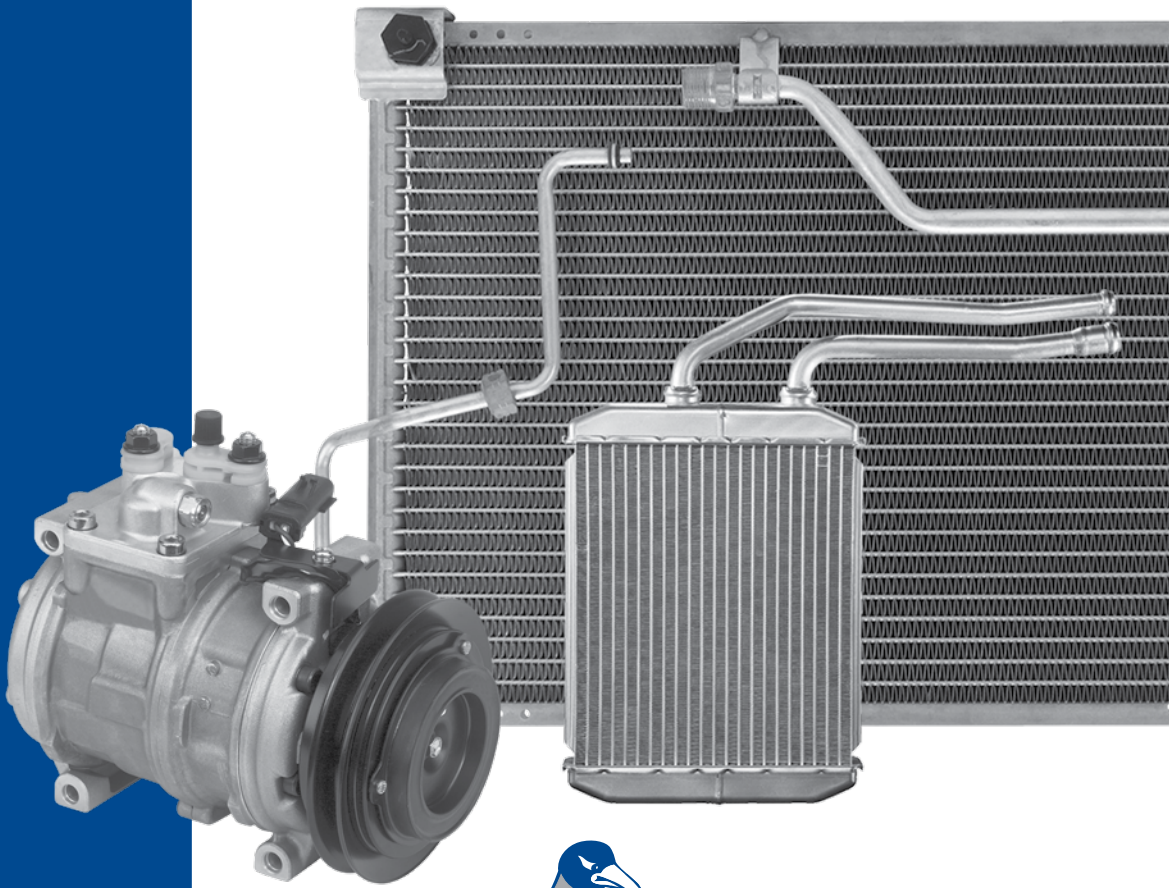
SPECTRA PREMIUM

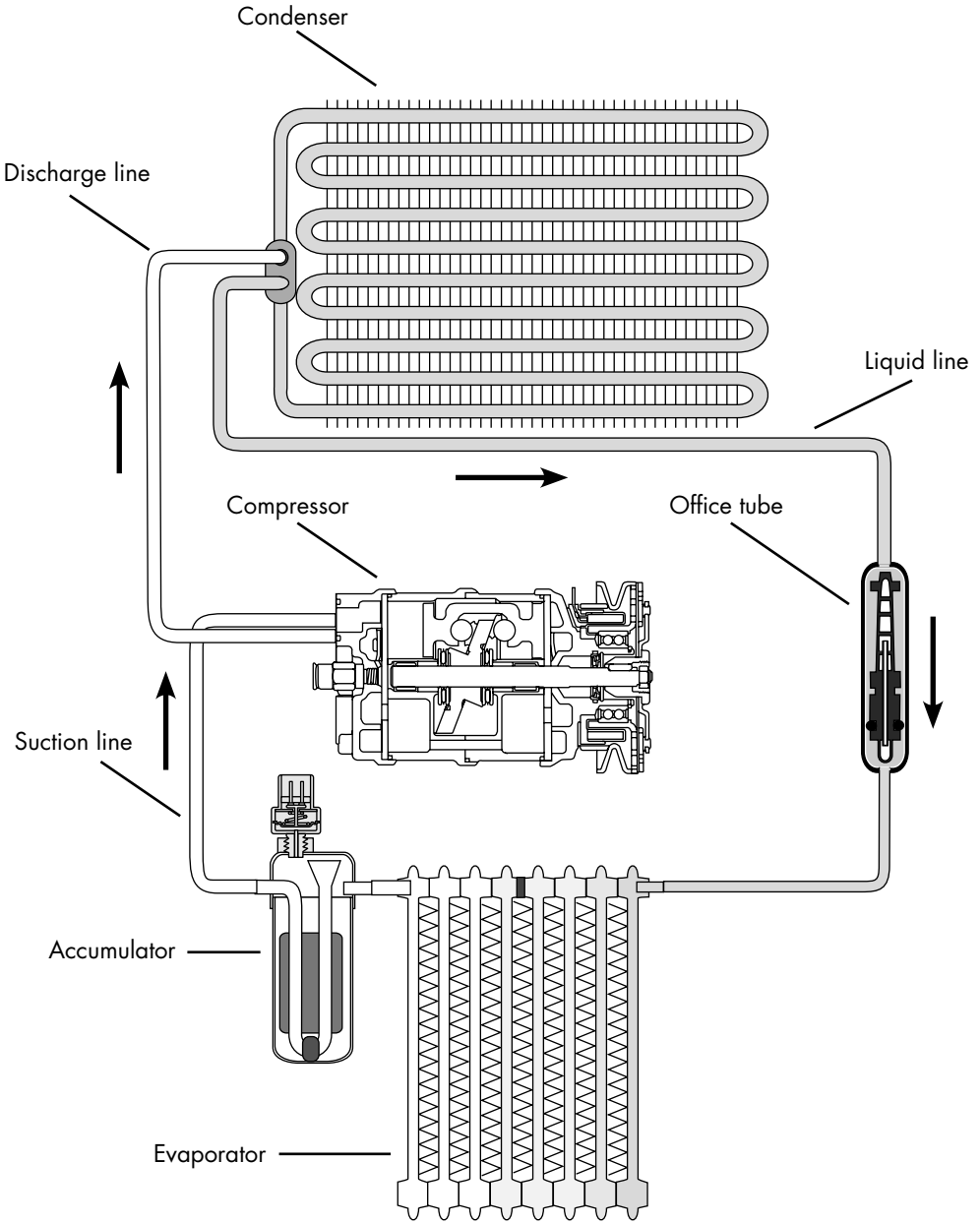
AUTOMOTIVE A/C

Tech Tip Guide



CertiCool

A Certified Climate Control Product By Spectra Premium Industries Inc.


Condenser
Discharge line
Liquid line
Compressor
Office tube
Suction line
Accumulator
Evaporator

QUICK DIAGNOSIS

1. Turn on the A/C system using the Dash controls.

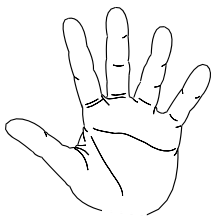
2. See if the clutch engages. If not, try the Defrost position. If the defrost turns on the compressor the A/C switch is defective.

3. If the compressor does not engage, put the gauges on the correct fittings and check for pressure. The standing (non operating) pressures must conform to the temp/press chart. Remember that the engine temperature