HOW TO DIAGNOSE AND CORRECT REVERSING VALVE PROBLEMS

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INTRODUCTION

Servicing heat pumps is no cinch. And the reversing valve is the part which is most difficult and time consuming to replace. Yet experience shows that more than half of the reversing valves replaced in the field are in perfectly good working order and needn't have been replaced at all.

This happens because all too often servicemen don't know enough about heat pumps and their operation to do a proper job of troubleshooting. They tend to leap to seemingly obvious conclusions. If the reversing valve doesn't reverse, they assume it is faulty. If the reversing valve is in the wrong position, they assume it is faulty.

In reality, these judgments usually are the result of faulty diagnosis, not faulty valves. Nine times out of ten, these conditions can be traced to electrical or low-on-charge problems.

Effective troubleshooting on heat pumps requires a thorough understanding of the heat pump system. Let's begin by trying to gain an understanding of the reversing valve and its function.

HOW A REVERSING VALVE WORKS

Heat pumps operate in one of two modes: with reversing valve and unit operating in the cooling phase when the solenoid coil is de-energized, or with valve and unit operating in the heating phase when the solenoid is de-energized.

One is no more proper than the other. The choice depends upon the decision of the manufacturer's design engineer as to which works best with his system.

For the purposes of this discussion, we'll assume that the system operates in the former mode: in the cooling phase when the solenoid is de-energized (Figure 1); in the heating phase when the solenoid is energized (Figure 2).

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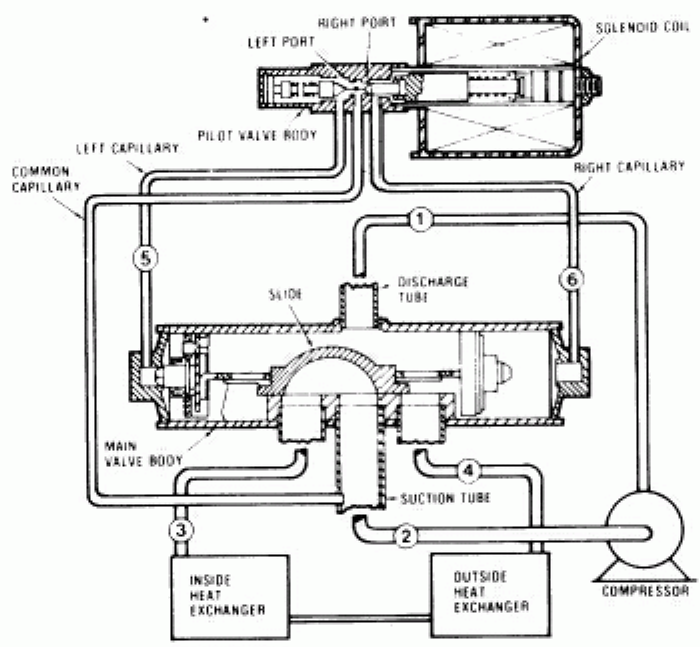

Figure 1

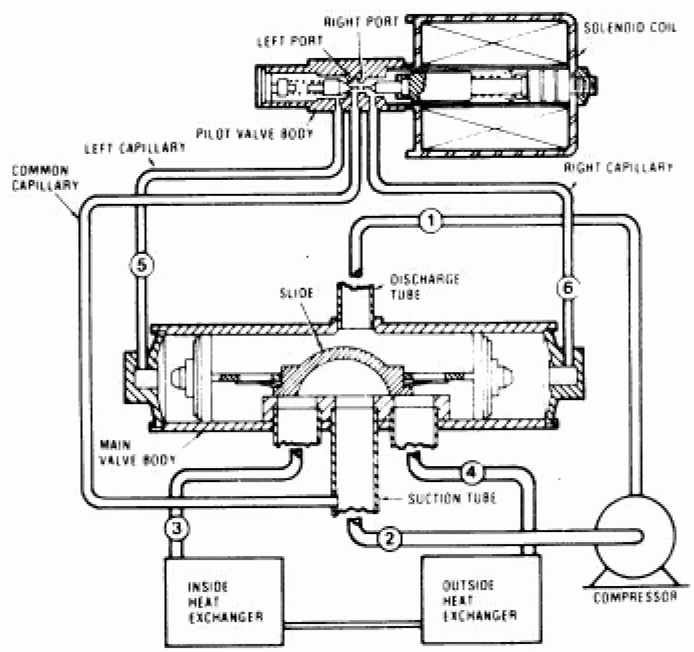

Figure 2

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The reversing valve is the same in either case. The mode in which the heat pump will operate is determined by which reversing valve tubes are piped to the inside and outside heat exchangers.

