Air Conditioning Rebuild

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1976 Jaguar XJ-S

Background

The air conditioning has rarely worked on my 1976 XJ-S. It ceased cooling a year or so after I bought the car in 1981. Two or three years later I had the compressor replaced, but it soon quit again. In 1989 my shop said they could fix it. They began by replacing the expansion valve, a hose here and there, all the vacuum control lines under the dash, and the control amplifier at a cost of over $1100; it worked for a couple weeks. Then they diagnosed the problem as a leak in the evaporator, requiring another $600 labor plus an equal amount for a new evaporator. They also recommended replacement of the condenser, which wasa reported to be deteriorating and introducing debris into the system. I decided against any more repairs, but let them try a stop leak substance. That cost about $150 and did not help. The next nine years were with the windows open.

After starting to do my own maintenance in 1998, I decided to tackle the AC myself. First, I took it to a Jag shop with highly recommended AC capability to confirm that the evaporator was indeed leaking. The report was that there were no leaks in the system. This surprised me, but I accepted the report and had them charge the system. This cost $145, and worked for less than a month. I then decided I needed to take it somewhere with better leak detection capability. I found an AC supply house that provides local auto shops with AC parts and equipment and also runs its own service center. Having all the latest equipment on display, I thought surely they could find a leak if anyone could. Well, they too said it had no leaks and I was suckered again: recharge for $100 plus their $25 testing fee. Of course, it quickly failed. Then they put dye in the system and found leaks in the compressor and at the high-side hose joint (this was a clamp joint on my car). I declined their $1100 estimate to replace the compressor and hose and instead asked them to remove the R-12. I then began serious planning for fixing it myself.

At this point I was still uncertain if the evaporator was leaking, but I knew that the compressor and hoses had to be replaced. I was also very suspicious of the expansion valve because the dye-detected leaks were slow, and there were periods when the system cooled and other times when it did not. Moreover, I was still concerned about the condenser because of the observations of my shop. So I realized I was headed toward a total overhaul of the system. Strangely, I had come full circle—from thinking the evaporator was at fault to thinking it was the only component to remain! I have to admit that the tremendous effort required for evaporator replacement influenced this thinking a bit.

I also had a strong desire to get rid of the R-12 for reasons given below. This began to look even more attractive when I began thinking about having to replace nearly all components anyway.

R-12 or R-134a?

Although most current advice for older cars is to stay with R-12, I decided otherwise. For one thing, without reclaim equipment you cannot work with R-12. The second consideration is the expense. Most of the time when someone advises you to stay with the R-12 they argue that the high cost of the R-12 is not important since "you don’t really have to buy that much of it." But that has not been my experience. In m my ordeal, I paid for two complete recharges in a period of 2 months just trying to find out what was wrong with my system. The high cost per pound is exacerbated by the inability of most shops to simply "top up" a system suspected of being low on charge. This is because most AC technicians seem to be unwilling, for whatever reason, to charge the system except according to published amount of refrigerant for the car. That is, they will not use methods such as watching the sight glass for bubbles or measuring the air temperature off the evaporator. Such methods take a higher level of talent and more time, so the techs are trained not to use them. It also needs to be said that *there is no reliable way to measure the amount of refrigerant in the system*; they can only pump it down completely and provide a full charge according to the car specifications. Although equipment is available for measuring the R-12 removed from the system, it is more expensive and not owned by any shop I’ve talked to. They have only machines capable of measuring the R-12 *added* to the system. Consequently, they have no capability of anything short of a complete recharge at $30-40 per pound. So my advice to home mechanics is to get rid of the R-12 unless you are very confident that your problems will be solved with a single recharge. And who can be certain of that?

Parallel Flow Condensers

A major concern when switching to R-134a is the higher condensing pressures. Indeed, an often-cited reason for *not* switching is that the higher pressures (along with smaller molecule size) will cause leaks where there were none before. The common advice to combat this is to add another, electric fan. I’ve read that this has worked for many people, so I cannot argue against it. However, it should be recognized that the newer cars that have R-134a from the factory have condensers made with radically different technology than commonly used in R-12 designs. These new condensers are more like high efficiency radiators than the old condensers. Old condensers, for example in the Jaguar XJ-S, are a single flattened tube in a serpentine pattern back and forth from inlet to outlet. The space between the adjacent runs of this single tube are wide. In contrast, the newer condensers have smaller tubes that are closer together, offering significantly more heat transfer area. The designs are proprietary so we cannot be sure exactly what is inside them without cutting them open, but talked about are smaller tubes, sometimes even "micro passages" inside the tubes we see from the outside. Some designs, called *parallel flow* condensers, have a header at each end, with internal webs that guide the flow into a series of parallel passages from one side to the other. I have also read that the number of tubes allocated to each pass diminishes with each pass, taking advantage of the lower volume as the refrigerant condenses. So, while I cannot be sure, my judgement is that switching to one of these advanced condenser designs is a viable alternative to an added fan. It is especially attractive if you are contemplating replacing the condenser anyway, as I was.

