. Therefore the meter will read 0 volts.

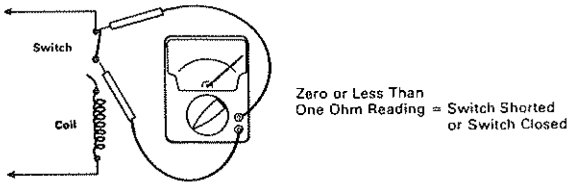
OHM METER

CONTINUITY CHART

CONTINUITY CHECK—SWITCHES (Disconnect Switch, Thermostat, Heat Relay Contacts, Blower Control Contacts, Limits)



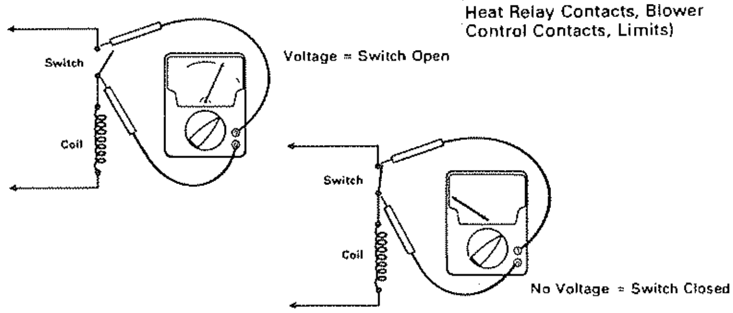
NOTE: The disconnect switch must be off to make a continuity (resistance) check. The component part to be checked must be isolated. To isolate a component part, remove one of the wires to the component. To make the continuity check, put the multimeter leads on the component part terminals.



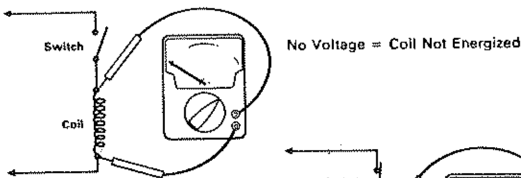
VOLTAGE CHART

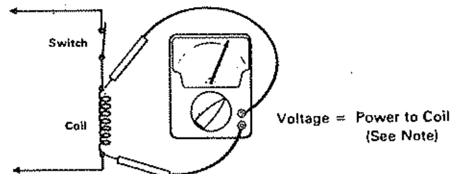
VOLTAGE CHECK — SWITCHES OR CONTACTS

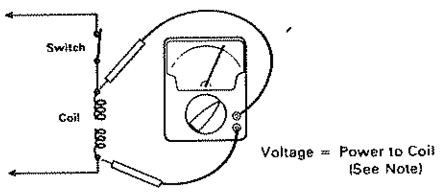
VOLT METER (Disconnect Switch, Thermostat, Heat Relay Contacts, Blower Control Contacts, Limits)



VOLTAGE CHECK—COILS (Transformer, Heat Elements, Heat Relay Heater, Motor Windings)
(WITH VOLTMETER)

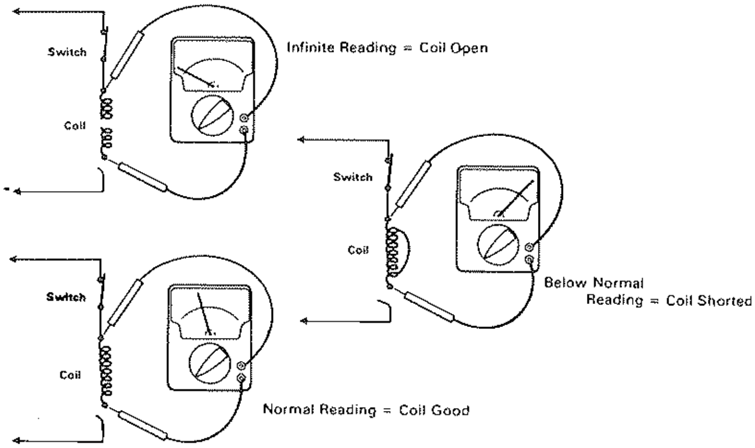






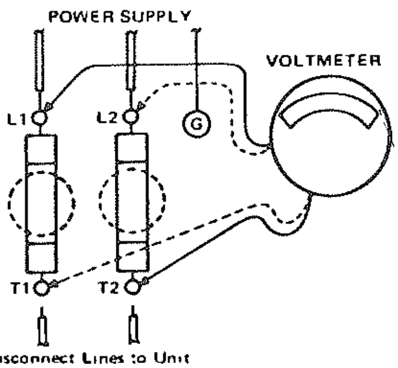
NOTE: The last two examples of a voltage check on a coil give the same meter reading, even though the coil is good in the first example and bad in the second example. The voltage check indicates only that there is power to the coil. A continuity check must be made to determine the condition of the coil.

CONTINUITY CHECK — COILS (Transformer, Heat Elements, Heat Relay Heater, Motor Windings)



CHECKING FUSES USING VOLTMETER

1. In actual equipment, safe practice would be to disconnect the load wires from the load terminals of disconnect switch T1 and T2 so that the equipment will not operate while making the following checks.
2. Check across terminals L1 and T2 — no voltage indicates No. 2 fuse defective.
3. Check across terminals L2 and T1 — no voltage indicates No. 1 fuse defective.



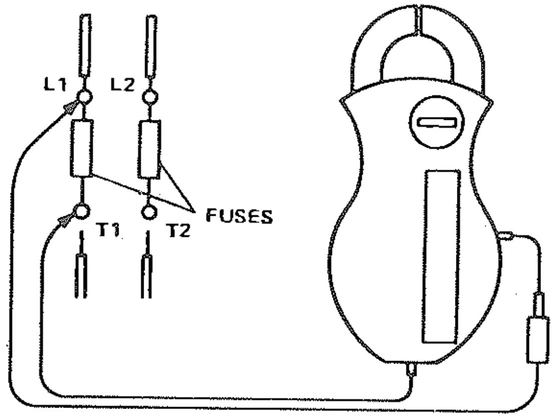
Checking fuses with voltmeter.

CHECKING FUSES USING OHMMETER

Fuses can also be checked by using the ohmmeter attachment or a standard volt ammeter set on the Rx 10 scale. With this setting, continuity is indicated by a deflection of the needle. No movement indicates an open circuit.

To check, proceed as follows:

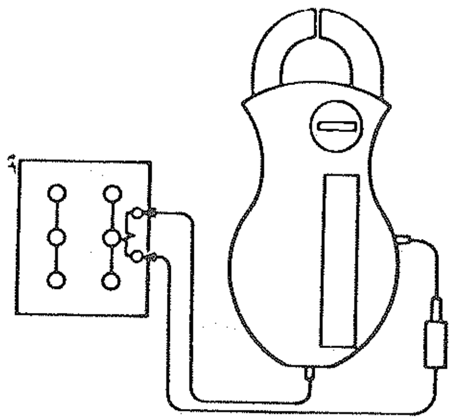
1. Be sure all power is off.
2. Disconnect the load wires from terminals T1 and T2 or turn switch off and pull fuses.
3. Check across fuse No. 1 for continuity. No continuity indicates No. 1 fuse defective.
4. Check across fuse No. 2 for continuity. No continuity indicates No. 2 fuse defective.



Checking fuses with ohmmeter.

CHECKING CONTACTOR COIL

1. Disconnect electric service.
2. Remove control wires from coil terminals.
3. Use an ohmmeter to check across coil terminals.
   a) Deflection of ohmmeter needle denotes continuity through coil.
   b) No movement of the needle indicates an open circuit through coil and that it is defective.



Checking contactor coil.

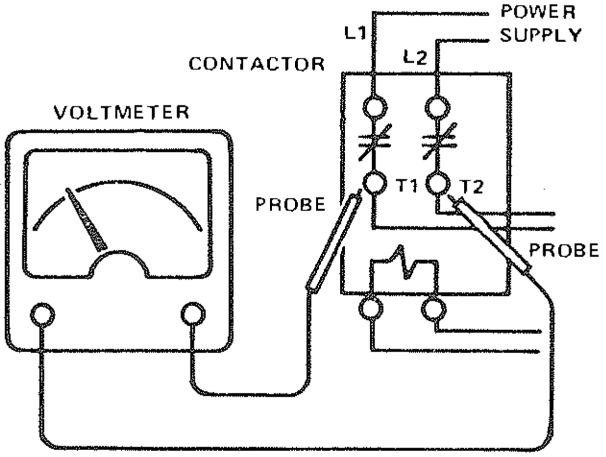
CHECKING CONTACTOR CONTACTS

1. Where possible, inspect contacts visually for burned or pitted areas. These should be cleaned or replaced.
2. Connect power supply and energize contactor coil.
3. An audible "snap" will indicate the contacts have pulled in.
4. If there is no snap, check voltage across L1 and L2. This should read 230 volt which indicates power to the contactor.
5. Voltage (230 volt) across T1 and T2 indicates the contacts have pulled in and power is available to the condenser fan motor and compressor.
6. An additional check can be made as follows.

   Using a voltmeter, check the voltage across terminals as follows:

   L1 - T1
   L2 - T2

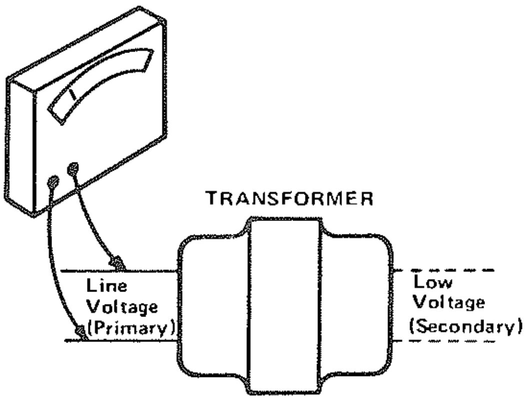
   A voltage reading across these contacts indicates that they should be replaced.



Checking contacts of contactor.

CHECKING CONTROL TRANSFORMERS

1. Energize supply power.
2. Check input (primary) voltage with a voltmeter. This can be done on the load side of the disconnect switch. This should equal nameplate voltage rating of the unit (nominally 230 or 230/208).
3. Check output (secondary) voltage with a voltmeter. This should read 24 volt (nominally 21-27 volt). No secondary voltage indicates a defective transformer.



CHECKING CONTROL TRANSFORMER

CAUTION: NEVER SHORT THE SECONDARY LEADS TOGETHER TO CHECK THE TRANSFORMER OUTPUT. IT IS POSSIBLE TO RUIN THE TRANSFORMER USING THIS PRACTICE.

CHECKING PROPER PHASE OF TRANSFORMER

If two or more transformers are connected in parallel for increased power, checking for correct phasing is very important. Improper phasing may take either of two forms. One is the error in connecting the transformer secondaries. This causes a short which will likely burn out one or the other transformer. In the other instance, improper phasing can result in excessive voltage. This can result in premature failure of coils and other components or shorts caused by two or more low voltage wires running close together.

Usually, built-in transformers are carefully phased with marked terminals and hook-up diagrams provided by the manufacturer. With separate transformers, terminals are not normally marked for phasing. Also, remember that even integral transformers should be checked for phasing.

PHASING OF TRANSFORMERS

Wire the primaries of the transformers in parallel. Connect one wire from each transformer as shown in Figure 1. With a voltmeter, read voltage at leads (A) and (D). If voltmeter reads 48 volts, transformers are out of phase and must be connected as in Figure 2.

With correct phasing as shown in Figure 2, voltmeter will show 0 volts. (A) and (C) leads may be tied together. Transformers are in phase.

Figure 3 shows connection to control circuit.

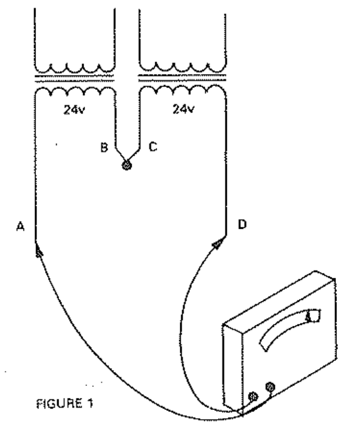


FIGURE 1

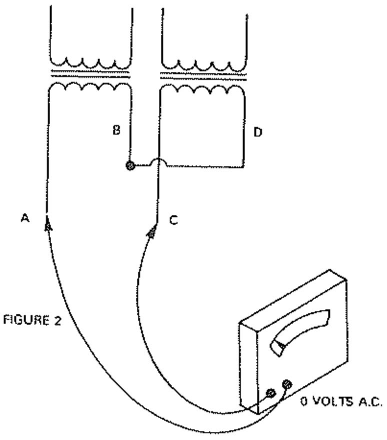


FIGURE 2

48 VOLTS A.C.

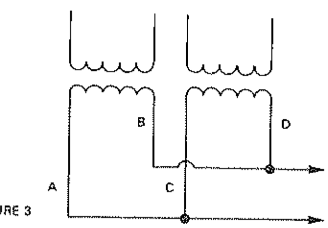


FIGURE 3

GENERAL DESCRIPTION OF POTENTIAL RELAYS

Potential relays operate on an entirely different principle than magnetic relays and this should be understood in the field. Potential relay contacts are normally closed and open after the compressor motor has gotten up to speed. The relay coil operates on generated voltage from the motor's magnetic field or back electromotive force. This generated voltage will normally be considerably greater than line voltage.