will cause the standing pressures to be higher. There must be 4Opsi of standing pressure in most vehicles to start the compressor. If not go directly to Leak Checking. If there is lots of pressure and the compressor does not engage there is an electronic or wiring problem. You can 'hot wire' the compressor to test the AC system independent of the normal controls.

4. With the engine warmed up and running and A/C working feel the hoses and components. The Discharge hose should be HOT, the Liquid line should be WARM ,the Suction Line should be COLD and the Compressor body should be WARM. If any variation from these temperatures is found, a problem is indicated.

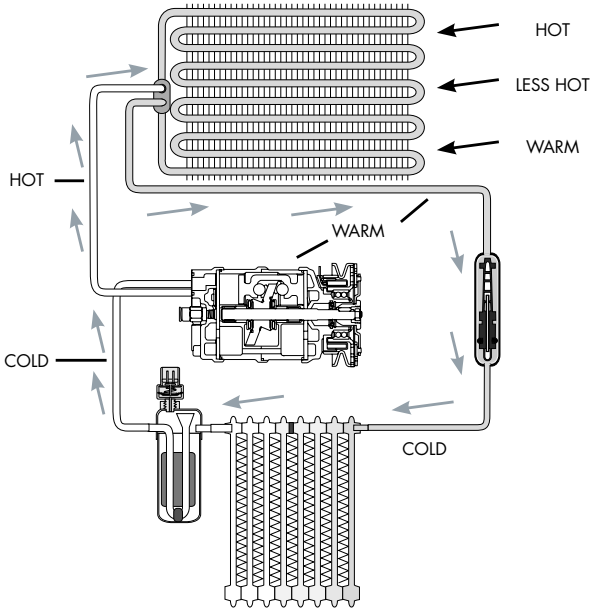
NORMAL LINE TEMPERATURES (on a Hot Summer Day (85F, 33C)