In the cutaway view of the pilot valve in Figure 1, the valve is shown in the de-energized position. The solenoid plunger is seated in the right port, sealing of the right capillary tube from leaking into the center portion, where suction gas is present. The solenoid plunger has pushed the back-seat valve open, so that the left capillary tube has suction pressure down to the piston seat.

When the coil is energized, the solenoid plunger is pulled to the right, opening the seat to the right pilot tube. This enables the right pilot tube to evacuate the high-pressure gas from the right piston seat to effect a reversal of valve operation.

As the solenoid plunger is pulled to the right, the spring forces the left plunger to the right also, sealing the left pilot tube from the suction pressure of the system.

In the cutaway view of the reversing valve in Figure 1, you can see the position of the slide and pilot valve in the cooling phase. Note that the slide now is as far to the left as it can possibly go.

Hot gas from the compressor enters the reversing valve through tube No. 1 and flows to the main cavity of the valve. Because the slide is covering the left tube opening (No. 3) and the suction tube opening (No. 2), the hot gas passes around the slide and on to the outside heat exchanger through tube No. 4.

Cool gas from the inside heat exchanger enters the valve through tube No. 3. flows under the slide, and exits through the suction tube (No. 2) on its way to the compressor. Hot gas passes through the bleed hole in the right end of the piston to the valve cavity beyond the piston, enters the end port, then passes up through tube No. 6 to the right port of the pilot valve, which is closed.

The hot gas also can pass through the left piston into the valve cavity, but cannot enter the left pilot tube, because the end port is sealed by the piston needle assembly. However, tracing tube No. 5 up to the pilot valve, you can see that the valve is open to the center pilot tube, which is connected to the suction tube. This provides suction pressure from the compressor on the back of the piston seat.

With high pressure on both ends of the piston and in the valve cavity, suction pressure under the slide holds the valve in this position until the solenoid is energized.

To start the reversal of the cycle from cooling to heating, the solenoid is energized. Figure 2 shows what the system looks like after that happens.

In the pilot valve, the plunger on the right has been pulled off its seat and has opened the port, allowing the high-pressure gas that was in the right capillary tube to escape into the suction tube.

The left port in the pilot valve is closed as its needle moves to the right, blocking the left capillary tube.

The open port on the pilot valve, due to its size, can reduce pressure faster than gas can bleed through the piston port, so the pressure in the cavity approaches compressor suction pressure. This reduction of pressure on the right side of the right end of the piston, combined with the high pressure already present on the left side of the piston, makes the slide start to move.

As the slide starts to move to the right, the left piston needle leaves its seat, allowing high-pressure gas to enter the left pilot tube, which is now blocked at the pilot valve. The high-pressure gas fills the left bleed tube, so that no pressure can exist on this side of the piston to impede the transfer.

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The lower pressure on the right side of the piston assembly combined with the high pressure on the left end of the piston forces the slide to the right. As it moves, it starts to cover the right tube and uncover the left tube.

When it reaches the midpoint of its travel (Figure 3), a dramatic transition takes place. The high pressure gas now can enter both the right and left tubes, while the dome of the slide has all three lower tubes common. This is an instantaneous happening which allows for rapid pressure equalization, preventing hammering.