The coil will be across terminals 2 and 5 and the contacts across 1 and 2. Terminals 4 and 6 are usually dummies to facilitate wiring.

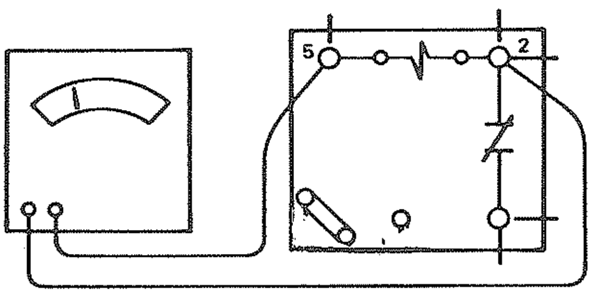
NOTE: *Before making any of the following tests on a potential relay, the start capacitor should be tested to insure that it is in good condition and working properly.*

CHECKING POTENTIAL RELAY COILS

1. Using an ohmmeter, set on Rx 100 scale, check for continuity across terminals No. 2 and No. 5. Meter should read about 5000 ohms.

   NOTE: *Remove leads to coil terminals so the compressor windings will not affect readings.*

2. If there is no continuity, the coil is defective and the relay should be replaced.



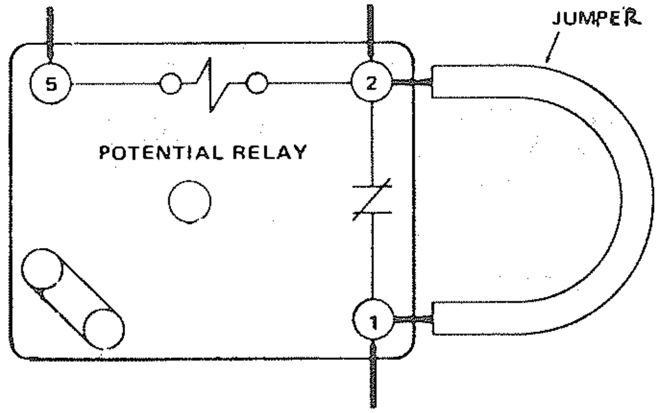
CHECKING POTENTIAL RELAY COIL

CHECKING POTENTIAL RELAY CONTACTS - OPEN POSITION

When the relay contacts remain in the "open" position, the compressor may make a humming sound and not start. (This will depend on the type of metering device used in system. On a capillary system the compressor will start if pressures are equalized). After about 15 or 20 seconds, the overload will trip and cut off the power to the compressor. After a lapse of 30 to 60 seconds, the overload switch will energize the compressor again. If the relay contacts are still open, the compressor may again make a humming sound and not start. The overload will again cut off power to the compressor. This cycling will continue until the relay is replaced.

To check for open contacts, proceed as follows:

1. Set thermostat on cooling.
2. Turn main switch on.
3. Using a jumper of No. 12 insulated wire, bared at both ends, (see Figure 12) touch terminals No. 1 and No. 2 on the relay.
4. Hold until the compressor starts and comes up to speed.
5. Remove jumper. If the compressor continues to run normally, the potential relay is defective and should be replaced.



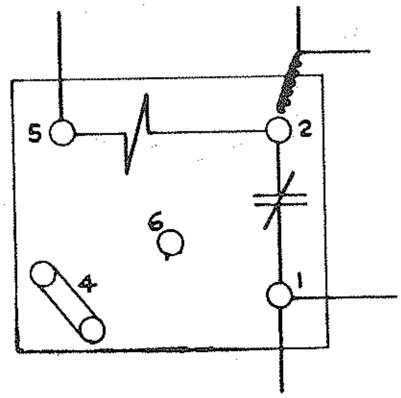
Checking potential relay contacts.

CHECKING POTENTIAL RELAY CONTACTS - CLOSED POSITION

When the relay contacts remain in a closed position, the compressor will start, but run with a loud growling hum. After the compressor has run for 10 to 30 seconds, the overload will trip and the compressor will stop. After the overload has cooled off, the compressor will start and run with the same growling hum. If the relay contacts remain closed, the overload again will stop the compressor for another interval. This cycling will continue until the relay is replaced.

To check for closed contacts, proceed as follows:

1. Turn off main disconnect.
2. Disconnect the two wires from the No. 2 terminal on the relay and fasten them together.
3. Turn thermostat to cooling.
4. Turn main switch "on".
5. Touch the two wires to terminal No. 2 on the relay.



Checking potential relay contacts.

6. When the compressor has started and comes up to speed, immediately remove the wires.
7. If the compressor operates without the loud growling hum, after the wires are removed, and if reconnecting them causes the compressor to again be noisy and cuts off on the overload, the contacts are remaining closed and the relay should be replaced.

NOTE: *With the relay contacts in the closed position, the start capacitor remains in the circuit. You will very likely also have a defective start capacitor. The above check should always be made if you find a defective start capacitor.*

Potential relays are position sensitive and replacement should be mounted in the same position as the original.

CHECKING THE COMPRESSOR MOTOR

Figure 1 shows a typical compressor terminal box with the common (top), start (lower left), and run (lower right) terminals. Since the arrangement of the terminals varies on different models and manufacture of compressors, it is important to establish the correct identity. All terminal box covers and/or cover gaskets, are marked to identify terminals.

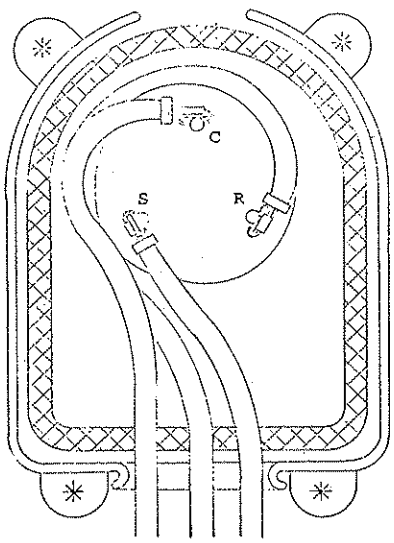


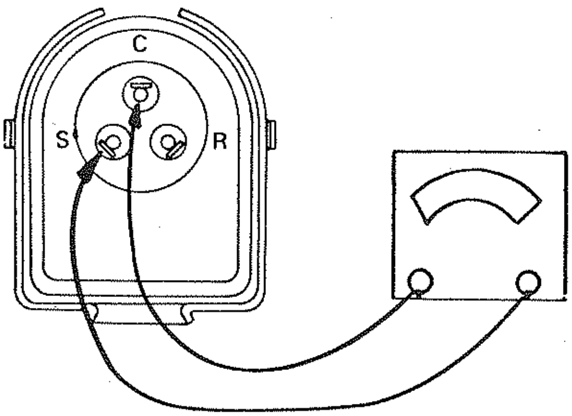
Fig. 1
Compressor Terminals

Designations of these terminals are as follows:

R or M	=	Run or Main Winding
S	=	Start Winding
C	=	Common Winding

CHECKING COMPRESSOR MOTOR - SINGLE PHASE

1. Shut off main power circuit.
2. Disconnect the power leads from the compressor motor terminals.
3. Use an ohmmeter set on the Rx 1 scale and check windings for continuity.



Checking compressor for open windings.

a) Check between C & S - no movement of needle indicates an open start winding - replace compressor.

b) Continuity (zero resistance) indicates a shorted start winding - replace compressor.

c) Meter should show some resistance when windings are good.

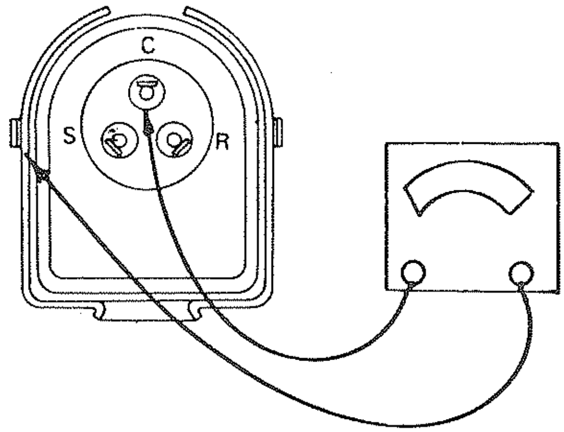
d) Check between R and C - no movement of needle indicates an open run winding - replace compressor.

e) Continuity (zero resistance) indicates a shorted run winding - replace compressor.

f) Meter should show some resistance when windings are good.

NOTE: On compressors equipped with an internal overload, be sure to check the internal overload before deciding the windings are open. (See "Checking Overload Protectors")

4. Set ohmmeter to Rx 10,000 scale. Check for ground by alternately checking each terminal - one probe on the terminal and the other to the compressor shell. There is leakage to ground if any reading of ohms is found between any terminal and the compressor shell. (See Figure



Checking compressor for short to ground.

CHECKING COMPRESSOR MOTOR - THREE PHASE

NOTE: These checks will not be valid for compressors equipped with an internal overload.

1. Shut off main power.
2. Disconnect main power leads from the compressor motor terminals.
3. With an ohmmeter set on the Rx 1 scale, check all three combinations of terminals. (i.e., 1 to 2, 1 to 3, 2 to 3)
4. If there is no continuity between any pair of terminals, you have an open winding. Replace compressor.
5. With the ohmmeter on the Rx 10,000 scale, check for ground by placing one probe on the shell and with the other probe touch each terminal in turn. There is leakage to ground if any reading of ohms is found between any terminal and the compressor shell.

NOTE: Always check the control components, particularly the overload and potential relay, before condemning the compressor motor.

CHECKING OVERLOAD PROTECTORS

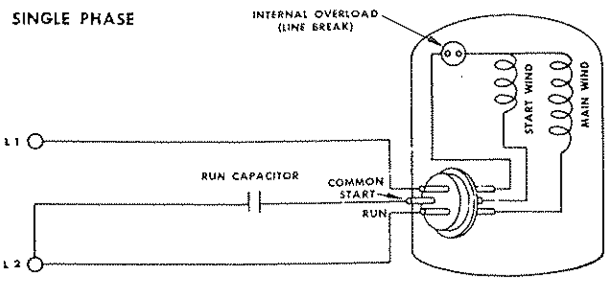
INTERNAL LINE-BREAK OVERLOAD TYPE. The scope of this check-out procedure is to cover all compressors that have an internal line-break overload. The type of overload protection can be determined by checking the wiring diagram on the unit. The internal overload carries the line current. When the overload opens, the line current will be broken inside the compressor shell.

The internal overload senses the current draw of the motor and is responsible to the temperature of the motor windings.

The overload is wired with one wire to the common terminal of the compressor and the other wire to the common terminal of the start and run winding inside the compressor shell. See Figure on next page.

Either high current draw such as locked rotor current, or high winding temperature will cause the overload to break the line current inside the compressor shell. If the overload opens, it will reset in from 15 seconds to an hour, depending upon the reason for it opening. If it opens due to high current draw, it will probably reset in the minimum time. If it opens due to motor winding temperature being too high, it can stay off up to an hour or more.

When the motor windings get too hot for some reason (loss of charge, extreme overload, or defective capacitor), the overload will open and will not reset until the motor windings are cooled to a safe temperature. The time required for the windings to cool off depends upon the loading of the compressor and the ambient temperature.



Schematic diagram of "Line Break" internal overload wiring.
Courtesy Tecumseh

To check an internal overload, proceed as follows:

NOTE: Remove leads from compressor terminals.

1. Using an ohmmeter, set at Rx 1 to check for continuity. Make a continuity check between the compressor (C) common and (R) run terminals.

2. If there is no continuity, proceed to compressor terminals (S) start and (C) common, and check for continuity.

3. If there is no continuity at either of these points and a resistance reading between (R) run and (S) start terminals, the overload is tripped.

4. Wait approximately 15 seconds to 1 hour or more until the compressor shell has cooled and recheck. If there is still no continuity, you have a defective overload.

NOTE: Because an internal overload has an extremely small mass in relation to the mass of the motor, it has a considerably longer reset time than the conventional external overloads. The reset time can be as much as one hour or more. Therefore, you should be absolutely sure that the compressor has had sufficient time to cool which will allow the overload to reset before deciding you have a defective overload.

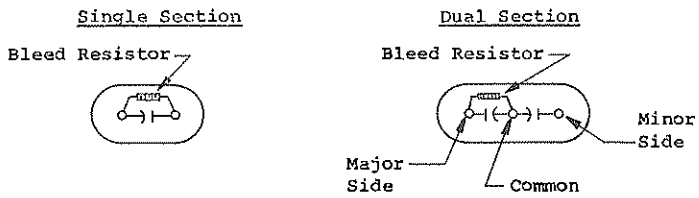
GENERAL DESCRIPTION OF CAPACITORS

Two types of capacitors are used with equipment. A start capacitor is used in conjunction with a potential relay to help the compressor motor come up to speed under a starting load. It is designed for short-term, intermittent duty only and must, therefore, be taken off the line when the motor comes up to speed. Some capacitors are equipped with a 15,000 ohm, 2 watt resistor. The purpose of this resistor is to bleed off the very large charge which may build up across the terminals and go to the relay contacts on the off cycle.

The start capacitor is used on original equipment and also as a field addition to PSC compressors which must start and operate under low voltage conditions.

Run capacitors are designed for constant duty and several may be hooked in parallel to increase the microfarad rating.