My choice was a universal parallel flow condenser (12-0440C) from AAPAK in Phoenix, (602) 254-1116 http://www.acsource.com/. I later saw the same unit elsewhere and was told it was made by Four Seasons (unconfirmed). It is 12 inches by 26 1/2 inches, making it about right for the XJ-S. The height is a perfect match with the original. The width is somewhat smaller, but that leaves room for the plumbing. The frontal area is smaller than the stock condenser, but I estimate that the overall heat transfer area is perhaps 15-20% greater. There are twice as many tubes, for example. And the construction of the unit appears to be suburb; in comparison, it makes the stock unit look like pre-war technology.

Installing the Parallel Flow Condenser

You can see how I mounted the new condenser in my car in Figure 1. The inlet and outlet are on the same side, and I chose to put them at the right (left in the picture). Obviously, all the plumbing had to be redone (See Plumbing below).

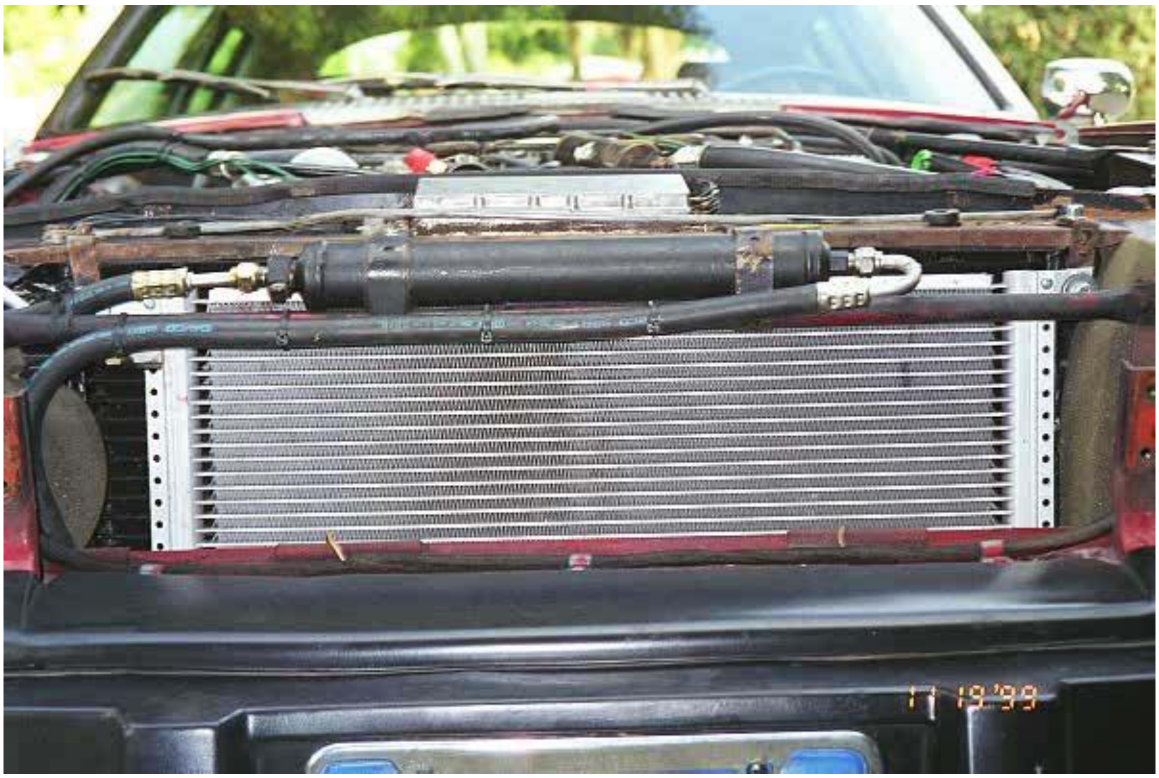

Figure 1. Parallel Flow Condenser installed in 1976 XJ-S.