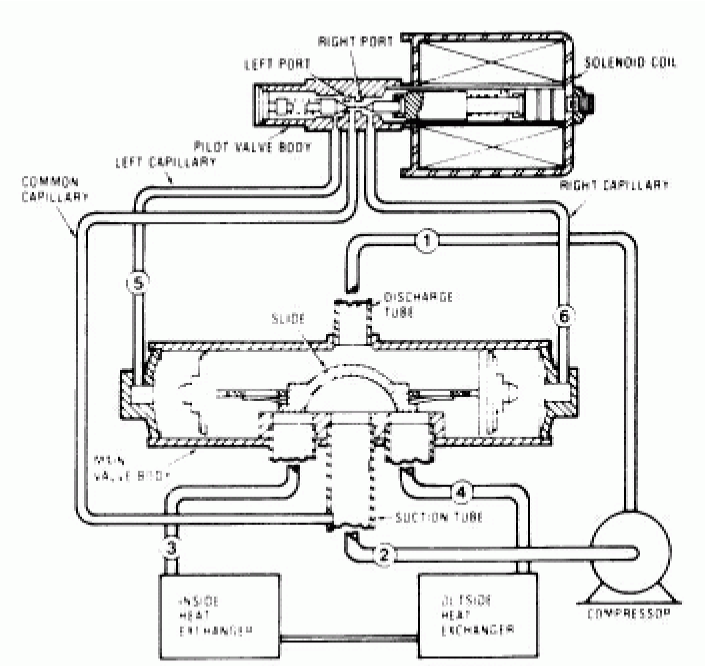

Figure 3

As the slide approaches the end of its travel to the right, the port to the inside heat exchanger becomes clear, and high-pressure gas now enters tube No. 3.

The high-pressure gas now occupies all of the valve cavity except for the diminishing space to the right of the piston. The compressor common suction is now connected to the outside heat exchanger through tube No. 4. Suction pressure is still present at the right end of the piston through the open right needle port of the pilot valve.

Figure 4 shows the reversal complete. The slide has reached the end of its travel to the right, and the piston needle has sealed the right pilot tube. With high pressure to both ends of the piston and in the valve cavity, suction pressure within the slide holds the valve in this position until the solenoid is de-energized.

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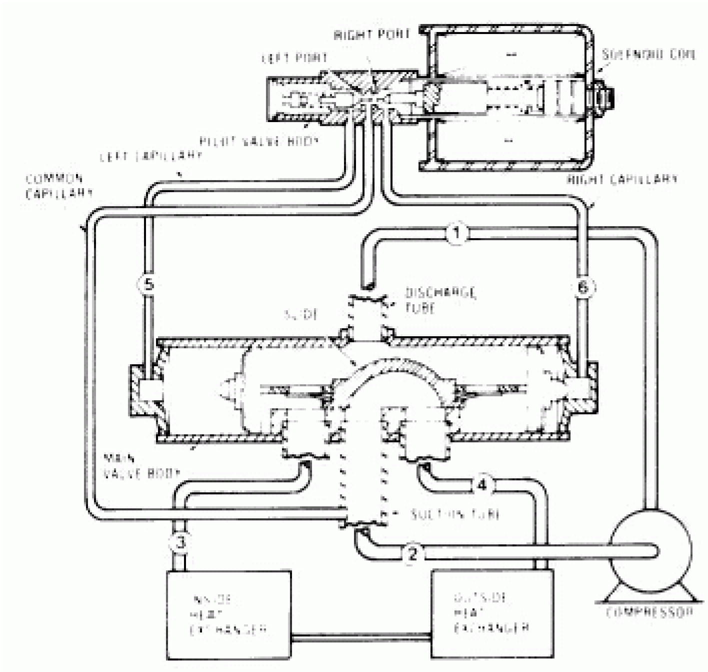

Figure 4

All of the reversal action detailed here takes place in a matter of 2 or 3 seconds in a normally operating system. The reversal is usually accompanied by an audible sw-o-o-sh, which is readily recognizable.

REVERSING VALVE PROBLEMS

Problems experienced with reversing valves fall into four general categories:

1. Valve will not shift from cooling to heating.
2. Valve will not shift from heating to cooling.
3. Valve starts to shift but does not complete reversal action.
4. Valve suffers apparent leak when shifting.

Failure of a valve to reverse properly does not necessarily mean that the valve is faulty. Often this failure may be caused by some other problem. So do not remove the valve from the system until you have checked the system thoroughly and are sure you have diagnosed the problem correctly. Be sure to find out what is making the valve malfunction before you consider replacing it. You'll save time and money.