Both start and run capacitors are rated in microfarads and voltage. Voltage ratings may seem abnormally high in relation to the line voltage but this is the actual operating voltage, not a safety factor. Replacements should be of the same or higher voltage, never lower.



CHECKING CAPACITORS

A common service problem is to distinguish between a defective capacitor and a good one whenever electrical troubles are encountered on single phase units. A defective capacitor may be either shorted or open, and it is desirable to be able to tell the difference. Following are several methods which may be used in checking capacitors.

NOTE: In all the test procedures shown below, if a dual section (three terminal) capacitor is being tested, it will be necessary to test both sections. The center terminal is the common, and a test will be required from the center terminal to each outside terminal to check both sides.

Also, on most compressor starting and running capacitors, a bleed resistor is wired across the terminals (on dual section run capacitors, wired across common and highest MFD side). For tests two and three below, this resistor can give a false indication and will probably have to be disconnected on one side.

1. CAPACITOR ANALYZER

The quickest and most accurate way to check capacitors is to use a capacitor tester such as the Sprague Model M-3 Mike-O-Meter. This instrument easily detects opens and shorts, and gives an actual read-out of the capacitance (MFD) and power factor if the capacitor is in working order. An added feature of the Mike-O-Meter is that it automatically discharges the capacitor when the slide-to-test switch is released. The capacitor must be disconnected from the unit in order to be tested by this instrument, as well as in the following methods.

2. "NEON LIGHT" TYPE CAPACITOR TESTER

A "Cappy" capacitor tester sold by Watsco may also be used for checking capacitors. This device utilizes a neon light for detecting of shorts, opens, and grounded capacitors. A capacitor that is working, that is, capable of retaining an electrical charge, is indicated when the test switch is operated and the neon light glows brightly at first and then dies out. The longer it glows, the higher the capacitance, but there is no way to determine exactly what the MFD is.

NOTE: On some capacitors, particularly large MFD motor-starting capacitors, the bleed resistor wired across the terminals can cause the neon light to glow brightly at first, and then fade but not go out. One side of the resistor should be disconnected and the capacitor rechecked.

After testing, discharge capacitor by shorting across its terminals with a 15,000 ohm, 2 watt resistor. DO NOT SHORT TERMINALS WITH SCREWDRIVER OR OTHER TOOL. Using the resistor, the charge is bled off without damaging the electrolyte or fuse.

3. OHMMETER TEST

(1) Remove leads and discharge capacitor.

(2) Set ohmmeter on its highest ohm scale and connect leads to the capacitor.

a. Good condition - Indicator swings to zero and slowly returns towards infinity.

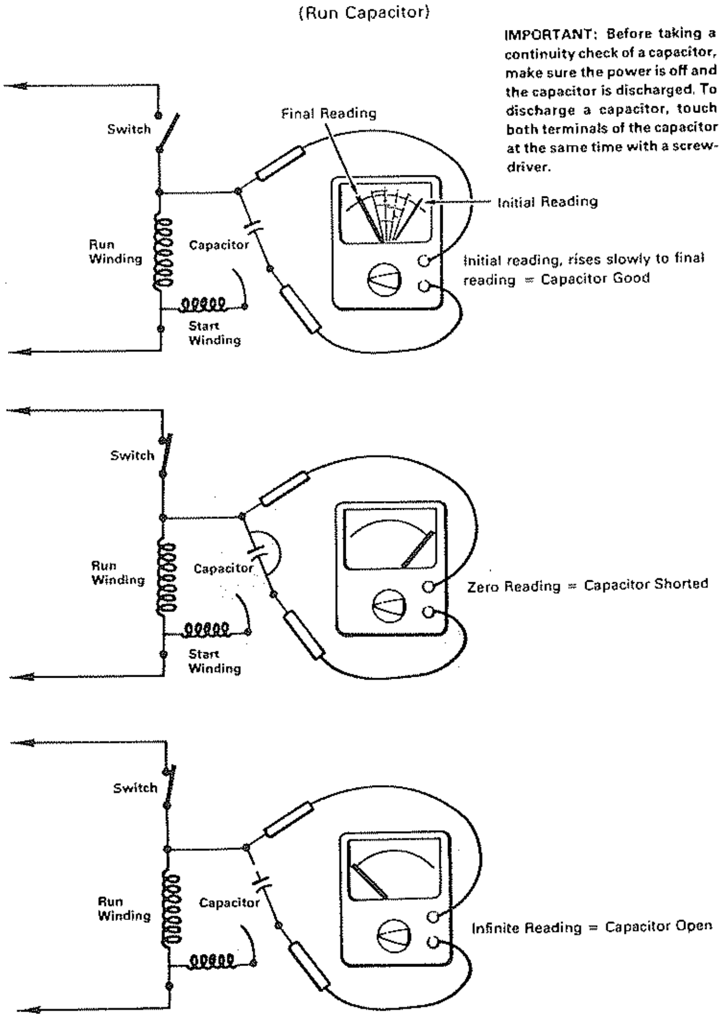
b. Shorted - Indicator swings to zero and stops there. Replace.

c. Open - No reading - replace.

NOTE: Remove resistor to make test.

CONTINUITY CHART

CONTINUITY CHECK — CAPACITORS
(Run Capacitor)



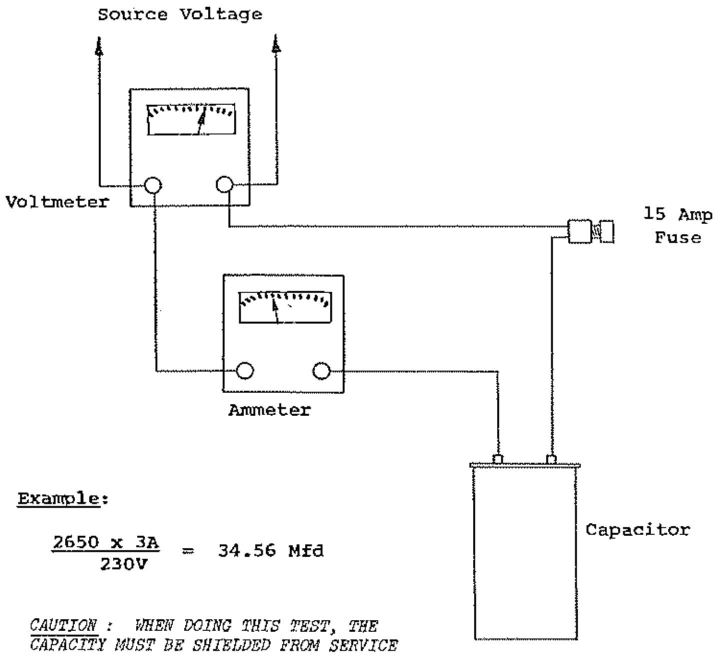
To accurately check capacitors, use a capacitor analyzer.

4. CAPACITANCE TEST

(1) Remove leads and discharge capacitor.

(2) Using the hookup shown, take the amperage and voltage readings and use them in the formula:

$$\text{Capacitance (Mfd)} = \frac{2650 \times \text{Amperage}}{\text{Voltage}}$$



Example:

$$\frac{2650 \times 3A}{230V} = 34.56 \text{ Mfd}$$

CAUTION : WHEN DOING THIS TEST, THE CAPACITY MUST BE SHIELDED FROM SERVICE PERSON IN CASE CAPACITOR EXPLODES.

FIELD REPLACEMENT

It is obviously best to replace a capacitor with one that has the same rating. However, this is not always possible and if you must substitute capacitors, certain practices should be followed. First, never substitute with a lower voltage rating. Always use the same or larger voltage rating as the original equipment. If there is any doubt as to the original voltage rating, use a 440 volt capacitor on 230 volt equipment.

Start capacitors with a microfarad rating of ± 10% of the original can be substituted as a temporary fix. Run capacitors are more critical with regard to capacitance rating and only very small deviations on the plus side can be used. You cannot use a capacitor with a lower voltage or capacitance rating.

These field service instructions will aid recognition of a malfunctioning Heat Pump System equipped with a reversing valve.

CHECKING SOLENOID VALVES

1. Check for loose wires or improper wiring.

2. Check supply voltage to the coil with a voltmeter. This should be within + 10% or - 15% of rated voltage.

3. Check for burned coil.

4. Check plunger visually and manually for restriction due to corrosion, bent parts, foreign material, or bent body. Corrosion may be removed with a fine emery cloth.

5. Check operation by sliding solenoid coil off and on. Pilot valve when energized will produce audible click as pilot valve moves. If done when heat pump is running, main valve will shift.

6. Check complete manufacturer's suggestions, such as Ranco Bulletin 1741-3, for more complete information on solenoids.

PROCEDURE FOR REPLACING THE VALVE

1. Remove the solenoid coil.

2. Heat the soldered joints (valve body is not to be heated above 250°F) to remove the valve.

   NOTE: Exercise care to prevent the valve body being heated above 250°F. Exceeding this temperature may introduce contaminants into the system. The valve body can be protected from excessive heat by wrapping it with wet cloths and keeping them wet during the removal operation.

3. It is imperative when installing a new valve that the inside of all tubes of the valve and the system be *protected and kept clean* of moisture and all other foreign matter, such as: flux, dirt, dust, flakes of copper oxide, filings, metal chips, etc.

4. The valve must be protected (the same as outlined in (2) above) from excessive heat (valve body is not to be heated over 250°F) when installed.

NOTES: (a) Avoid rough handling of the valve to prevent dents or bends occurring on any portion of the valve.
(b) Keep the axis of the valve body in a horizontal plane which may be rotated to any angle around its axis.
(c) Make certain the limits of the valve capacity are not outside the specified "refrigerant-tonnate" of the system.

5. After the valve has been completely installed in the system and tested for leaks, return the solenoid coil to the pilot valve.

6. Recharge the unit with the *weight of the refrigerant gas specified by the manufacturer*, then determine that the unit is operating properly before attempting to operate the reversing valve.

   NOTE: The valve will not operate properly on a partially charged system.

7. Cycle the valve at least a dozen or more times to check the proper operation of the system.

CHECKING REFRIGERANT CHARGE HEAT PUMPS AND AIR CONDITIONERS

SAFETY

1. Always wear safety glasses when working with refrigerant.
2. Be careful of refrigerant burn when removing hoses.
3. Use caution when working with pressurized hoses.
4. Use only hoses with side wall designed for high pressure.

GAUGE MANIFOLD

A very necessary instrument in checking and servicing air conditioning equipment is the gauge manifold. Its purpose is to determine the operating refrigerant pressures in order for the serviceman to analyze the condition of the system.

1. Install gauge manifold to unit.

   NOTE: As a safety measure, it is wise to attach refrigerant hoses at the lowest pressure readings on the system. To do this:

   a) Put high pressure hose (B) on first. (Unit should not be running).

   b) Put low pressure hose (A) on second. (Unit should be running).

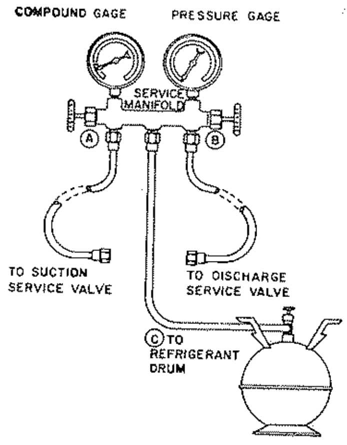
2. Check unit operating pressures recorded at gauge manifold with the normal operating pressure curve for this unit.

3. If the system is operating properly, make sure all service valves are open, disconnect gauge manifold, and replace all gauge port caps.

NOTE: As a safety measure, it is wise to detach refrigerant hoses at the lowest pressure readings on the system. To do this:

a) Remove the suction pressure hose (A) first. (Unit is running.)

b) Remove the high pressure hose (B) next. (Unit is not running.)

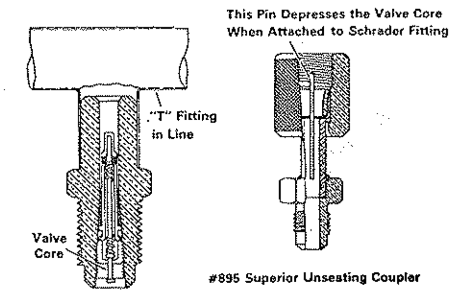


ATTACHING MANIFOLD HOSE TO SCHRADER VALVE

1. Remove cap from valve.

2. Make sure gauge manifold valves are closed.

3. If hose does not have an unseating pin, a number 895 Superior Unseating Coupler (or equivalent) must be used.



4. Make sure coupler is lined up straight with Schrader valve. Screw coupler on to valve.

5. Open gauge manifold valve slightly and purge air from hose with refrigerant.

6. Read the suction pressure on compound gauge and head pressure on pressure gauge.

7. To remove, push end of coupler tight against end of Schrader valve and hold in place while quickly unscrewing coupler nut from Schrader valve.