DISCHARGE:	HOT (60C,140F, OR HOT ENOUGH TO TOUCH BUT NOT HOLD)
LIQUID:	WARM (48C,120F)
SUCTION:	COLD (8 to10C, 45 to 50F)
COMPRESSOR:	WARM (60C,140F or a little less hot than Valve cover)

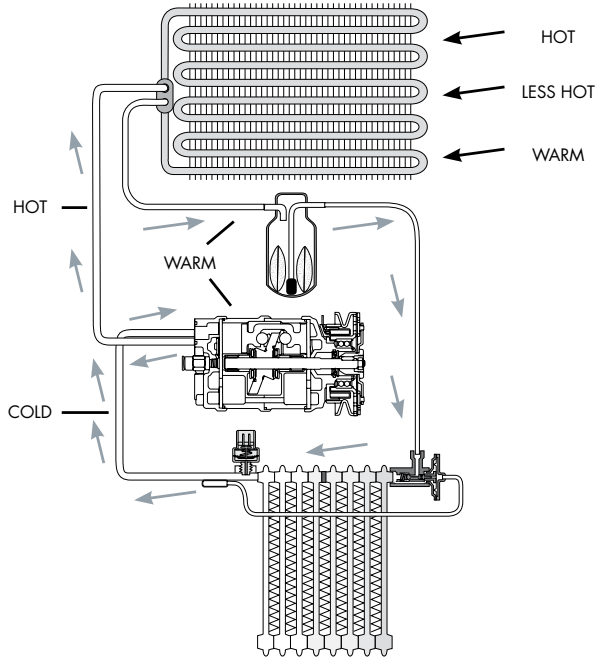


ABNORMAL LINE TEMPERATURES

<u>DISCHARGE LINE</u>	
Extremely Hot	Restriction in the line or high in the condenser
Very Hot	Overcharged, condenser not losing enough heat, air in the system
Warm	Low on Refrigerant (leak), Worn out Compressor
<u>LIQUID LINE</u>	
Hot	Condenser not losing enough heat, air in the system, overcharged
Cold	Restriction in the system (Normal if the orifice tube is in the condenser)
<u>SUCTION LINE</u>	
Warm	Low on refrigerant, compressor not sucking, blocked TXV or OT
Cool	Worn out compressor, TXV stuck open
<u>COMPRESSOR BODY</u>	
Extremely Hot (burns your hand)	Restriction in the discharge line or high in the condenser
Very Hot	Low on oil
Cool	Too much oil or refrigerant



ORIFICE TUBE SYSTEM



THERMAL EXPANSION VALVE SYSTEM

DETAILED DIAGNOSIS

1. Connect the gauges to the system using the correct shutoff valves.
2. Check the standing pressures. They should correspond to the charts, if too low, there is leak, too high, may have air in the system.
3. Start the engine, set to high idle (1200 rpm) and warm up the engine. Wait for the thermostat to open.
4. Start the A/C system, and check the pressures to the correct chart for the system.
5. If the gauges do not move when the compressor engages or if only one gauge moves, it is probably due to the valves or adaptors not opening properly.

Watch the gauges for correct performance, and check the results to the Normal readings, then see the diagnosis diagram on the next page.
Note that the Temperature dial is inside the Pressure dial

Example: If the evaporator is at 35PSI, the air temperature is 38F

Example: if the system is shut off and temperature is 70F (21C), system pressure would be 74PSI

NORMAL OPERATING PRESSURES : FAN RUNNING, R134A, HUMIDITY 50%
High side pressure should always be twice the ambient temperature in Fahrenheit degrees + 10-20 psi. E.G.: if outside temperature is 80 F (27 C), high side should be 160-180 psi. Add 10psi more pressure for every 10% of humidity over 50%.

This does not apply to variable displacement systems, whose high sides will vary with cooling load. In that case, the high side pressure on start-up should conform to the above formula, but after cool down, the high side can be ignored providing the following exists:
1. low side normal pressure, inside air cold
2. all lines correct temperatures
3. high side not over 300 psi.