Here are the necessary steps to follow in diagnosing the cause of a reversing valve malfunction. Perform each step systematically. Do not skip any of these steps because you think you know what the problem is. The true cause of the trouble isn't always apparent.

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INSPECT FOR PHYSICAL DAMAGE

This point is often overlooked on the assumption that since the valve had been functioning properly, damage could not be the cause of the failure. The truth is that a physically damaged valve, in conjunction with some other problem, can result in a malfunction.

Look closely for any dents or scratches on the valve. Inspect the capillaries for damage. A partially closed or blocked capillary tube and a dirty system can combine to cause a malfunction.

Inspect the valve to see if there is any evidence of overheating when the valve was installed. Torch flare marks, wide areas of burned paint, and heavy oxide scaling can give you a clue. These valves can withstand heat of 250°F during installation, but overheating can cause distortion of plastic parts within the valve which may result in a malfunction when certain other conditions exist.

CHECK ELECTRICAL SYSTEM

Make sure you have voltage to the solenoid coil at the proper time. This coil is only energized during certain modes of operation. We know of one case in which a service mechanic replaced a valve, only to find later that the real cause of the trouble was that the coil wire had been left disconnected inadvertently when a previous cooling problem was corrected.

With the coil in the energized mode, remove the nut holding the solenoid coil on the pilot valve. Slide the coil partly off the stem. If the coil and valve are operating, you'll hear a clicking or snapping sound when the plunger moves.

Another check to determine it the solenoid coil is energized is to remove it from the stem and insert the blade of a small screwdriver in the hole. The magnetic field created will exert a pull on the screwdriver. One caution, however: *Do not leave the coil off the stem while energized*; without the plunger in the magnetic field, the coil will overheat.

CHECK REFRIGERATION SYSTEM

If you have determined that the electrical system is operating correctly, check the refrigeration system carefully. This step is extremely important. Make certain that the refrigeration system is operating correctly and has the proper charge.

Check against the manufacturer's recommendations for the particular equipment involved, with pressure gauges connected and thermometers in place as necessary. An undercharge or overcharge of refrigerant can cause the reversing valve to malfunction. Undercharge is a frequent cause of valves failing to reverse. Adjust the charge as necessary, following the manufacturer's instructions.

If you have followed all of these procedures and everything checks out okay, then make the Touch Test on the reversing valve, following the chart in Figure 4A. This is a simple test made by feeling temperature relationships at certain recommended locations on the valve. Once you have determined the comparative temperatures, you can determine the possible cause of the malfunction and take corrective action.

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Touch Test Chart (Figure 4A)

VALVE OPERATING CONDITION	DISCHARGE TUBE from Compressor	SUCTION TUBE to Compressor	Tube to INSIDE COIL	Tube to OUTSIDE COIL	LEFT Pilot Capillary Tube	RIGHT Pilot Capillary Tube	NOTES: *Temperature of Valve Body. **Warmer than Valve Body.	
	1	2	3	4	5	6	**Possible Causes**	**Corrections**
NORMAL OPERATION OF VALVE								
Normal COOLING	Hot	Cool	Cool as (2)	Hot as (1)	*TVB	*TVB		
Normal HEATING	Hot	Cool	Hot as(1)	Cool as (2)	*TVB	*TVB		
MALFUNCTION OF VALVE								
	Check electrical circuit and coil						No voltage to coil.	Repair electrical circuit.
							Defective coil.	Replace coil.
	Check refrigeration charge						Low charge.	Repair leak, recharge system.
							Pressure differential too high.	Recheck system.
Valve will not shift from cool to heat	Hot	Cool	Cool as (2)	Hot as (1)	*TVB	Hot	Pilot valve okay. Dirt in one bleeder hole.	De energize solenoid, raise head pressure, reenergize solenoid to break dirt loose. If unsuccessful, remove valve, wash out. Check on air before installing. If no movement, replace valve, add strainer to