8. Remove coupler from Schrader valve.

CAPILLARY SYSTEMS

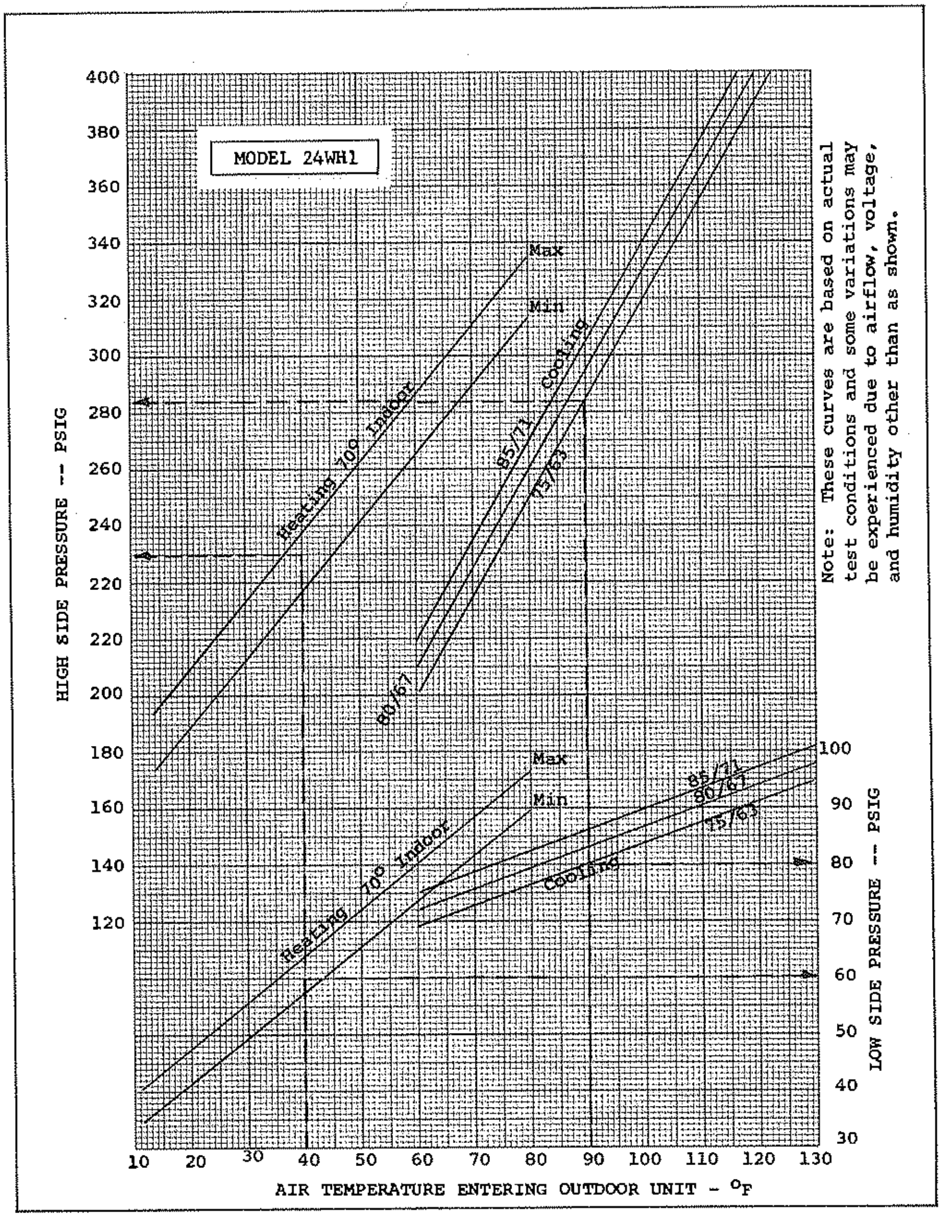
Weight Method:

Where no other method is available for checking a cap tube system for low charge and the operating pressure indicates a low charge, the remaining refrigerant in the unit must be discharged and the system evacuated before weighing in the new charge. Refer to the unit nameplate or "Unit Listing" for the correct charge.

CHECK REFRIGERANT USING A PRESSURE CURVE

NOTE: Normal operating pressure curve charts are found inside the Installation Instructions for each unit.

1. Connect high pressure side of the gauge manifold to discharge line service port and suction side to service port on suction line.
2. Start the unit. Operate until pressures stabilize.
3. Using a thermometer, find the correct condenser entering air temperature. Read the suction and discharge pressure at gauge manifold.
4. On the normal operating pressure curve for the unit:
   a) Find the air entering outdoor temperature.
   b) Draw a line straight up through the outdoor unit and indoor unit pressure curves.
   c) Then find the high pressure recorded in the left hand column.
   d) Follow across until it crosses the temperature of outdoor entering air. Mark this point.
   e) Then find the suction pressure recorded in the right hand column.
   f) Follow across until it also crosses the temperature of outdoor entering air. Mark this point.
   g) If unit is properly charged and has proper air flow over indoor coil, the two marked points should fall between the Max and Min curves shown on the graph.
   h) On heat pumps, repeat procedure with unit operating in heating mode.
5. If pressure reading is more than 3 psig over proper value on the curve, system is overcharged. If this is the case, discharge a quantity of R-22 from the suction gauge port into a waste drum. Close valve and allow unit to run for a few minutes to stabilize pressures. *NOTE: Be sure to rule out all air system problems (dirty filters, closed or obstructed registers, plugged outdoor coil, etc.,) before making any charge adjustments.*
6. If the discharge pressure is more than 10 psig under the proper value shown on the chart, the system is undercharged. Check for leaks and recharge unit by weight method after making repairs.



EXAMPLES:

Cooling Cycle - 90°F O.D. Temp. w/75°DB/63°WB I.D. Temp. = 80 PSIG Suction and 284 Discharge Pressure.

Heating Cycle - 40°F O.D. Temp. w/70° I.D. Temp. = 60 PSIG Suction and 228 Discharge Pressure.

EVACUATING THE SYSTEM

GENERAL

A refrigeration system should be evacuated whenever the system has been open in such a manner that there is a possibility that air and moisture could have entered the system. The evacuation process is intended to remove non-condensable gases and moisture from the portion of the system to be evacuated. The most important contaminant to be removed is moisture. To remove moisture from the system, it must first be boiled into vapor. Before water will boil at ordinary room temperature, for example at 70°F, the vacuum must be 29-1/4 inches of mercury at 30 inches of mercury barometric pressure. This means that the system must be within 3/4 inches of mercury of absolute zero pressure. This low vacuum should be measured by using an absolute pressure gauge, such as an electronic gauge. For this reason, a good vacuum pump must be used to accomplish good dehydration.

EVACUATION

1. Evacuate the system to less than 1000 microns, using a good vacuum pump and an accurate high vacuum gauge. Operate the pump at 1000 microns, or less, for several hours and then allow the system to stand for several additional hours to be sure the vacuum is maintained.

2. An alternate method of removing moisture and non-condensables from the system is:

   (a) Evacuate system to 29 inches vacuum for ten minutes per ton of system. Break vacuum with refrigerant to be used for final charging of system and vapor charge to 35-50 lbs. gauge pressure. Leave vapor charge in system for a minimum of five minutes. Reduce pressure to five to zero gauge pressure.

   (b) Repeat step (a) two more times.

   (c) Evacuate system to 30 inches vacuum for twenty minutes per ton. Charge system with the specified kind and quantity of refrigerant (charge into vacuum).

   NOTE: At no time use the compressor to evacuate the system or any part of it.

3. Disconnect charging line at vacuum pump and connect to refrigerant supply. (Dial-A-Charge Cylinder) crack valve and purge charging line at center on manifold. Then close valve.

4. The system is now ready for the correct operating charge of Refrigerant 22.

CHARGING THE SYSTEM WITH REFRIGERANT AIR CONDITIONING - HEAT PUMP

1. SINGLE PACKAGE UNITS - Refer to the unit serial plate for the full operating charge.

2. SPLIT SYSTEMS - The outdoor unit factory charge is shown on the unit serial plate. The total system charge required to recharge the system after service repairs should be marked on the serial plate under TOTAL R22 CHARGE. This is normally marked by the installer and is determined from the R22 System Charge Table located on the inside of the outdoor unit access panel.

3. CTO ADAPTER KITS - When using CTO adapters and field tubing, use the procedure outlined in approximately the middle of each of the System Charge Tables. This determines the correct ounces of R22 for the tubing only.

4. FILTER-DRIER CHARGES - If a liquid line filter-drier is used, either in conjunction with field tubing and a CTO adapter kit, or as part of procedure for system clean-up after a compressor burn-out, additional R22 must be added to the system when recharging. This is in addition to the amount determined from the R22 System Charge Table.

PART NO.	MODEL NO.	OZ'S OF R22
5201-001	C-083S	8
5201-002	C-163S	10
5201-009	BFK-083S	7
5201-010	BFK-163S	13

PRELIMINARY CHARGING STEPS

If the system has been open to the atmosphere, it should be first evacuated. Then proceed as follows:

1. Attach a drum of proper, clean refrigerant to the center port of the charging manifold with one of the charging hoses.

2. Attach a second charging hose to the suction gauge (low pressure) side of the gauge manifold.

3. Remove the cap from the suction line valve.

4. Loosely attach the suction gauge hose to the line valve. Open the valve on the refrigerant drum and the suction valve on the charging manifold slightly to purge the air from the manifold and hoses before tightening the fitting.

5. Attach the third hose to the high pressure side of the manifold and the liquid line valve. Repeat steps 3 and 4 above.

CHARGING THE SYSTEM BY WEIGHT*

1. Connect manifold as instructed.

2. Place refrigerant drum upright on scale and determine exact weight of refrigerant and cylinder or use a Dial-A-Charge cylinder.

3. With manifold suction valve closed and manifold discharge valve open, open refrigerant cylinder valve and allow pressure in system to balance with pressure of cylinder. For charging in the liquid phase, drum is placed upside down (valve down).

4. When there is approximately a full charge, front seat (close) the discharge manifold valve and let the system stabilize for about five minutes.

5. Start compressor by setting thermostat.

6. Finish charging with vapor by placing drum upright (valve up). Open drum valve and manifold low pressure valve to allow refrigerant to flow into the system. Throttle refrigerant drum valve to keep pressure about 100 psig for R22.

7. When the correct weight of refrigerant has been added to the unit, close refrigerant cylinder valve and allow unit to run for 30 minutes. Refer to "Start-Up Procedure and Check List" for further start-up details. Check the charge against the allowable head pressure as shown in the "Head Pressure Chart" and correct if needed.

   Front seat gauge manifold valves, disconnect charging and gauge hoses and replace all valve caps.

NOTE: To speed refrigerant flow, it may be necessary to place refrigerant drum in a pan of warm water (not greater than 130°F). Remember to either consider the total weight of the pan of water or remove the drum for weighing frequently to keep track of the charging process.

*This charging method requires the scales or Dial-A-Charge cylinder to be extremely accurate since the charge in this type of system is quite critical.

PROPER USE OF DIAL-A-CHARGE REFRIGERANT CYLINDERS

A charging cylinder is as easy to use as one, two, three.

1. To fill the cylinder, a charging line is connected from the refrigerant drum or can to the lower valve on the cylinder. By opening both the drum and cylinder valves and placing the drum higher than the cylinder, gravity will permit the refrigerant to transfer. The cylinder top valve can be cracked to hasten the filling operation. The cylinder should be filled to the top graduation line of the type refrigerant being transferred at the indicated pressure.

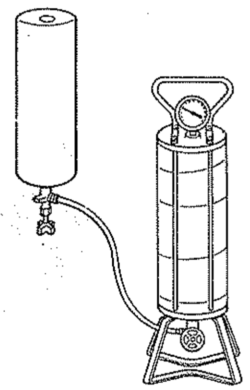


Fig. 4. Using the charging cylinder—Step 1.

2. While the refrigerant system is being prepared for charging, the charging cylinder should be plugged into a 110 volt outlet and allowed to heat up to develop a positive pressure advantage for charging. This would normally require approximately ten minutes. After the desired pressure advantage has been attained (an additional 30 psi will suffice) the cylinder should be unplugged and the shroud dialed to the pressure heading corresponding to the gauge reading. (See Figure 5.

3. To charge a system, the center hose of the manifold should be connected to either the bottom or top valve of the charging cylinder. The bottom valve will dispense liquid refrigerant; the top valve will dispense gaseous refrigerant. (See Figure 6). The correct amount of charge is specified by the manufacturer of the system and is normally indicated on a plate or decal placed on the product.

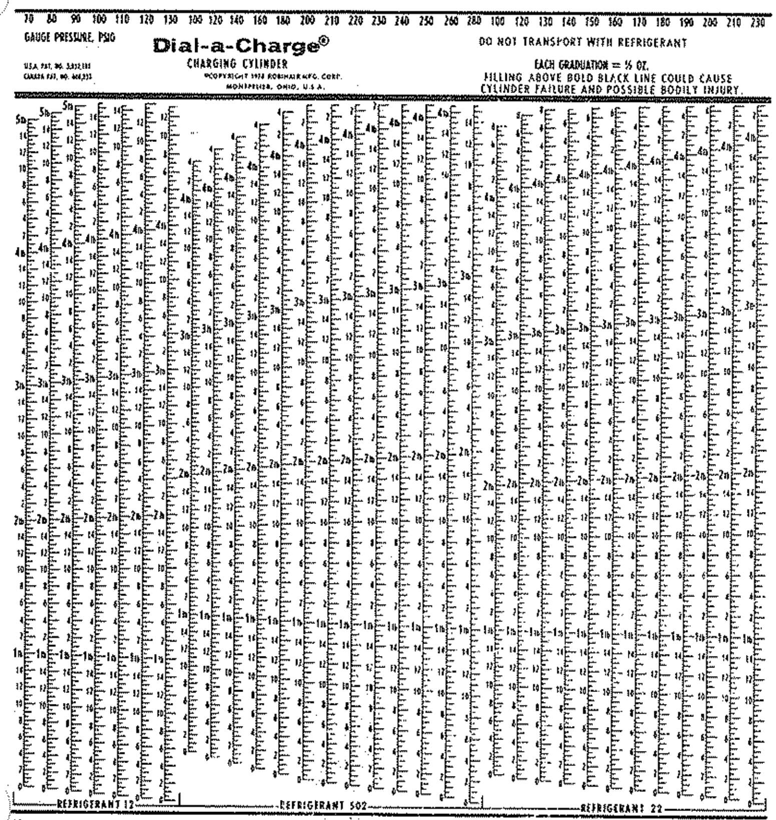


Chart A. Reaction of liquid refrigerant to pressure in metal cylinder.