The mounting relies heavily on the original design. I attached a flat strip of 1" by 1/8" aluminum alloy stock across the bottom of the condenser, fastening it to the mounting flange that is integral with the condenser headers. This strip provides a place for the register pins that secure the bottom of the condenser to the oil cooler, just like the original design. Figure 2 shows this detail at the left side of the condenser. The pins are fashioned from 10-24 "long nuts" used to join threaded stock, available from a local hardware store. Counter-sunk screws from the top of the strip hold the pins to the mounting strip. I filed the crown edges of the long nuts, rounding them a bit, to make them fit easily into the standard Jaguar rubber grommets. This allows the new condenser to register on the top of the oil cooler exactly like the original. You can also see in Figure 2 the angle bracket, made from 1/16" x ¾" x ¾" aluminum alloy angle stock, that secures bottom strip to the header flange. The angle bracket is held to the bottom strip by the same countersunk flat head screw that holds the register pin.

The bottom right side mounting, not shown, is a little different due to the condenser being offset. The angle bracket is longer, and attaches to the bottom strip with an additional flat head screw. A minor but important point: this screw has to go in from the bottom of the strip, countersunk, so as not to interfere with the oil cooler. I tried it the other way at first and had to rework it.

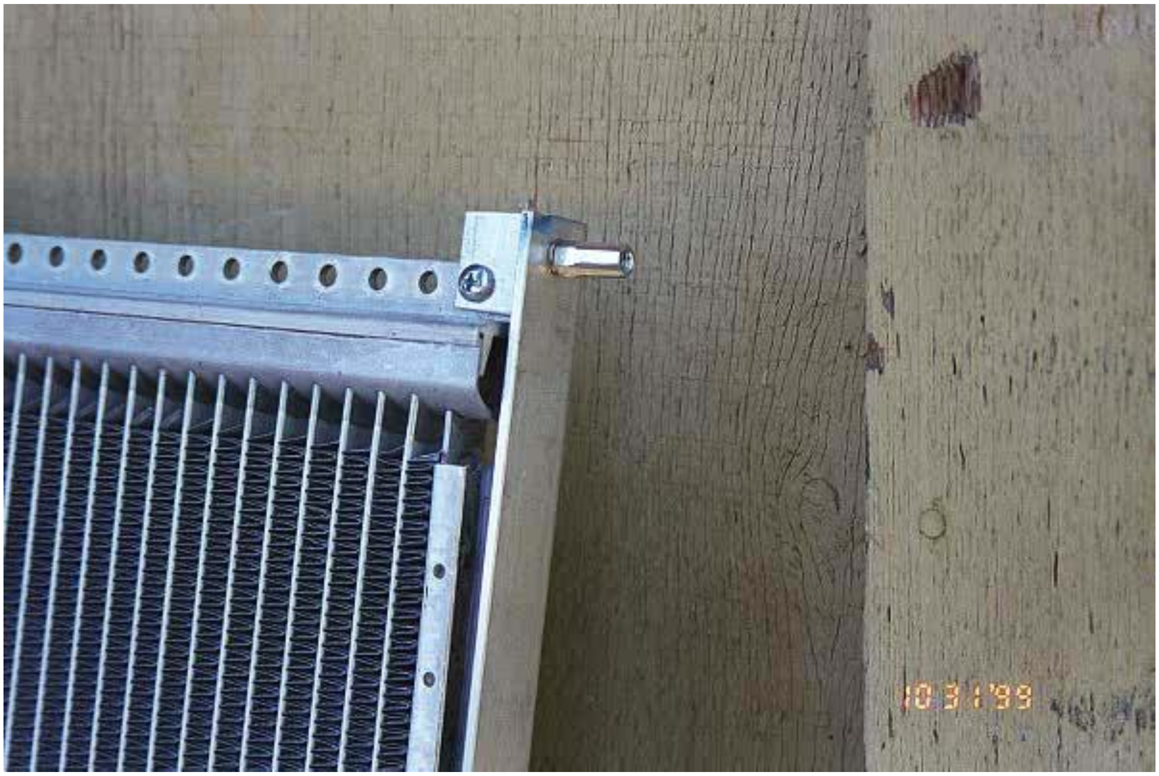

Figure 2. Bottom mounting strip with register pins.

The top mounting employs the angle brackets that held the original condenser at the top. The unmodified left side bracket was attached to a tab fabricated from the 1" x 1/8" aluminum strip stock and screwed to the condenser mounting flange, Figure 3. I fashioned a grommet of sorts with a rubber washer on each side and a very short length of plastic tubing around the screw as it passes through the mounting tab.

Figure 3. Left top mounting bracket attached to mounting tab.