Normal low side pressures

TXV Systems
Low side 15-30 psi
(Cycling)

Orifice Tube Systems
Low side 22-46 psi
(Cycling)

Variable Displacement systems
Low side 28-35 psi
(Steady)

EPR systems
evap 31 psi (Steady)
Suction 14-28 psi

PRESSURES TOO HIGH

HIGH SIDE

A. air flow through the condenser; check gaps around the condenser, folded over fins
B. check fan clutch or electric fan operation and check for correct rotation.
C. Also check fan shroud for leaks or gaps.
D Radiator not cooling, or touching condenser, transferring heat into A/C system
E. If recently serviced, may be overcharged or have air in the system
F. Blockage in the top of the condenser or in the discharge muffler; after the gauge port
G: Big Transmission cooler attached to the condenser
H: Missing or bypassing Orifice Tube

LOW SIDE

T. Orifice tube or TXV not installed correctly, or stock open, allowing excess refrigerant into the low side
V. Blockage in the suction line after the gauge port, not allowing the compressor to suck down the low side.
L. Compressor not pumping properly
E. Air in the system
S. EPR stuck open (if equipped)
PS/TS. Cycling switch (pressure or thermal) turning compressor off too soon

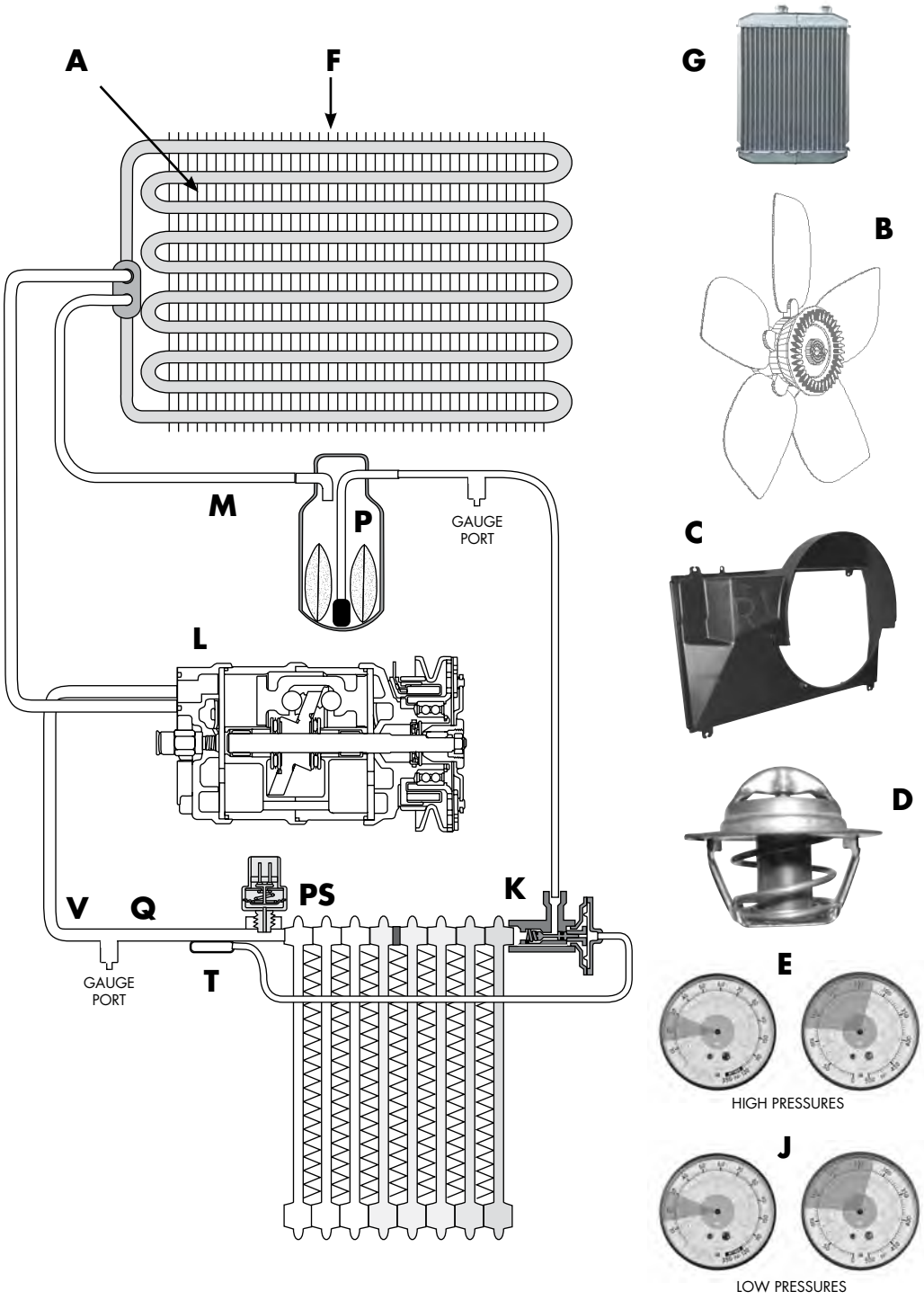
PRESSURES TOO LOW

HIGH SIDE

J. Low on refrigerant, most likely due to a leak
K. Restriction in the system, most likely a plugged orifice tube or TXV, putting all the refrigerant in the condenser and dryer
L. Compressor not pumping properly
M. Blockage before the gauge port