Once the charge has been determined a calculation should be made to determine the shut-off point completing the charge. (Examples 1 and 2)

The cylinder valve is opened (top for gas—bottom for liquid) and the refrigerant allowed to enter the system. After the liquid level in the cylinder has dropped to the calculated figure, the cylinder and system valves should be shut off.

Assuming that proper service procedures were followed in preparing the system for charging (such as evacuation, dehydration, leak checking, etc.) the serviceman can walk away feeling confident the system contains the proper charge.

The charging cylinder was developed to provide a fast, positive field procedure for charging refrigerant systems. Its proper use will save time, permitting additional service work to be performed by the same man or industry.

Example 1

Cylinder filled to	4 lb. 6 oz.
Charge specified	3 lb. 4 oz.
Shut-off point	1 lb. 2 oz.

Example 2

Cylinder filled to	4 lb. 6 oz. = (4 × 16 oz. + 6 oz.) 70 oz.
Charge specified	2 lb. 8 oz. = (2 × 16 oz. + 8 oz.) 40 oz.
Shut-off point	30 oz.

To convert back to lb. and oz:
(30 oz. ÷ 16 oz. = 1 lb. 14 oz.)

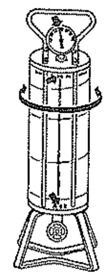


Fig. 5. Dial shroud to pressure heading corresponding to gauge reading.

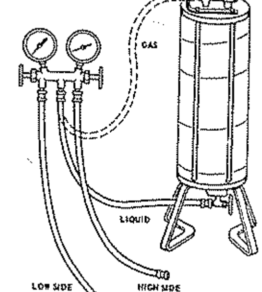


Fig. 6. Bottom valve dispenses liquid refrigerant; top valve dispenses gaseous refrigerant.

*Dial-A-Charge® Charging Cylinder.

CHECKING FOR LEAKS

GENERAL

In order to check a system for leaks it is necessary that the system or portion of the system first be pressurized. This will naturally be true of a new system prior to evacuation and charging, or an old system which has lost its charge.

1. If the system has been in operation and has lost its entire charge, it is desirable to pressurize the entire system to find the leak or leaks.

2. When the entire unit is to be pressurized, it is usually desirable to pressurize the system through both the suction and discharge service valves. In this manner, the pressure is supplied to the system on both sides of the capillary tube.

Refrigeration systems are commonly pressurized for purposes of leak checking with either refrigerant or dry nitrogen or a combination of both. Test pressures should be adjusted to 100 psig or higher (Max. 175).

The advantages of nitrogen are:

1. It is less expensive than refrigerant.

2. Nitrogen will leak approximately twice as fast as R-12 or R-22 from the same size hole at the same pressure.

3. The valve arrangement on a nitrogen bottle provides an excellent means of checking if a leak exists.

4. Nitrogen will not be absorbed by refrigerant oil, thereby causing a misleading pressure drop.

5. Test procedures are easier to obtain.

The advantages of refrigerant are:

1. Refrigerant leaks can be detected with a Halide or electronic leak detector. Nitrogen cannot be detected unless it is used with a portion of refrigerant.

2. Refrigerant may be more readily available to a serviceman because he will need refrigerant in any event.

NOTE: On existing systems which have been in operation, it is usually wise to make a visual check of the system piping since a refrigerant leak will often be indicated by the presence of oil. This is because some of the oil in the system will escape through the leak with the refrigerant.

TO APPLY PRESSURE ON ENTIRE SYSTEM

1. Attach the gauge manifold to the suction and discharge Schrader valves.

2. Attach the refrigerant or nitrogen drum to the center port of the gauge manifold. If nitrogen is used, be sure the bottle is equipped with a pressure regulator.

3. Open the drum valve. If nitrogen is used, adjust the pressure regulator to 100 psig.

4. Open both valves on the gauge manifold and allow the gas to flow into the system. When refrigerant is used, do not try to pressurize beyond the saturation pressure of the refrigerant corresponding to the ambient temperature.

5. Proceed to leak checks.

6. When all the leaks are found, remove the pressure from the system before brazing.

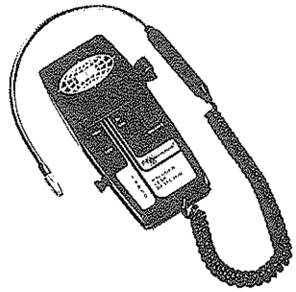
LEAK TESTING A SYSTEM CHARGED WITH REFRIGERANT USING AN ELECTRONIC LEAK DETECTOR

An electronic leak detector such as illustrated in Figure is the preferred tool for leak checking. It is highly sensitive and measures the electronic resistance of gas samples.

1. Turn detector on and attach proper probe.

2. Pass probe along the lines going around the joints and connections. Be sure to check below all points since both R-12 and R-22 are heavier than air.

3. Presence of a leak will be indicated either by an indication on the milliammeter dial or a buzzing sound.



CHECKING FOR LEAKS WITH A SOAP SOLUTION

An alternate method for checking for leaks is to use a soap solution around the suspected area to pinpoint the actual leak. A soap solution usually used by most servicemen is merely a soap and water mixture using a sudsy type of soap. Another popular soap solution is a soap bubble solution sold as a toy for purpose of blowing soap bubbles. Most popular applicator of soap solution is a plastic squeeze bottle such as used for ketchup or mustard. DO NOT shake the soap solution bottle. It works far better when applied as a liquid. This method is not as accurate as using the Halide or electronic leak detector, but it can be a matter of convenience to a serviceman who does not have the proper tools. It is a good method to check for pinhole leaks.

LEAK TESTING A SYSTEM CHARGED WITH REFRIGERANT USING A HALIDE LEAK DETECTOR

This is the least desirable method of detecting leaks since it is only about 1/20th as efficient as an electronic detector and it uses and open flame.

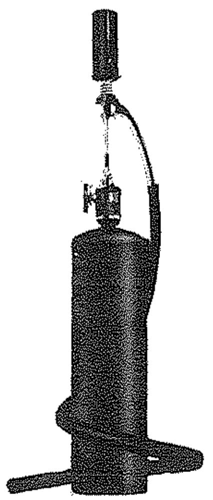
1. With a Halide leak detector, turn the flame as low as possible without losing easy sight of the flame. This will usually give a stable flue flame.

2. Hold the snifter hose or flame as close as possible to the joints in the piping being checked. Preferably, this should be below the possible leak since R-12 and R-22 are heavier than air and will therefore drop.

3. Green flame indicates the presence of refrigerant, therefore, the location of the leak.

4. After all piping has been checked, leaks located and marked, remove the refrigerant from the system or pump down the system before attempting to braze the leaks.

CAUTION: Do not breathe the products of combustion from a Halide leak detector when refrigerant is present. Phosgene which is a very deadly gas is formed when refrigerant is exposed to an open flame or even a hot wire. There should be no welding in an enclosed space where refrigerant gas has escaped and where area has not been properly ventilated.



CHECKING FOR RESTRICTIONS

The following procedures may be used for locating restrictions in the system:

CAPILLARY TUBES

A restricted cap tube may be located by measuring or feeling the temperature of the various evaporator circuits as they leave the evaporator.

A warm circuit at this point indicates a restricted capillary tube feeding this circuit. This condition will also be indicated by lower than normal suction pressure. A restricted capillary tube must be replaced.

LIQUID LINE

A restriction in the liquid line will be indicated by low suction pressure and loss of capacity. An obvious temperature difference will be noted at the point of restriction. The restriction may be at:

1. Liquid line strainer.
2. Drier or drier fitting.
3. Liquid line valve.
4. Flattened or kinked tubing.
5. Quick connect fitting.

SUCTION LINE

A restriction in the suction line will be indicated by low suction pressure, loss of capacity and a warm evaporator coil. It may be necessary to install a gauge port at the evaporator outlet to determine the pressure difference between this point and suction service port. A pressure differential greater than 2 to 5 psig would indicate a restriction.

DISCHARGE LINE AND CONDENSER

A restriction of either of these is quite rare but would be indicated by high discharge pressure (possibly cutting off on high pressure) and loss of capacity. An excessive pressure drop between discharge service valve and the liquid line valve would indicate a restriction.

DISTRIBUTOR LINE AND DISTRIBUTOR

A restriction at this point would be indicated by low suction pressure, loss of capacity and accompanied by frost at the point of restriction. A restriction in a distributor line will result in the evaporator circuit being fed by that line being warmer than the other circuits.

ICING OF INDOOR COILS

A condition which is often encountered in the field is icing or frosting of the indoor coil. Since there are several causes for this condition, it can sometimes be difficult to diagnose.

First, there are actually two separate and distinct conditions; icing and frosting.

1. *ICING* is defined as a covering of slick, smooth ice on the surface. This can be a very thin coat or it may become quite thick. It may further build up over a fairly large area.

2. *FROSTING* is just what the name implies and has a snowy, crystal-like appearance. It is generally confined to a very small area. Following are causes of each.

INDOOR COIL FROSTING OR ICING

Generally the cause:
1. Low suction pressure
2. Blower belt slipping
3. Air volume of indoor coil low
4. Air filters of indoor coil dry
5. Small or restricted ductwork

Occasionally the cause:
1. Refrigerant charge low
2. System operation temperature
3. Check valve sticking closed
4. Indoor capillary tube dirty (internally)
5. General restrictions
6. Air stratification in conditioned space

ICE BUILDUP ON LOWER PART OF OUTDOOR COIL
(Heat Pump only heating mode)

Generally the cause:
1. Faulty defrost relay
2. Refrigerant charge low
3. Defrost control out of adjustment, 30 versus 60 min.
4. Defrost control sensing element loose or poorly located

Occasionally the cause:
1. Compressor valves defective
2. Defrost control cycle too long
3. Reversing valve leaking
4. Reversing valve defective
5. Poor drainage during defrost cycle

NOTE: Under normal operation, there will be frosting between cycles if outdoor temperature below 40-50°F.

EXCESSIVE ICE BUILDUP ON OUTDOOR COIL

Generally the cause:
1. Defrost relay
2. Compressor valves defective
3. Refrigerant charge low
4. Defrost control out of adjustment
5. Defrost control sensing element loose or poorly located
6. Timer or relay of defrost control defective

Occasionally the cause:
1. Faulty wiring in control circuit
2. Loose terminal in control circuit
3. Defrost control cycle too long (clock timer)
4. Reversing valve defective
5. Outdoor capillary tube internally dirty

PRESSURE AND TEMPERATURE CHECKS

CHECKING REFRIGERANT PRESSURES

The suction and discharge pressures are checked by attaching the gauge manifold to the service valve gauge ports. Connect the suction gauge to the suction service valve and the discharge gauge to the discharge service valve. Before reading the gauge pressure, the gauge hoses to be purged through the center tap of the test manifold by momentarily opening manifold valves. (See Checking Refrigerant Using A Pressure Curve).

HEAD OR DISCHARGE PRESSURE

Head or discharge pressure is the pressure that exists in the discharge line, condenser, receiver and liquid line. On air-cooled condensing units, the head pressure increases with an increase in ambient air temperature.

HEAD PRESSURE TOO HIGH

Generally the cause:
1. Refrigerant overcharge
2. System operation temperatures
3. Non-condensables
4. Outdoor coil fins dirty or plugged
5. Outdoor coil air volume low (for cooling)
6. Indoor coil blower belt slipping (if belt drive)
7. Indoor coil air volume low
8. Indoor coil air filters dirty

Occasionally the cause:
1. Excessive load (cooling)
2. Outdoor coil - coil air short circuiting
3. Indoor coil fins dirty or plugged
4. Air stratification in conditioned space
5. If all checks fail to locate cause, check the following:
   (a) Small or restricted ductwork
   (b) General restrictions
   (c) Auxiliary heat upstream from indoor coil

HEAD PRESSURE TOO LOW

Generally the cause:
1. Refrigerant charge low
2. Low suction pressure
3. Reversing valve leaking
4. Outdoor coil - low temperature coil air (for cooling)
5. If all checks fail to find cause, check for defective compressor valves

SUCTION OR BACK PRESSURE

Suction or back pressure is the pressure that exists in the evaporator, the suction line and the crankcase of the compressor. Normally, the suction temperature will range from 40°F to 50°F, depending on equipment application. Light evaporator loading will cause the suction pressure and temperature to decrease, while heavy evaporator loading will cause the suction pressure and temperature to increase.