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								discharge tube, mount valve horizontally.
							Piston cup leak.	Stop unit. After pressures equalize, restart with solenoid energized. If valve shifts, reattempt with compressor running. If still no shift, replace valve.
	Hot	Cool	Cool as (2)	Hot as (1)	*TVB	*TVB	Clogged pilot tubes.	Raise head pressure, operate solenoid to free. If still no shift, replace valve.
	Hot	Cool	Cool as (2)	Hot as (1)	Hot	Hot	Both ports of pilot open (Back seat port did not close.)	Raise head pressure, operate solenoid to free partially clogged port. If still no shift, replace valve.
	Warm	Cool	Cool as (2)	Warm as (1)	*TVB	Warm	**Defective Compressor.**	
Start to shift but does not complete reversal	Hot	Warm	Warm	Hot	*TVB	Hot	Not enough pressure differential at start of stroke or not enough	Check unit for correct operating pressures and charge.

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							flow to maintain pressure differential.	Raise head pressure. If no shift, use valve with smaller ports.
							Body damage.	Replace Valve.

VALVE OPERATED SATISFACTORILY PRIOR TO COMPRESSOR MOTOR BURN OUT—caused by dirt and small greasy particles inside the valve. **To Correct**: Remove valve, thoroughly wash it out. Check on air before reinstalling or replace valve. Add strainer and filter dryer to discharge tube between valve and compressor.

Start to shift but does not complete reversal	Hot	Warm	Warm	Hot	Hot	Hot	Both parts of Pilot open.	Raise head pressure, operate solenoid. If no shift, replace valve.
							Body damage.	Replace Valve.
	Hot	Hot	Hot	Hot	*TVB	Hot	Valve hang up at mid-stroke. Pumping volume of compressor not sufficient to maintain reversal.	Raise head pressure, operate solenoid. If no shift, use valve with smaller parts
	Hot	Hot	Hot	Hot	Hot	Hot	Both parts of Pilot open.	Raise head pressure, operate solenoid. If no shift, replace valve.
Apparent leak in heating	Hot	Cool	Hot as (1)	Cool as (2)	*TVB	**WVB	Piston needle on end of slide leaking.	Operate valve several times than recheck. If excessive leak, replace valve.
	Hot	Cool	Hot	Cool as	**WVB	**WVB	Pilot needle	Operate

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			as (1)	(2)			and piston needle leaking.	valve several times then recheck. If excessive leak, replace valve.
	Hot	Cool	Hot as (1)	Cool as (2)	*TVB	*TVB	Pressure differential too high.	Stop unit. Will reverse during equalization period. Recheck system.
							Clogged Pilot tube.	Raise head pressure operate solenoid to free dirt. If still no shift, replace valve.
	Hot	Cool	Hot as (1)	Cool as (2)	Hot	*TVB	Dirt in bleeder hole.	Raise head pressure, operate solenoid. Remove valve and wash out. Check on air before re-installing. If no movement, replace valve. Add strainer to discharge tube. Mount valve horizontally.
Will not shift from heat to cool	Hot	Cool	Hot as (1)	Cool as (2)	Hot	*TVB	Piston cup leak.	Stop until, after pressures equalize, restart with

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								solenoid de-energized with compressor running. If it still will not reverse while running, replace valve.
	Hot	Cool	Hot as (1)	Cool as (2)	Hot	Hot	Defective Pilot.	Replace Valve.
	Warm	Cool	Warm as (1)	Cool as (2)	Warm	*TVB	Defective compressor.	

Before you can effectively use this method of troubleshooting, you need to be familiar with the temperatures around the reversing valve on a normally operating heat pump in both the cooling and heating phase.

With the heat pump operating in the cooling phase (Figure 1), you will find that the discharge tube (1) from the compressor is hot and the suction tube (2) to the compressor is cool. (It is important to understand that these two tubes will have the same comparative temperatures in both the cooling and heating phase.)

You'll also find that the tube (3) connected to the inside heat exchanger is cool, while the tube (4) connected to the outside heat exchanger is hot.

If a normal system is transferred to the heating phase, (Figure 2), the discharge tube (1) will still be hot and the suction tube (2) will still be cool. However, the tube (3) connected to the inside heat exchanger will now be hot, and the tube (4) connected to the outside heat exchanger will now be cool, just the reverse of the situation in the cooling phase. Rerouting of the gas flow causes the reversal of functions of the inside and outside heat exchangers.