LOW SIDE

J. Low on refrigerant
P. Restriction in the system, plugged Orifice tube or TXV or Receiver Dryer
Q. Restricted Suction line before the gauge port
R. EPR stuck closed (if equipped)
PS/TS. Cycling switch (pressure or thermal) keeping compressor on too long


A
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HIGH PRESSURES
J
LOW PRESSURES

HIGH SIDE PRESSURES:

Beware of high side pressure readings that are taken on a liquid line. The true high side pressure is the Discharge coming out of the compressor. But some manufacturers put the fitting for the service hose on the liquid line or dryer. That's after the condenser. So if the condenser gets clogged up, the pressure rises in the discharge line and falls in the liquid line. Put your hand on the discharge line or shoot an infra-red temp reading in this case to make sure the discharge pressure is OK. Volvo doesn't even put a high side fitting on some of their cars because they (rightfully) expect the tech to check line temperatures on the high side. That is a more thorough way to check it anyway.

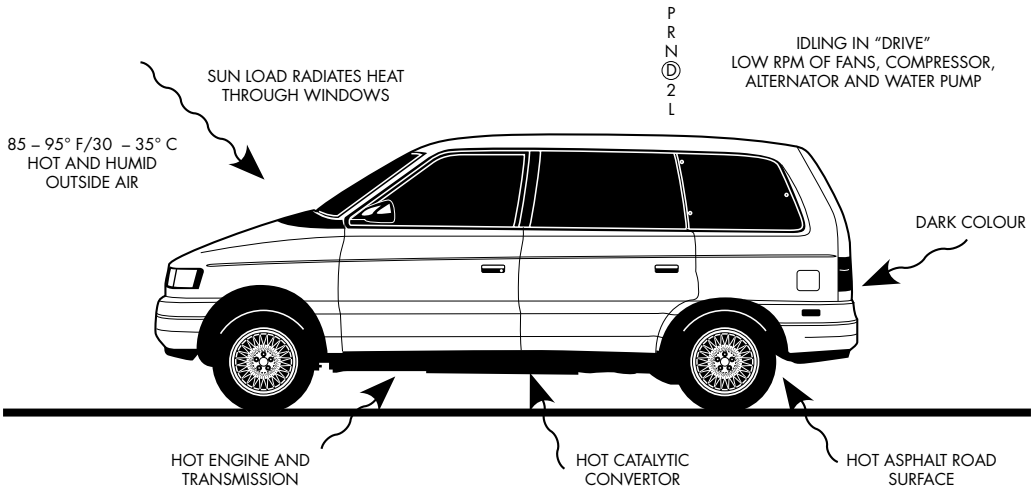
Always make sure that the high side pressure is correct before finishing an A/C job. The high side should be only two times the ambient temperature in Degrees F. (+ 20psi) with the engine fully warmed up and the fan on. (any refrigerant) When the vehicle leaves the shop, the high side pressures will only go up.

Why? The customer will put the A/C system through more punishment than you can in the shop. Always repair the system to that when the customer needs it the most, it will work properly. That is when the vehicle is stuck in traffic on a hot, humid day!

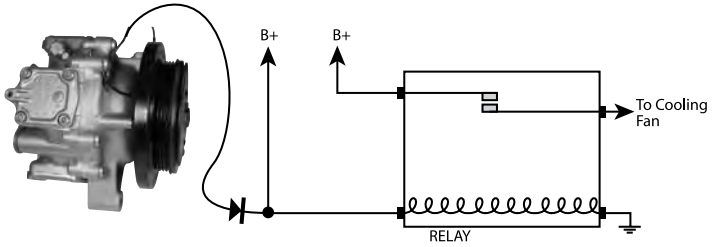
The electric fans should come on when the compressor is running, but on more expensive cars, this does not happen due to the noise the fans make. The pressure controls on the electric fans can be somewhat unreliable, so if the vehicle appears to have some repairs that were due to excess pressure, check the fan function carefully.

In order to make the fans come on with the compressor, make a circuit as shown.
When working on a vehicle with electric fans, always check the condition of the battery and charging system. A shorted cell in a battery can destroy your AC job. If the system voltage drops below 12v, the fans will not turn fast enough to prevent high side pressures from rising. Coupled with less magnetic force holding the clutch, slippage may begin to occur and there goes your compressor!

CUSTOMER STUCK IN TRAFFIC IN JULY



TYING THE COMPRESSOR TO THE COOLING FAN



TO MAKE THE ELECTRIC FAN COME ON WITH COMPRESSOR, ADD A WIRE SPLICED FROM COMPRESSOR CLUTCH FEED TO HOT SIDE OF FAN RELAY COIL.