If high suction pressure is accompanied by high head pressure and the temperature of the air over the evaporator and condenser is high, the high inside and outside air temperature may be causing the condition and no malfunction may be indicated.

SUCTION PRESSURE TOO HIGH

Generally the cause:
1. Defective compressor valves
2. High head pressure
3. Excessive cooling load
4. Check valve leaking or defective

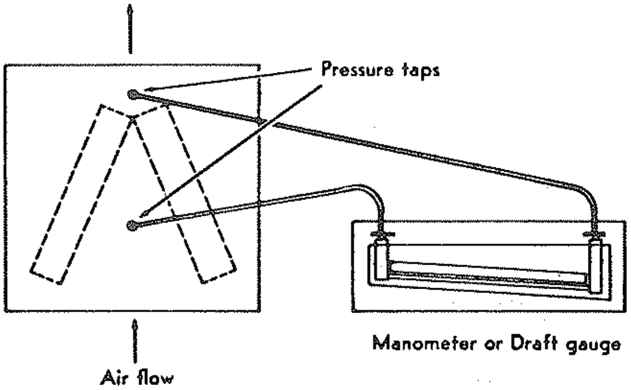
Occasionally the cause:
1. Refrigerant overcharge
2. System operation temperatures
3. Reversing valve leaking

SUCTION PRESSURE TOO LOW

Generally the cause:
1. Refrigerant charge low
2. Blower belt of indoor coil slipping
3. Indoor coil air volume low
4. Indoor coil air filters dirty

Occasionally the cause:
1. System operation temperatures
2. Leaking or defective check valve
3. Outdoor capillary tube plugged
4. Outdoor coil fins dirty or plugged
5. Outdoor coil - coil air short circuiting
6. Indoor capillary tube plugged
7. Small or restricted ductwork - indoor coil
8. Check valve sticking closed
9. Leaking or defective check valve
10. General restrictions
11. If all checks fail to find cause, check the following:
    (a) Low head pressure
    (b) Indoor coil fins dirty or plugged
    (c) Air stratification in conditioned space
    (d) Refrigeration piping incorrect

AIR PRESSURES



Checking static pressure of low side.

One quarter inch holes are drilled in the inlet and outlet of evaporators for the purpose of measuring the static pressure drops across the evaporator coil. (Coil must be dry).

The "pressure drop" can be measured with an inclined manometer or draft gauge (see Figure

1. Insert an awl or screwdriver into the hole to open up the insulation behind it.
2. Level the manometer if used.
3. Check for rubber hoses from the manometer or draft gauge for leaks.
4. Insert the rubber hose into the holes in the evaporator cabinet so that about 1/4 inch extends inside the cabinet, and seal around the hole with Permagum or putty. The hose from the lower end of the inclined gauge should go into the downstream hole. The pressure differential between the pressure of the air entering and leaving the coil is the pressure drop through the coil.
5. Adjust blower speed to obtain correct pressure drop for coil used (see manufacturer's specifications). This will then give you the required air volume for unit.

CHECKING TEMPERATURES

EVAPORATOR AIR TEMPERATURE

Before making the following temperature check, the system should be in proper balance with the *approximate design conditions entering coil (80°db and 67°wb) and rated air flow.*

1. Find temperature of air entering coil.
2. Subtract temperature of air leaving coil.
3. Temperature difference (TD) should be 14°F to 18°F.
    (a) Excessive TD indicates blower speed too slow. Check pressure drop. (Check for dirty filters and restricted duct work).
    (b) Insufficient TD indicates blower speed too fast. Check pressure drop. (Check refrigerant charge and for restriction in strainer).

CHECKING AIR VOLUME ON INDOOR COIL (WITH ELECTRIC HEAT)

NOTE: Low air volume causes excessive operating costs.

Velometers and draft gauges are generally used for checking air quantities, however, there is an easier and more accurate way of checking air volume on indoor heat pump units, if they are equipped with electric auxiliary heat. First, discount the compressor and then turn on the indoor blower and strip heat. All grilles and registers should be in normal operating position. Obtain the return air temperature as near the blower as possible but away from the effect of radiant heat from the strip heaters. Obtain supply air temperature in plenum. (*FOR BEST RESULTS TAKE SEVERAL READINGS IN EACH LOCATION AND TAKE AN AVERAGE OF EACH).*

To find air flow on units with electric strip heat:

MEASURE:
a. volts at the contactor
b. amps at the contactor
c. temperature rise through unit

$$\text{Airflow (CFM)} = \frac{\text{Volts X amps X 3.413}}{\Delta\text{T °F X 1.1 (Sensible Heat Constant)}}$$

Then to find the output of heat pump, run only the heat pump on heating cycle and:

MEASURE: a. ΔT °F rise through coil

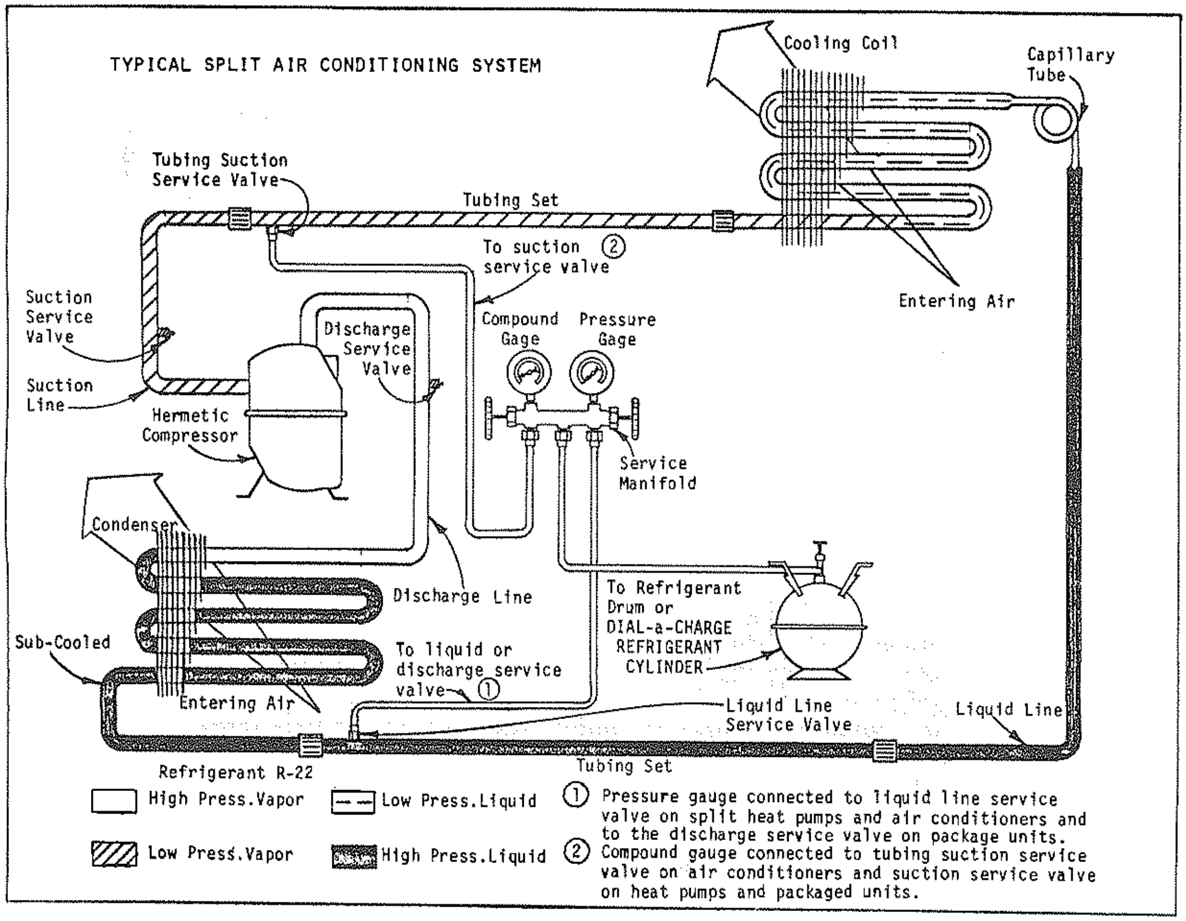
$$\text{Unit Output(BTUH)} = \text{CFM (found while on electric heater) X } \Delta\text{T °F rise X 1.1}$$

Check the specifications for unit at outdoor conditions and it should be within 10% of rated capacity if unit is properly charged. If not, install gauges, check for leaks, discharge unit and recharge by weight.

On a fossil fuel add-on, determine the fuel BTUH input to the furnace (oil nozzle size with pump at 100 psig) (gas - natural cu.ft. of gas per hour X BTU per cu.ft. - contact local gas company) then do a combustion efficiency test. This will give you the BTUH out of furnace.

$$\text{CFM} = \frac{\text{furnace BTUH}}{\Delta\text{T °F rise X 1.1}}$$

Now operate heat pump and determine BTUH of the heat pump as above.



AIR CONDITIONING AND HEAT PUMP ON COOLING CYCLE

TROUBLESHOOTING — SYSTEM PRESSURE CHECK

Low Suction — Low Head Pressure

1. Low charge.
2. Low indoor and outdoor temperature.
3. Restricted air flow over indoor coil.
4. Defective indoor fan motor.
5. Iced indoor coil.
6. Restricted liquid line, drier, or capillary tube.