The capillary tubes connecting the pilot valve to the main valve eventually will become the same temperature as the main valve body. Be sure to allow enough time for this to occur.

Inside the reversing valve, the compressor discharge gas, hot from compression, heats the discharge tube, the valve, and the tube to the inside heat exchanger. As the cool suction gas returns to the compressor, it cools the outside heat exchanger, the suction tube to the outside heat exchanger, and the suction tube leading back to the compressor.

Since the valve is in a static condition, the valve body and pilot valve capillary tube will approach the same temperature they had in the cooling phase.

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VALVE CHANGE-OUT

After completing the Touch Test you should know if the valve needs to be replaced. Before tackling the job, you should be aware that a reversing valve change-out is probably the toughest part of servicing a heat pump.

Here are some tips on proper procedures for removing the faulty valve.

Use an oxy-acetylene torch for unsoldering the connections. Other torches may not have the heat capacity to do the job with minimum time and temperature.

Removing the valve by using a tube cutter instead of unsoldering the joints usually means that you will have to fabricate new sections of refrigerant line. Never use a hacksaw under any conditions to cut tubing.

Be careful to protect the valve from excessive heat. Temperatures above 250°F are apt to damage internal parts. Wrapping a wet rag around the valve body while using the torch should do the trick.

Applying too little heat is also a problem. Not only will the soldered joints be difficult to separate, but also the buildup of heat over the longer period of time required will transfer to the valve body and possibly damage internal parts.

The joint should be separated in seconds, not minutes. Use enough heat to accomplish this, while relying on the wet rag to protect the valve body. And remember that the remelt temperature of any solder alloy is much higher than the initial soldering temperature.

Some old timers in the business like to apply silver solder flux to the outside of the joint to make the unsoldering easier. They claim it lowers the remelt temperature and helps prevent heat oxidation. It seems to work.

After removing the valve, inspect the lines to make sure they are round and do not have any large solder blobs, which would interfere with the mechanical fit of the new joints.

And, above all, keep dirt and moisture from entering the tubes.

Installing the new valve also requires certain precautions.

Be sure you have a replacement reversing valve with correct capacity for the heat pump system. Check it for shipping damage: dents, cracks, deep scratches, flattened tubing, poorly aligned solenoid coil.

Make sure the system is completely clean. If you have a choice of locations, choose one where the valve will be subjected to minimum vibration.

When changing the valve be sure to protect all tubes from entry of foreign matter, such as moisture, metal filings, dust or dirt. It takes only a tiny bit of scale, flux, lint, or the like to clog a pilot valve.

Use wet rags around the valve body and adjoining tubing to prevent overheating. Direct the flame of the torch away from the valve body.

Use low-temperature brazing rod as local code will permit, and use an inert gas to prevent oxide scale on the inside of the tubing.

Preferably use a phosphorus-bearing silver solder, which requires no external flux. The entrance of even a tiny bit of flux may be enough to damage the new valve.

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If you must use silver solder with externally applied flux, be sure the sections to be joined are bright and clean, and that you use the flux sparingly. This will do the job, but because this type of solder requires exceptional skill, most valve manufacturers are reluctant to recommend it.

The need for care in replacing reversing valves can't be stressed too strongly.

Connecting tubes, and often the valve body, are made of copper. Copper is an excellent conductor of heat, so you must take precautions to keep the valve body temperature from rising above 250°F; otherwise, the needle valves, piston seats, piston seals, and slide seat may be damaged from overheating.

Avoid rough handling of the valve during installation. This especially includes the use of vise-type pliers to manipulate the valve body while inserting the piping into the connection tubes. If the valve body or the capillaries are dented or flattened, the reversing action may be impaired or stopped completely.

After soldering is completed, inspect the joints, with a mirror if necessary, to make sure you have not left any voids or created any potential leaks. If the joints look good, pressurize the system with refrigerant to at least 100 psi and check for leaks.

If you find any leaks, dump the leak check charge, repair the leaks, pressurize the system again, and retest.

When all leaks have been repaired, triple evacuate the system with a good vacuum pump, charge the system fully, start it up, and check it out. Cycle the reversing valve a dozen times or so to make sure it is operating properly.

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