SOLDER AND SHRINKWRAP A SIMPLE DIODE IN LINE SO THAT IF THE FAN COMES ON FROM THE RAD TEMP SENDER, IT WILL NOT TURN ON THE COMPRESSOR ALSO.

LEAK CHECKING

When standing or operating pressures are too low, there may be a leak. Leaks must be checked by at least three methods. Note that any one of these methods indicates a leak.

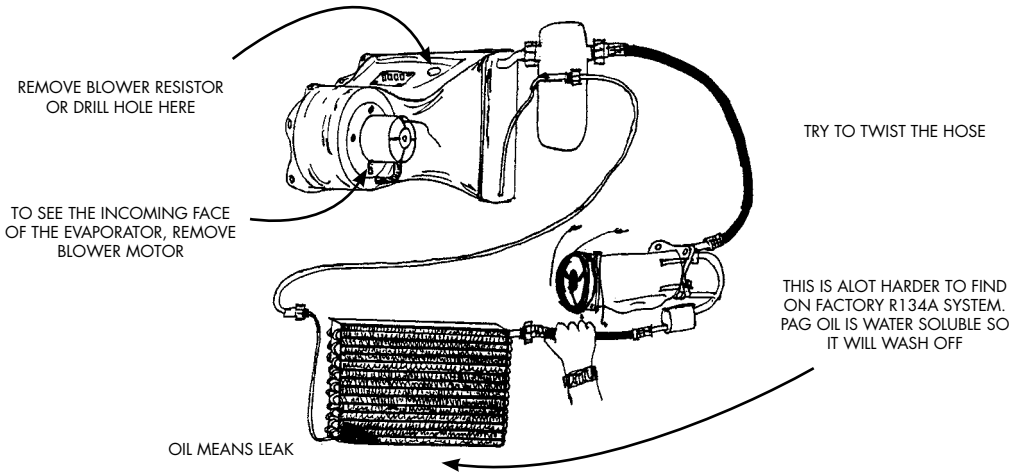
1. CHECK FOR OIL STAINS OR DYE

This is a positive indication of a leak. The oil stain or Dye is from a leak which has let oil out from the inside of the system. Check the cap of the service port with the black light to see if the vehicle has dye. Most vehicles built from 1999 have already got dye installed at the factory

Evaporators: Remove the blower or the blower speed resistors to get a view of the evaporator face on the incoming side. Any indication of oil means a leak. If it is difficult to see the evaporator, drill a hole ,VERY CAREFULLY, in the case to get a view of the evaporator face and silicone a plug into the hole when finished. Keep some plugs from new A/C parts for this purpose. Try to look at the evaporator drain, any faint indication of dye indicates a leak.

2. TWIST THE HOSES

If the flexible section twists where it is crimped to the aluminum or steel section, the hose has loosened and needs recrimping or replacement. Be sure to check underneath vans with rear air as these lines rot frequently. Manipulate where metal tubing is clamped to the body. The dissimilar metals cause local corrosion.



3. PRESSURE AND VACUUM

After recovering the refrigerant, fill the system with Nitrogen through the low side fitting to 200 PSI. Spray soapy water over the system and look for bubbles. Use some glycerin mixed with the soap to make the bubbles grow or use the 'Locator' soap solution. The nitrogen can be discharged into the atmosphere. Then use the Electronic Leak Detector. (see below) Discharge the Nitrogen right away after testing as you may forget and it will blow up in your face when you try to disconnect components for replacement.

After repairs are completed, evacuate to 29.5" vacuum using a vacuum thermistor gauge, and check to see that the system holds for 5 minutes with no drop. If it does, re-examine the system for leaks

A sensitive microphone and earphone set is available to examine the system for slight hissing when under pressure but it is hard to hear in a noisy shop.