The top right mounting offered a greater challenge since, due to the offset of the condenser to the left of the vehicle, the condenser mounting flange is several inches inboard from where the stock mounting bracket attaches to the radiator cross bar. The detail can be seen in Figure 4.

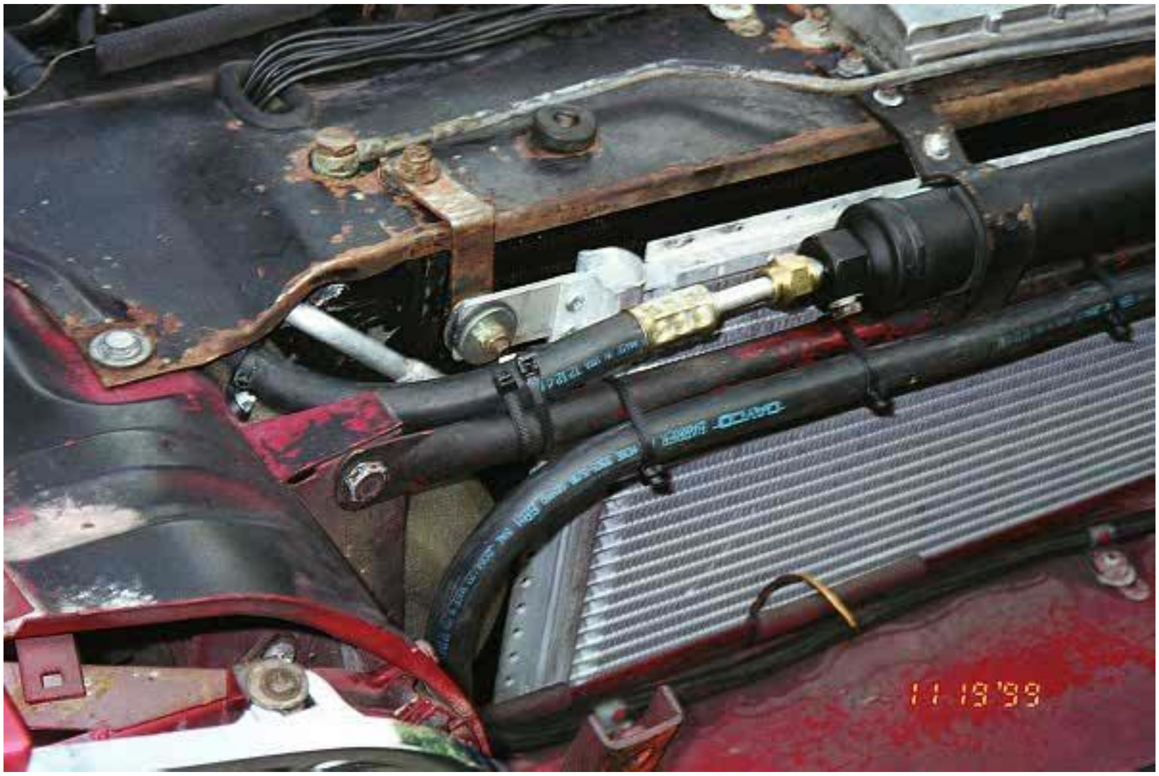

Figure 4. Right top mounting.

First, the mounting tab had to be somewhat longer, as can be seen in the picture. Moreover, in order to allow good access to the refrigerant inlet hose fitting, the bottom of the tab has to be notched, reducing the width of the tab by an 1/8" or so up to the header flange. (You can't use narrower stock because it has to be at least an inch in order to allow attachment to the header flange with two screws.) Then, the stock angle bracket for attachment to the radiator top rail had to be modified significantly. I first straightened it in a vice and pounded it flat with a hammer. Then I rebent it at an angle that would bring it to a point where it could mate with the mounting tab on the condenser. Actually, it took several tries of straightening and rebending, but fortunately it is quite malleable, so it wasn't as difficult as it sounds. Then I had to cut off about an inch of its length and drill a new hole. As can be seen, it worked out quite well. But this is not something you would want to pay your mechanic $65 per hour to do!

Some other notes. I got all of the aluminum stock from a local metal supplier who sells scraps like this by the pound— really cheap. I did all the fabrication in my garage with nothing more than a ¼" hand drill, a saber saw, and a file. I have sketches of the fabricated parts. If there is sufficient interest, I'll clean them up a bit and post them here. Meanwhile, the critical dimensions are as follows. The bottom strip is 1/8" x 1" x 28 ½". The register pin screws (#10 screw clearance) are positioned on center and 3/8" from each end. The spacing of the register pins is thus 27 ¾". Unless you have a good machine shop in which to work, and are used to precision layout, drilling, and cutting, the angle brackets and mounting tabs should be cut and drilled to measure, working directly to hole patterns on the condenser header flanges. I used #8 fine screws with locknuts for attaching to the condenser header flanges, and #10 screws for attaching the bottom strip.