High Suction — Low Head Pressure

1. Defective or broken valves.
2. IPRV valve open.

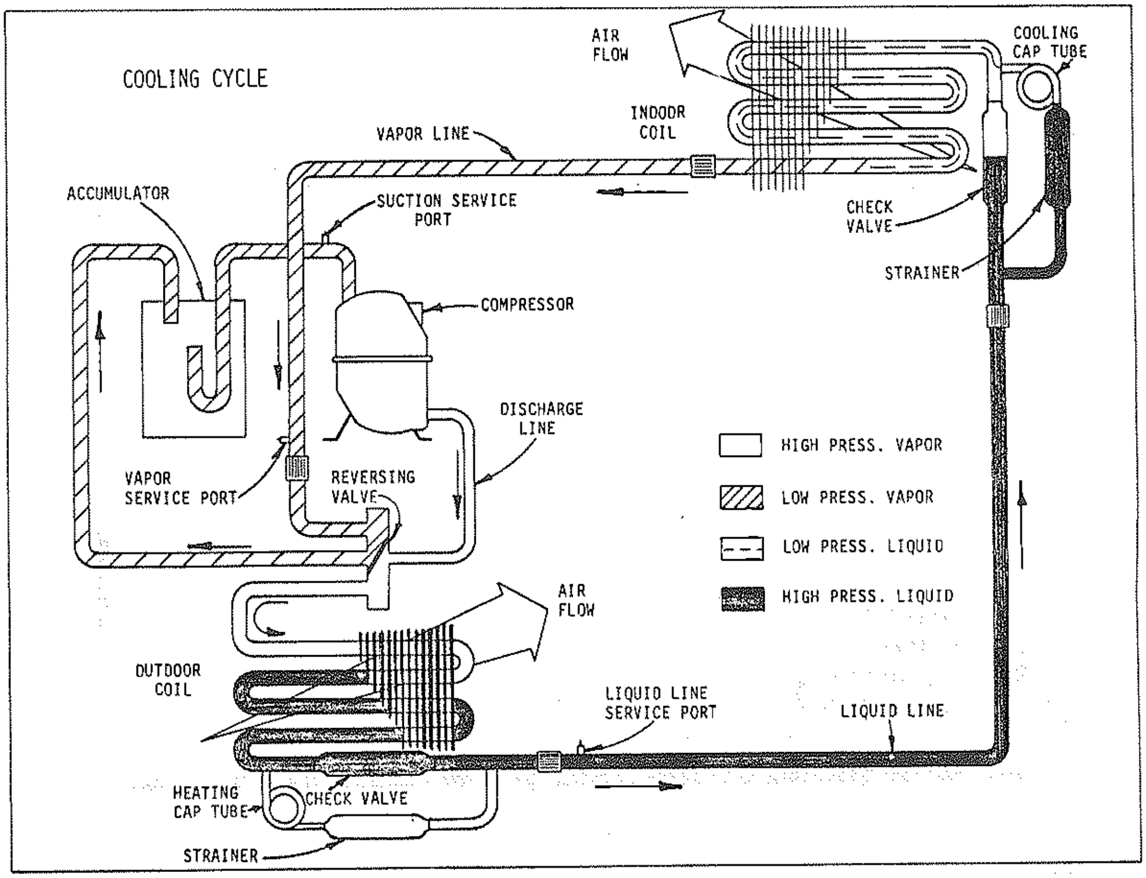
Low Suction — High Head Pressure

1. Partial restriction and then overcharged.

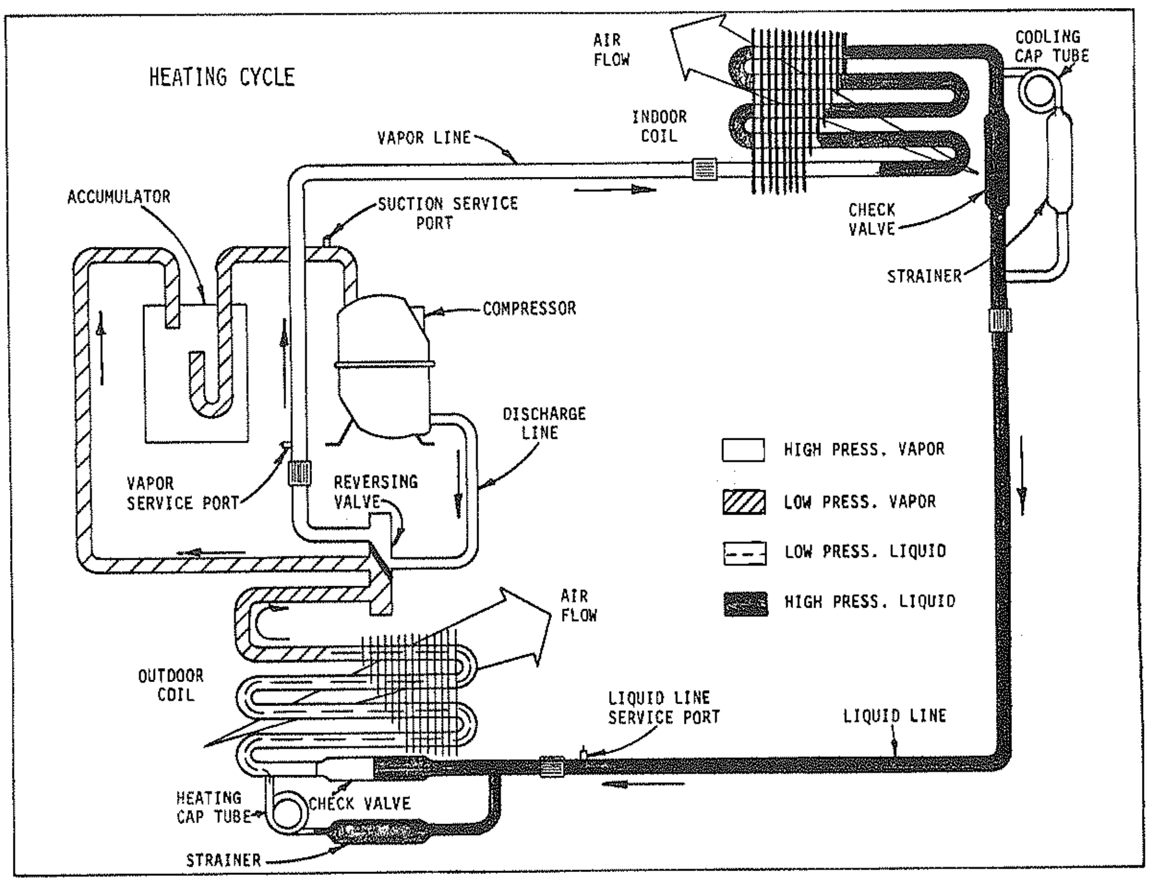
NOTE: On a split heat pump the vapor line should be within 10 psig of the pressure in liquid line on cooling mode and within 10 psig of suction line on heating mode. If not, check for sticking check valves.

High Suction — High Head Pressure

1. High ambient.
2. Low outdoor air flow
3. Overcharged
4. Air in system.
5. Restricted condenser.



TYPICAL HEAT PUMP SYSTEM



TROUBLE-SHOOTING CHART FOR AIR CONDITIONERS

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● GENERALLY THE CAUSE—ALWAYS MAKE THESE CHECKS FIRST.

▲ OCCASIONALLY THE CAUSE. MAKE THESE CHECKS ONLY IF FIRST CHECKS FAIL TO LOCATE TROUBLE.

■ RARELY THE CAUSE, MAKE THIS CHECK ONLY IF PREVIOUS CHECKS FAIL TO LOCATE TROUBLE.

POWER SUPPLY

	METER TO LINE SIDE OF CONTACTOR								LOAD SIDE OF CONTACTOR TO MOTOR TERMINAL									
	POWER FAILURE	BLOWN FUSES OR TRIPPED CIRCUIT BREAKER	FAULTY WIRING	LOOSE TERMINALS	LOW VOLTAGE	SINGLE Ø FAILURE OF 3Ø	UNBALANCED POWER SUPPLY 3Ø	VOLTAGE TOO HIGH	OPEN DISCONNECT SWITCH	FAULTY WIRING	LOOSE TERMINAL	LOW VOLTAGE	DEFECTIVE CONTACTS IN CONTACTOR	COMPRESSOR OVERLOAD	POTENTIAL RELAY FAILS TO OPEN	POTENTIAL RELAY FAILS TO CLOSE	RUN CAPACITOR	START CAPACITOR
COMPRESSOR AND CONDENSER FAN MOTOR WILL NOT START	●	●	●	●	▲	■	■		●	●	●	▲	▲	●				
COMPRESSOR WILL NOT START BUT CONDENSER FAN WILL RUN				▲	▲	▲	▲			●	●	▲	▲	●		▲	●	●
CONDENSER FAN MOTOR WILL NOT START										●	●							
COMPRESSOR "HUMS" BUT WILL NOT START			●	●	▲	▲	▲			●	●	▲	▲	●	●			●
COMPRESSOR CYCLES ON OVERLOAD			●	●	●	■	●			●	●	●	●	▲	●		●	
COMPRESSOR SHORT CYCLES ON LOW PRESSURE																		
COMPRESSOR RUNS CONTINUOUSLY—NO COOLING																		
COMPRESSOR RUNS CONTINUOUSLY—COOLING																		
COMPRESSOR NOISY																	▲	
COMPRESSOR LOSES OIL																		
HEAD PRESSURE TOO HIGH																		
HEAD PRESSURE TOO LOW																		
LIQUID LINE FROSTING OR SWEATING																		
SUCTION PRESSURE TOO HIGH																		
SUCTION PRESSURE TOO LOW																		
EVAPORATOR FROSTING																		
SUCTION LINE FROSTING OR SWEATING																		
EVAPORATOR BLOWER WILL NOT START	●	●	●	●	■	■				●	●	■						
CONDENSER FAN MOTOR RUNS CONTACTOR NOT PULLED IN																		
LIQUID REFR. FLOODING BACK TO COMP.—(CAP TUBE SYSTEM)																		
SPACE TEMP. TOO HIGH																		

	CONTROL CIRCUIT									MOTORS			
	FAULTY WIRING	LOOSE TERMINALS	CONTROL TRANSFORMER	LOW VOLTAGE	THERMOSTAT	CONTACTOR COIL	PRESSURE CONTROL	CONDENSER FAN RELAY	EVAPORATOR FAN RELAY	COMPRESSOR MOTOR	CONDENSER MOTOR	EVAPORATOR MOTOR	COMP. OFF ON INTERNAL OVERLOAD
COMPRESSOR AND CONDENSER FAN MOTOR WILL NOT START	●	●	●	▲	▲	●	●				■	■	
COMPRESSOR WILL NOT START BUT CONDENSER FAN WILL RUN										●			
CONDENSER FAN MOTOR WILL NOT START								●			●		
COMPRESSOR "HUMS" BUT WILL NOT START										▲			
COMPRESSOR CYCLES ON OVERLOAD										▲			
COMPRESSOR SHORT CYCLES ON LOW PRESSURE													
COMPRESSOR RUNS CONTINUOUSLY—NO COOLING													
COMPRESSOR RUNS CONTINUOUSLY—COOLING	●				●								
COMPRESSOR NOISY													
COMPRESSOR LOSES OIL													
HEAD PRESSURE TOO HIGH													
HEAD PRESSURE TOO LOW													
LIQUID LINE FROSTING OR SWEATING													
SUCTION PRESSURE TOO HIGH													
SUCTION PRESSURE TOO LOW													
EVAPORATOR FROSTING												▲	
SUCTION LINE FROSTING OR SWEATING													
EVAPORATOR BLOWER WILL NOT START	●	●	●	■	■				●			●	
CONDENSER FAN MOTOR RUNS CONTACTOR NOT PULLED IN													●
LIQUID REFR. FLOODING BACK TO COMP.—(CAP TUBE SYSTEM)													
SPACE TEMP. TOO HIGH					●								

HIGH PRESSURE SIDE OF SYSTEM

	COMPRESSOR						SYSTEM OPERATION								
	HOLD DOWN BOLTS	DEFECTIVE COMPRESSOR BEARINGS	SEIZED COMPRESSOR	DEFECTIVE COMPRESSOR VALVES	COMPRESSOR OIL LEVEL	OPEN OR SHORT MOTOR WINDING	REFRIGERANT CHARGE LOW	OVERCHARGE OF REFRIGERANT	HIGH HEAD PRESSURE	HIGH SUCTION PRESSURE	LOW SUCTION PRESSURE	TEMPERATURES	NON-CONDENSABLES (AIR ETC.)	EXCESSIVE LOAD IN SPACE	LIQUID VALVE PARTIALLY CLOSED
COMPRESSOR AND CONDENSER FAN MOTOR WILL NOT START							●	■	●		●		●		
COMPRESSOR WILL NOT START BUT CONDENSER FAN WILL RUN		●	●			●									
CONDENSER FAN MOTOR WILL NOT START															
COMPRESSOR "HUMS" BUT WILL NOT START		●	▲			▲		■	■		■	■			
COMPRESSOR CYCLES ON OVERLOAD				■	■	▲	▲	▲	▲	▲			▲	▲	
COMPRESSOR SHORT CYCLES ON LOW PRESSURE							●				●				
COMPRESSOR RUNS CONTINUOUSLY—NO COOLING				●			●			▲			▲		
COMPRESSOR RUNS CONTINUOUSLY—COOLING														●	
COMPRESSOR NOISY	●	●		●	●										
COMPRESSOR LOSES OIL							●				●				
HEAD PRESSURE TOO HIGH					■			●				●	●	▲	
HEAD PRESSURE TOO LOW				▲			●				●				
LIQUID LINE FROSTING OR SWEATING															●
SUCTION PRESSURE TOO HIGH				●				▲	●			▲		●	
SUCTION PRESSURE TOO LOW							●					▲			
EVAPORATOR FROSTING							▲				●	▲			
SUCTION LINE FROSTING OR SWEATING								●							
EVAPORATOR BLOWER WILL NOT START															
CONDENSER FAN MOTOR RUNS CONTACTOR NOT PULLED IN															
LIQUID REFR. FLOODING BACK TO COMP.—(CAP TUBE SYSTEM)								●				■			
SPACE TEMP. TOO HIGH				▲			●				●				

	HIGH PRESSURE SIDE: CONDENSER AIR					LOW SIDE: EVAPORATOR AIR						GENERAL					
	CONDENSER FINS DIRTY OR PLUGGED	CONDENSER FAN BELT SLIPPING	CONDENSER AIR SHORT CIRCUITING	LOW CONDENSER AIR VOLUME	CONDENSER AIR TEMPERATURE LOW	PLUGGED OR RESTRICTED CAP-TUBE	EVAPORATOR FINS DIRTY OR PLUGGED	EVAPORATOR BELT SLIPPING	LOW EVAPORATOR AIR VOLUME	DIRTY FILTERS	DUCTWORK SMALL OR RESTRICTED	RESTRICTIONS	THERMOSTAT SETTING	THERMOSTAT LOCATION	STRATIFIED AIR IN SPACE	INCORRECT REFRIG. PIPING	SYSTEM TOO SMALL
COMPRESSOR AND CONDENSER FAN MOTOR WILL NOT START	■	■	■	■									■				
COMPRESSOR WILL NOT START BUT CONDENSER FAN WILL RUN																	
CONDENSER FAN MOTOR WILL NOT START																	
COMPRESSOR "HUMS" BUT WILL NOT START																	
COMPRESSOR CYCLES ON OVERLOAD	■	■	■	■	■							■					
COMPRESSOR SHORT CYCLES ON LOW PRESSURE						●	●	●	●	●	●	●			■		
COMPRESSOR RUNS CONTINUOUSLY—NO COOLING	■	■	■	■	■	▲	●	●	●	●	●	▲	■	▲	▲		
COMPRESSOR RUNS CONTINUOUSLY—COOLING														●			▲
COMPRESSOR NOISY																▲	
COMPRESSOR LOSES OIL							■	■	■	■	■	▲				●	
HEAD PRESSURE TOO HIGH	●	●	▲	●		▲						■					
HEAD PRESSURE TOO LOW					●												
LIQUID LINE FROSTING OR SWEATING						▲						●					
SUCTION PRESSURE TOO HIGH																	
SUCTION PRESSURE TOO LOW						▲	▲	●	●	●	●	▲			▲	■	
EVAPORATOR FROSTING						▲	▲	●	●	●	●	▲			▲	■	
SUCTION LINE FROSTING OR SWEATING						▲	●	●	▲	■							
EVAPORATOR BLOWER WILL NOT START																	
CONDENSER FAN MOTOR RUNS CONTACTOR NOT PULLED IN																	
LIQUID REFR. FLOODING BACK TO COMP.—(CAP TUBE SYSTEM)							▲	▲	▲	▲	▲				■		
SPACE TEMP. TOO HIGH						▲	●	●	●	●	●		●	▲	▲	■	●