4. ELECTRONIC LEAK DETECTOR

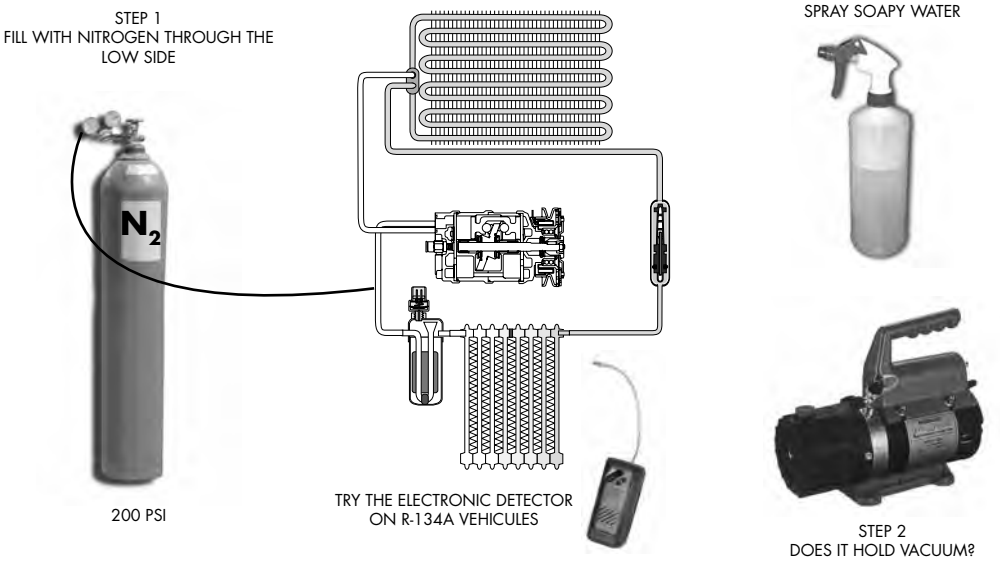
Although this is recommended in most shop manuals, it is difficult to use an electronic leak detector, because it is so sensitive, it seems to indicate a leak everywhere when refrigerant has escaped in the engine bay. This tool is best used after repairs are completed and the system has been refilled and allowed to warm up. That allows the high side to get hot and the low side to get cold and the components to stretch or contract. Then shut the engine off and use the electronic detector to check for leaks.

Always put the tip under the component being tested as refrigerant is heavy and will fall down. Use a blow gun to blow away the leaking refrigerant if there is a leak that is difficult to pinpoint, then quickly put the detector back under the suspected leak. The probe should be no further than 1/4" from the item being checked and moved at a rate of 1-2" per second. Slower and Closer is better.

The best way to find leaks on R134a cars is when it is still full of nitrogen. A sensitive detector will pick up residual refrigerant being pushed out of small leaks by the nitrogen. Since the nitrogen was put in the low side, put the tip of the detector over the high side fitting to see if it goes off. That tells you there is enough refrigerant still in the system for the detector to find. Then cap the high side fitting. Stick the tip into the hole you used to examine the evaporator. Lower the tip between the radiator and condenser to check the back of the condenser.

Pull the wiring harness off of in line switches to check the body of the switch for leaks where the plastic is crimped into the steel hex section and where the terminals protrude out of the switch body.

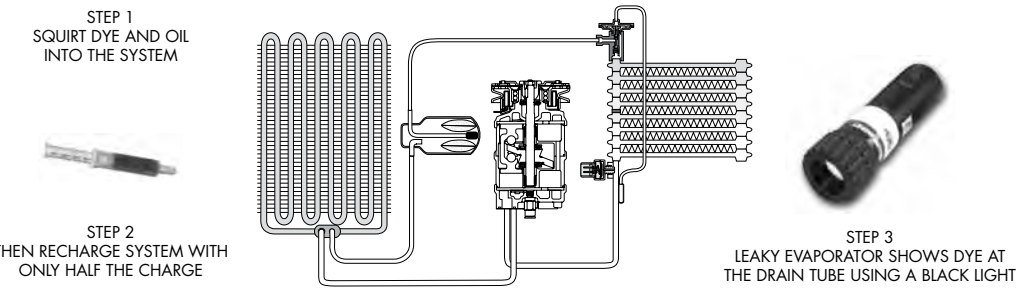
If the tip of the leak detector gets dirt or oil on it, the sensing will become distorted, usually beeping continuously. Keep the tip clean and change the tip protector or filter frequently. Make sure your detector meets the SAE standards.(J2791) The OFFICIAL leak test is to add enough refrigerant to develop 50 psi and then use the electronic leak detector. This works, of course, but some leaks won't show up under that little pressure.



5. DYE

If there was no dye in the system when it came in, it is recommended that dye be put in every car. Introduce the dye with oil into the system, recharge with refrigerant, run the system and re-examine the vehicle as soon as an hour later. Be careful not to spill the oil and dye mixture on A/C components. Look for the dye when the vehicle comes back with the ultraviolet light. It is also a good idea to put some dye into the oil container so that you are adding dye whenever adding oil to a system. Should you get a comeback, it is then very easy to spot your leak. Remember to charge the system with only a partial refrigerant charge. If it goes out with a full charge, the owner may not return if it is blowing cold air.

Remember that any indication of a leak by any of these techniques has exposed a leak. Just because and oil stain does not "beep" with the electronic detector does not mean it is not a leak. Why? Because the leak may only occur when the components are under pressure or are at operating temperatures.



SERVICE TECHNIQUES

RECEIVER DRYERS AND ACCUMULATORS

Moisture in the system will destroy EVERYTHING, as it mixes with the refrigerant and becomes acid. Moisture mixes with the refrigerant oil and becomes sludge. It reacts with steel and causes rust. The acid will rot the system from inside and the oil sludge will cause blockages and will not lubricate the compressor properly, causing noisy operation and failure. Moisture is always present in air and will enter the A/C system with air. The A/C system is sealed unit, everything inside stays there until removed by the technician.