One final note. As you can see in Figure 4, there is about 3-4" of space at the right side (left in picture) of the condenser. It should not be blocked because there is radiator frontal area behind it. On the other hand, common wisdom is that we should carefully seal the space around the condenser, oil cooler, and radiator to keep the air going where it is supposed to go. The worry here is that the condenser air, or at least some of it, will take the easy path, rolling off the face of the condenser rather than trying to push through all those fins.

So what should be done here? I is my thought that ideally the air that strikes the condenser should go through the condenser (and thence the radiator), while that striking the radiator should go through it. One way to encourage this here would be to attach an air dam at the right side of the condenser, perhaps fashioned from sheet metal and attached to the condenser header flange. This would tend to keep air from rolling off the edge of the condenser. However, I resolved not to solve non-existent problems and left it alone. If I later have reason to believe I'm not getting good air flow through the condenser I'll reconsider the air dam idea.

Plumbing

Unlike the stock unit, the universal parallel flow condenser has both inlet and outlet fittings at the same end. Additionally, it does not have extension tubes extending to connection points for the inlet hose and the receiver/dryer like the stock unit does. This means that that the plumbing has to be entirely reworked. This did not bother me too much, as I wanted to replace all hoses and lines anyway, and moreover did not particularly like the original plumbing layout. For example, the inlet line on the original condenser made it necessary to remove the radiator top rail to remove the condenser. This is no longer necessary with my new plumbing.

You can see some of the new plumbing in Figure 1. The inlet is at the top, obscured somewhat by the hose from the outlet at the bottom to the receiver/dryer. After first trying to fit a vertical style unit at the right of the condenser, I chose to use the original style horizontal receiver/dryer mounted in the original position. This allows for easier access without removal of the bonnet, and does not block air flow to the radiator or condenser.

At first, my plan was to have hard lines custom made for all connections in front of the radiator. These lines were to connect the condenser outlet to the receiver/dryer, and bring connections from both the receiver/dryer and condenser inlet to the same points where the stock condenser and fittings connect to engine bay hoses. I took careful measurements and did sketches for these lines, but was unsuccessful in finding a shop that would make them. After several days of calling around my own area as well, as around the country, I found a local shop that said they would do it. However, in the end the shop convinced me that we would both be better off if I brought the car to him and let him "cut to fit." There is just too much risk of an error for people not used to working from drawings.

Additionally, as you can see in Figure 1, he talked me into more hoses than I would have liked. These guys love hoses! They use standard fittings wherever possible, and when that won't work they cut up these fittings and weld them back together to get the wanted shape. You can see some of this in the U-fitting seen in Figure 1, which was made by welding two right angle fittings. In Figure 4 you can see a bit of the fitting that attaches to the condenser inlet. He fashioned this by welding a length of tubing between a straight fitting (at the condenser inlet) and a hose barb. My guess is he would have used hose all the way if it had not been for the limited space going under the radiator rail. I had to look quite a while before finding a shop that would work with me at all, so I went along with it, but frankly my design would have looked neater!

Originally, the 1976 XJ-S AC system used flange style fittings throughout, while newer systems use the O-ring style. I decided to go with O-ring fittings everywhere possible, since this is what my new condenser uses, as does the receiver dryer. The only place where I could not do this was at the evaporator, the only thing that remains of my original system, and the expansion valve since it attaches tot he evaporator. Additionally, I decided to avoid all hose clamps, using crimped fittings everywhere. This meant that my AC shop had to weld (braze, solder? Don't know.) new hose barbs to the muffler at the compressor outlet and the fuel cooler so he could crimp hoses to them. Actually, I would have had to fight him if I wanted otherwise, since this seems to be standard practice today.

Originally, I had planned to have the line from the receiver/dryer to the expansion valve run along the chassis, as it normally does. (I have an aversion to unnecessarily changing things least my Jaguar gradually mutate into some lessor creature.) Naturally, my AC shop approached this without enthusiasm, but did as I asked. He attached new hose from the short hose section in the original line to the fabricated line connecting to the receiver/dryer. He later called to tell me the effort failed, as the fitting at the end of the line connecting to the expansion valve was leaking. He was pleased that I let him proceed, as he wanted to in the first place, using hose all the way. He managed to run it along the wing brace so it doesn't look too bad.