QUICK REFERENCE TROUBLE-SHOOTING CHART FOR AIR TO AIR HEAT PUMP

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● DENOTES COMMON CAUSE

▲ DENOTES OCCASIONAL CAUSE

POSSIBLE CAUSE

POWER SUPPLY — LINE VOLTAGE

Cycle	PROBLEM CONDITION	POWER FAILURE	BLOWN FUSE OR TRIPPED BREAKER	FAULTY WIRING	LOOSE TERMINALS	LOW VOLTAGE	SINGLE 1Ø FAILURE OF 3Ø	UNBALANCED 3 Ø	DEFECTIVE CONTACTS IN CONTACTOR	COMPRESSOR OVERLOAD	POTENTIAL RELAY	RUN CAPACITOR	START CAPACITOR
HEATING OR COOLING CYCLES	COMPRESSOR AND O.D. FAN MOTOR DO NOT OPERATE	●	●	●	●		▲	▲	▲	▲			
HEATING OR COOLING CYCLES	COMPRESSOR WILL NOT RUN O.D. FAN MOTOR RUNS			●	●	●	▲	▲		●	●	●	●
HEATING OR COOLING CYCLES	COMPRESSOR "HUMS" BUT WILL NOT START			●	●	●	●	▲	▲		●	●	●
HEATING OR COOLING CYCLES	COMPRESSOR CYCLES ON OVERLOAD			●	●	●	▲	▲	▲	●	●	●	●
HEATING OR COOLING CYCLES	COMPRESSOR OFF ON HIGH PRESSURE CONTROL												
HEATING OR COOLING CYCLES	COMPRESSOR NOISY												
HEATING OR COOLING CYCLES	HEAD PRESSURE TOO HIGH												
HEATING OR COOLING CYCLES	HEAD PRESSURE TOO LOW												
HEATING OR COOLING CYCLES	SUCTION PRESSURE TOO HIGH												
HEATING OR COOLING CYCLES	SUCTION PRESSURE TOO LOW												
HEATING OR COOLING CYCLES	I.D. BLOWER WILL NOT START	●	●	●	●								
HEATING OR COOLING CYCLES	I.D. COIL FROSTING OR ICING												
HEATING OR COOLING CYCLES	HIGH COMPRESSOR AMPS					●							
COOLING CYCLE	COMPRESSOR RUNS CONTINUOUSLY—NO COOLING												
COOLING CYCLE	LIQUID REFRIGERANT FLOODING BACK TO COMPRESSOR												
HEATING CYCLE	COMPRESSOR RUNS CONTINUOUSLY— NO HEATING												
HEATING CYCLE	DEFROST CYCLE INITIATES NO ICE ON COIL												
HEATING CYCLE	REVERSING VALVE DOES NOT SHIFT			●	●								
HEATING CYCLE	ICE BUILD UP ON LOWER PART OF O.D. COIL												
HEATING CYCLE	LIQUID REFRIGERANT FLOODING BACK TO COMPRESSOR												
HEATING CYCLE	AUX. HEAT ON I.D. BLOWER OFF			●	●								
HEATING CYCLE	EXCESSIVE OPERATING COSTS			▲	▲								
HEATING CYCLE	EXCESSIVE ICE ON O.D. COIL			▲	▲								

POWER SUPPLY — CONTROL CIRCUIT

PROBLEM CONDITION	FAULTY WIRING	LOOSE TERMINALS	CONTROL TRANSFORMER	LOW VOLTAGE	THERMOSTAT	CONTACTOR COIL	PRESSURE CONTROL OR IMPEDANCE RELAY	INDOOR FAN RELAY
COMPRESSOR AND O.D. FAN MOTOR DO NOT OPERATE	●	●	●	▲	▲	●	●	
COMPRESSOR WILL NOT RUN O.D. FAN MOTOR RUNS								
COMPRESSOR "HUMS" BUT WILL NOT START								
COMPRESSOR CYCLES ON OVERLOAD								
COMPRESSOR OFF ON HIGH PRESSURE CONTROL							▲	●
COMPRESSOR NOISY								
HEAD PRESSURE TOO HIGH								
HEAD PRESSURE TOO LOW								
SUCTION PRESSURE TOO HIGH								
SUCTION PRESSURE TOO LOW								
I.D. BLOWER WILL NOT START	●	●	●	▲	▲			●
I.D. COIL FROSTING OR ICING								
HIGH COMPRESSOR AMPS								
COMPRESSOR RUNS CONTINUOUSLY—NO COOLING								
LIQUID REFRIGERANT FLOODING BACK TO COMPRESSOR (COOLING)								
COMPRESSOR RUNS CONTINUOUSLY— NO HEATING								
DEFROST CYCLE INITIATES NO ICE ON COIL								
REVERSING VALVE DOES NOT SHIFT								
ICE BUILD UP ON LOWER PART OF O.D. COIL								
LIQUID REFRIGERANT FLOODING BACK TO COMPRESSOR (HEATING)								
AUX. HEAT ON I.D. BLOWER OFF	●	●			▲			●
EXCESSIVE OPERATING COSTS					▲			
EXCESSIVE ICE ON O.D. COIL								

OUTDOOR SECTION — COMPRESSOR / REFRIGERANT SYSTEM

PROBLEM CONDITION	DISCHARGE LINE HITTING INSIDE OF SHELL	BEARINGS DEFECTIVE	SEIZED	VALVE DEFECTIVE	MOTOR WINDINGS DEFECTIVE	REFRIGERANT CHARGE LOW	REFRIGERANT OVERCHARGE	HIGH HEAD PRESSURE	LOW HEAD PRESSURE	HIGH SUCTION PRESSURE	LOW SUCTION PRESSURE	NON-CONDENSABLES	UNEQUALIZED PRESSURES
COMPRESSOR AND O.D. FAN MOTOR DO NOT OPERATE													
COMPRESSOR WILL NOT RUN O.D. FAN MOTOR RUNS		▲	●		●								●
COMPRESSOR "HUMS" BUT WILL NOT START		●	●		●								●
COMPRESSOR CYCLES ON OVERLOAD		▲		▲	▲	●	●	▲		▲		●	
COMPRESSOR OFF ON HIGH PRESSURE CONTROL							●					●	
COMPRESSOR NOISY	▲	▲		●									
HEAD PRESSURE TOO HIGH							●					●	
HEAD PRESSURE TOO LOW				●		●					●		
SUCTION PRESSURE TOO HIGH				●			●	●					
SUCTION PRESSURE TOO LOW						●			▲				
I.D. BLOWER WILL NOT START													
I.D. COIL FROSTING OR ICING						●					●		
HIGH COMPRESSOR AMPS		●	●				●	●		●		●	
COMPRESSOR RUNS CONTINUOUSLY—NO COOLING				●		●							
LIQUID REFRIGERANT FLOODING BACK TO COMPRESSOR (COOLING)							●	●					
COMPRESSOR RUNS CONTINUOUSLY— NO HEATING				●		●							
DEFROST CYCLE INITIATES NO ICE ON COIL						▲							
REVERSING VALVE DOES NOT SHIFT						▲			▲				
ICE BUILD UP ON LOWER PART OF O.D. COIL						●					▲		
LIQUID REFRIGERANT FLOODING BACK TO COMPRESSOR (HEATING)							●	●					
AUX. HEAT ON I.D. BLOWER OFF													
EXCESSIVE OPERATING COSTS						●	●						
EXCESSIVE ICE ON O.D. COIL						●							

OUTDOOR SECTION — DEFROST CONTROL / REV. VALVE / CHECK VALVE

PROBLEM CONDITION	SENSING BULB LOOSE-POORLY LOCATED	CYCLE TOO LONG (CLOCKTIMER)	DEFECTIVE CONTROL, TIMER OR RELAY	REV. VALVE: LEAKING	REV. VALVE: DEFECTIVE VALVE OR COIL	CHECK VALVE: STICKING CLOSED	CHECK VALVE: LEAKING OR DEFECTIVE
COMPRESSOR AND O.D. FAN MOTOR DO NOT OPERATE							
COMPRESSOR WILL NOT RUN O.D. FAN MOTOR RUNS							
COMPRESSOR "HUMS" BUT WILL NOT START							
COMPRESSOR CYCLES ON OVERLOAD				▲			
COMPRESSOR OFF ON HIGH PRESSURE CONTROL	▲	●	●			●	
COMPRESSOR NOISY							
HEAD PRESSURE TOO HIGH	▲	▲			▲	▲	
HEAD PRESSURE TOO LOW				●			▲
SUCTION PRESSURE TOO HIGH				●			▲
SUCTION PRESSURE TOO LOW						▲	
I.D. BLOWER WILL NOT START							
I.D. COIL FROSTING OR ICING						▲	
HIGH COMPRESSOR AMPS						▲	
COMPRESSOR RUNS CONTINUOUSLY—NO COOLING							
LIQUID REFRIGERANT FLOODING BACK TO COMPRESSOR (COOLING)							
COMPRESSOR RUNS CONTINUOUSLY— NO HEATING		▲	▲	●			
DEFROST CYCLE INITIATES NO ICE ON COIL			●				
REVERSING VALVE DOES NOT SHIFT					●		
ICE BUILD UP ON LOWER PART OF O.D. COIL	●	●	●				
LIQUID REFRIGERANT FLOODING BACK TO COMPRESSOR (HEATING)							
AUX. HEAT ON I.D. BLOWER OFF							
EXCESSIVE OPERATING COSTS			●	●	●		
EXCESSIVE ICE ON O.D. COIL	●	●	●		●		

OUTDOOR SECTION — OUTDOOR FAN MOTOR & COIL

PROBLEM CONDITION	PLUGGED OR RESTRICTED CAP-TUBE(HTG)	FINS DIRTY OR PLUGGED	MOTOR WINDING DEFECTIVE	RE-CIRCULATION OR AIR	AIR VOLUME LOW (CLG)	LOW TEMPERATURE COIL AIR (CLG)
COMPRESSOR AND O.D. FAN MOTOR DO NOT OPERATE						
COMPRESSOR WILL NOT RUN O.D. FAN MOTOR RUNS						
COMPRESSOR "HUMS" BUT WILL NOT START						
COMPRESSOR CYCLES ON OVERLOAD		▲	▲	▲	▲	
COMPRESSOR OFF ON HIGH PRESSURE CONTROL	▲	●	●	●	●	
COMPRESSOR NOISY						
HEAD PRESSURE TOO HIGH	▲	●	●	▲	●	
HEAD PRESSURE TOO LOW						●
SUCTION PRESSURE TOO HIGH						
SUCTION PRESSURE TOO LOW	▲	●	●	▲		▲
I.D. BLOWER WILL NOT START						
I.D. COIL FROSTING OR ICING						
HIGH COMPRESSOR AMPS						
COMPRESSOR RUNS CONTINUOUSLY—NO COOLING		▲	▲	▲	▲	▲
LIQUID REFRIGERANT FLOODING BACK TO COMPRESSOR (COOLING)						
COMPRESSOR RUNS CONTINUOUSLY— NO HEATING						
DEFROST CYCLE INITIATES NO ICE ON COIL						
REVERSING VALVE DOES NOT SHIFT						
ICE BUILD UP ON LOWER PART OF O.D. COIL						
LIQUID REFRIGERANT FLOODING BACK TO COMPRESSOR (HEATING)						
AUX. HEAT ON I.D. BLOWER OFF						
EXCESSIVE OPERATING COSTS		▲	▲	▲		
EXCESSIVE ICE ON O.D. COIL						

INDOOR SECTION — INDOOR BLOWER MOTOR & COIL / CHECK; AUX. HEAT

PROBLEM CONDITION	PLUGGED OR RESTRICTED CAP-TUBE(CLG)	FINS DIRTY OR PLUGGED	MOTOR WINDING DEFECTIVE	AIR VOLUME LOW	AIR FILTERS DIRTY	UNDERSIZED OR RESTRICTED DUCTWORK	CHECK: STICKING CLOSED	CHECK: LEAKING OR DEFECTIVE	AUX. HEAT: AUX. HEAT UPSTREAM OF COIL
COMPRESSOR AND O.D. FAN MOTOR DO NOT OPERATE									
COMPRESSOR WILL NOT RUN O.D. FAN MOTOR RUNS									
COMPRESSOR "HUMS" BUT WILL NOT START									
COMPRESSOR CYCLES ON OVERLOAD		▲	▲	▲	●	▲			
COMPRESSOR OFF ON HIGH PRESSURE CONTROL	▲	●	●	●	●	●	●		●
COMPRESSOR NOISY									
HEAD PRESSURE TOO HIGH	▲	▲	▲	●	●	▲	▲		●
HEAD PRESSURE TOO LOW								▲	
SUCTION PRESSURE TOO HIGH								▲	
SUCTION PRESSURE TOO LOW	▲	●	▲	●	●	▲	▲		
I.D. BLOWER WILL NOT START									
I.D. COIL FROSTING OR ICING	▲	●	●	●	●	▲			
HIGH COMPRESSOR AMPS		●	●	●	●	▲	▲		
COMPRESSOR RUNS CONTINUOUSLY—NO COOLING		●	●	●	●	▲			
LIQUID REFRIGERANT FLOODING BACK TO COMPRESSOR (COOLING)		●	●	●	●	▲	▲		
COMPRESSOR RUNS CONTINUOUSLY— NO HEATING									
DEFROST CYCLE INITIATES NO ICE ON COIL									
REVERSING VALVE DOES NOT SHIFT									
ICE BUILD UP ON LOWER PART OF O.D. COIL									
LIQUID REFRIGERANT FLOODING BACK TO COMPRESSOR (HEATING)									
AUX. HEAT ON I.D. BLOWER OFF			●						
EXCESSIVE OPERATING COSTS		▲	▲	▲					
EXCESSIVE ICE ON O.D. COIL									