Ternary Switch Solenoid

The original, early XJ-S has no provision for over pressure protection other than the relief valve in the compressor. Current regulations require an overpressure switch of some kind. Although one can be fitted in the A-6 compressor, I decided to combine this need with a recommendation from fellow XJ-S owner and mechanic Walt Acker to control the auxiliary fan off of condenser pressure. To this end, I had the AC shop install service port and a ternary switch (#211-176), Figure 5. This switch has two sets of connections, each of which is a pressure-activated switch. One opens under conditions of over pressure or under pressure and is to be connected in series the compressor clutch power. The other controls the fan, coming on when condenser pressure rises above some preset level. (I had these settings written down but lost the file!) The fan control hookup will eventually be discussed in a separate document. The basic idea is simple---instead of taking the power directly from the "AC-on" 12 volts, run it through the other switch in the 211-176 device before going to the fan control relay coil. The fan then will come on only when road spead plus the mechanical fan is insufficient to cool the condenser.

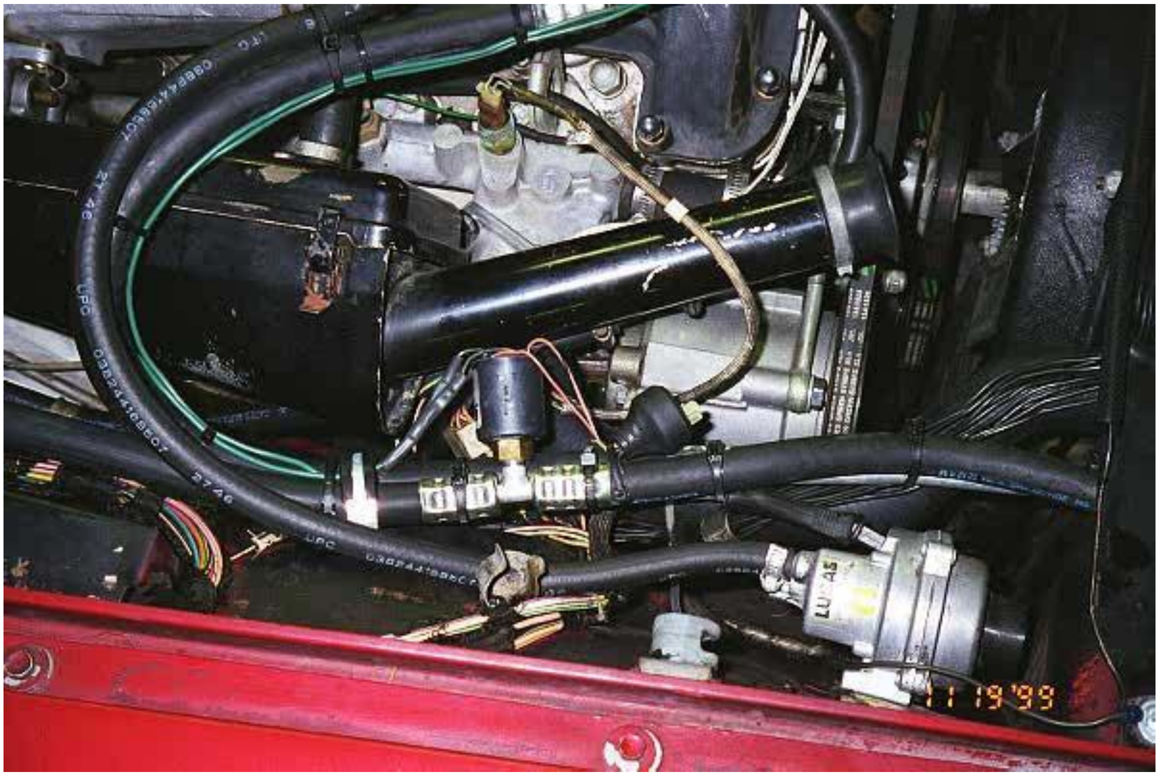

Figure 5. Overpressure solenoid.

Expansion Valve

The expansion valve was high on my list of suspected causes of nonoperation. Even after I had confirmed leaks in the system, they were slow and I should have been getting better performance than I was most of the time. I used to look at the expansion valve often, and frequently saw that it would frost up on start up, but the frost would soon melt away. Moreover, since they are not expensive I would be foolish not to replace it.

Removal of the expansion valve can be difficult. I had read that the connections tend to be very tight, and if the evaporator side of the fitting is not properly restrained one can break the pipe where it is joined to the evaporator. Indeed, I had worried for years that this had already happened and was the cause of all my problems. So, still hopeful that it was not broken, I was anxious to not break it now. As can be seen in Figure 6, space is extremely tight. What worked for me was a crow-foot wrench and a water pump pliers. I used the former on the fitting nuts and the latter to restrain the fitting. Perhaps because it had been installed only about 10 years earlier, it came off without too much difficulty. As far as I can tell, it’s not broken.

Some parts stores tell you that R-134a expansion valves are the same as for R-12. Nonetheless, AAPAK (Phoenix) sells valves with R-134a stamped on the body, so somebody must think otherwise. I believe that these valves should be sized a little differently, as the properties are a little different. On the other hand, we all know that many people have successfully moved to R-134a without changing the expansion valve, so the difference is probably slight. I feel more comfortable knowing that I have the "right" one in there.

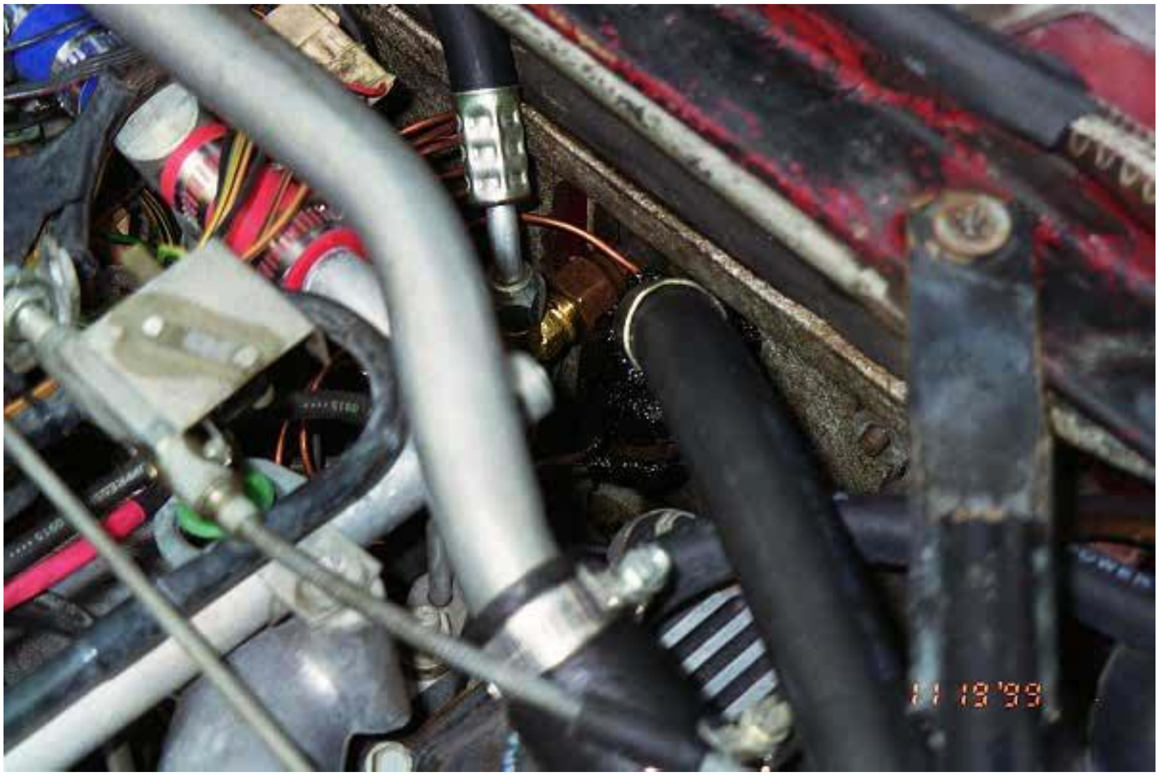

Figure 6. New expansion valve in place (center).

Compressor

My compressor was leaking at the body joint near the aft end, so it had to be replaced. After extensive enquiry, I got a APCO rebuilt one at AAPAK for $105. I know that many shops avoid rebuilts on grounds like "they are noisy" or "they throw oil." However, I decided that once I got rid of the R-12 replacing a bad compressor should not be that big of a problem. New ones cost 2-3 times that much. So far, I have had no problems.

Removing the compressor was easy, following the directions in the XJ-S Repair and Operations Manual (ROM). Once removed, I could not resist the temptation to clean out under there, and that led me to removing the rear mounting bracket so I could clean under it. The only problem was getting it back on. The bolt holes are oversize, leaving room for adjustment so the space between the rear and front brackets is exactly the same as the length of the compressor. Unfortunately, you cannot get a wrench on the bolts when the compressor is in place, so its hard to get it right. I had make several passes at positioning the bracket, tightening the bolts, and lifting the compressor into place to check the fit before getting it right. I should have scribed a mark on the engine block before removing it.

By the way, before I installed the compressor, I poured the prescribed amount of the oil into it and bolted a cover plate over the ports. Even then, I was sure that the clutch was not connected while driving it to the shop for recharging. You don’t want the new compressor spinning without lubrication.

On thing that was really foolish was to disconnect the hose from the compressor outlet, then drive the car without disconnecting the clutch. My engine bay was thoroughly covered with oil from the refrigerant. I was able to clean it up pretty well except for the bonnet insulation, which is still soaked.

Flushing

A good R-134a conversion must include thorough flushing of the systems. A tip at www.airconditioning.com is to use brake cleaner to flush the AC system. Not only is it cheaper than the special purpose flushing fluid, but it is available is smaller quantity, in pressurized cans. The real stuff comes in gallon cans for over $100, whereas a couple cans of brake cleaner is about $7.00.

The technique I settle on was to work the system a piece at a time, e.g., the muffler, the fuel cooler, and the evaporator. Just aim the brake cleaner spray nozzle into one end of the passageway to be cleaned and let it blast until it starts running out the other end. Then, use compressed air to blow it out. I did this 2-3 times on each piece.

Actually, I did not flush my evaporator; the shop doing the hoses and charging offered to do it for nothing, so I let them. However, I had already figured out how to do it myself without too much mess. The idea is to attach hoses to both evaporator connections to bring the mess out of the engine bay where you can introduce the fluid and collect it without drenching sensitive parts of your engine with the dirty brake cleaner. To attach to the evaporator inlet I drilled out the old expansion valve. For the outlet, I got a right angle fitting from the AC parts store. To these I planned to attach common clear plastic tubing. Would have worked, I'm sure.

Evacuation, Hookup and Charging

My original plan was to do everything myself. I spent a lot of time thinking about how I was going to evacuate and charge the system, and even bought gauges and several cans of R-134a. The fly in the ointment was system evacuation. This is essential, and has to be done right or you will not get proper cooling.

The standard advice is to use an old refrigerator compressor as a vacuum pump. However, I simply could not find one after three days on the telephone and trying to find junk yards. In our area, they are no longer listed in the Yellow Pages, if they exist at all. They are called recycling centers, and don't want scavengers interfering with high volume processing of bulk materials. The best I could do would have been to buy a whole refrigerator and yank it out my self. Had I taken this course, I would have had to begin by renting a truck. And then, I would have had to acquire a decent torch and learn how to solder, to say nothing about tracking down fittings etc.

I finally decided the best thing to do was to go to a shop for the charging the system. I'm not sorry, because the same shop that made up my hoses was able to do a good job of buttoning up the system, leak checking, and charging much better than I would have been able to do myself. As it turned out, they installed the expansion valve, new hoses, and recharged and leak-checked the system for about $200. They did an excellent job. So, the only down side was the time wasted. The gauges may come in handy some day—who knows.

Controls

The controls were in pretty good shape, probably because of work done several years earlier. For example, the amplifier and all of the "spaghetti tubes" under the dash were replaced.

However, there were two problems. One was the temperature adjustment control, which could not be turned except with great force. This turned out to be the result of a faulty radio/tape deck installation (of all things!), years earlier. The technician had, for unknown reasons, removed the temperature setting pot mounting bracket and replaced it using an over-sized screw. This caused the bracket to be distorted and to bind the pot shaft. Unfortunately, I had to remove the console and a lot of other stuff to get at it to fix it.

The other problem was inoperative recirculation air flaps. In addition, there was a mysterious repositioning of various flaps and things upon acceleration. It turned out that both were the result of a severed spaghetti tube behind the instrument cluster. Apparently, it was positioned incorrectly and such that the instrument cluster pinched and eventually severed it. I traced it by methodically following the diagnostic tests in the ROM. These were hard to follow at first, but once I learned the layout of the table it worked very well, leading me right to the bad line.

Results

I am very pleased with the outcome of the project. For the first time since I've owned the car the AC actually works! I set it at 75 degrees and forget about it. Of course, this all came about well after summer was over, so the real test will come in June or July, but all present indication are that it works perfectly. Blows very cold, heats when it's supposed to, the whole enchilada!