The Receiver Dryer/ Accumulator is installed in the system to absorb assembly line moisture It is already saturated when the vehicle leaves the assembly plant. CHANGE IT. Do not use an old R-12 dryer on a R-134a system. It will absorb refrigerant instead of moisture and will be effectively useless. Always keep the A/C system sealed when working on it and install the Dryer or Accumulator last.

Late model vehicles may have dryers that need to be disassembled, cleaned and have new desiccant installed. Do these quickly and leak test them with Nitrogen. Some even have the dryer built into the condenser. That means replacing the condenser. If possible, use a condenser without a dryer, then reconfigure the hoses to accept a remote mounted (and therefore independently replaceable) receiver dryer.

EVAPORATOR FAILURE

This is common on orifice tube systems. Why? Firstly, many vehicle assembly plants are humid, so the desiccant gets saturated with moisture that enters with air as the vehicle was being built. The dryer is already used up when the vehicle leaves the plant. Weak acid forms inside the system and with an orifice tube, the refrigerant and acid mixture floods the floor of the evaporator (a TXV meters the refrigerant more precisely, so it all evaporates). Since Northern systems operate so often in the defrost mode (and then sit all winter), the heat content of the air passing through the evaporator is low, so evaporation is slow. The acid/refrigerant slowly climbs up the evaporator which gives it lots of time to eat away at the core. That is why the evaporators rot out at the bottom. The Accumulator/ Dryer MUST be replaced when this rotting damage has occurred and any time a vehicle is in for service and the original Dryer or Accumulator has not been replaced.

Evaporators in R134a cars tend to suffer leaks where the metal has fatigued from heat and pressure cycling. Near the ocean salt in the air rots them from the outside. There is such a thing as an evaporator that will not cool. Inside the evaporator there are usually three passes from side to side or top to bottom. Occasionally, a manufacturer will install the wrong outlet tube which causes the refrigerant to enter the evaporator and then come out the outlet without circulating through the whole core. That is called Evaporator Bypassing. How to detect it? The new evap will show normal pressures and a very cold outlet line but poor vent cooling. By getting an infrared temp gun inside the evap box and shooting the temps across the face of the core, you will see a marked difference in temperature where the refrigerant is bypassing. In that case, buy the replacement elsewhere as this manufacturing defect occurs in batches of the same part number.

Orifice tubes belong at the inlet of the evaporator. They are often placed well before the

evaporator (even in the condenser outlet on some models). This is done to keep the hissing noise away from the driver. It is not necessary to replace the orifice tube in its remote location, as pressures in Northern climates will not build up enough to cause an annoying hiss. I recommend that the orifice tube be put in the evaporator inlet if it will fit. Most aftermarket evaporators have the correct tube size and retaining dimples in the inlet line. The colour of the orifice tube represents its diameter (of the little brass tube). UH, GM uses .062" for all their cars, but Ford and Chrysler like to be more specific. (Does it really matter?)

Test Mount Difficult Evaporators! Nothing is perfect all the time. If a vehicle has taken all day to remove an evaporator, attach the new evaporator to the lines while the dash is out and pressure test it with Nitrogen and soapy water. Check all the welds for pinholes. Maybe even recharge the system to see how cold the evaporator gets. Better to find any problems now than later.

EVAPORATOR TYPES:

Tube and Fin:
These are made with copper tubes and aluminum fins. They are much more resistant to rot than any other types. Most manufacturers have changed to newer designs but many models are available aftermarket.

Serpentine:
This type has a flat band snaking from bottom to top. The band has several internal divisions.

Plate and Fin:
Very common design. The plates are crimped together to leave lots of surface area for the refrigerant to contact. But the pressure/temperature cycling seem to be hardest on this type.

CONDENSER FAILURE

Condensers will leak at the bottom due to corrosion caused by acid internally and salt/moisture externally. TXV systems are particularly prone to lower condenser rot because of the moisture in the system that enters during vehicle assembly turning into acid later. The TXV meters the liquid into the evaporator so efficiently that even the acid is atomized and passes quickly through the evaporator. Then it gets pumped into the condenser where it sits in the bottom all winter.

Condensers leak at the top due to leaks forming under high pressure and temperature. Make sure the Hi side pressures are normal after replacing a condenser.

Condensers clog up due to compressor parts and oil becoming lodged in the tubes. It's a good idea to change a condenser if you find a compressor seized due to lack of oil or complete blowup. Check the temperature drop from top to bottom. Depending on humidity and ambient temperature, it should drop 35F (18C) in low humidity/temperatures and at least 10F (6C) in high. Less drop in temperature indicates a blockage and too little drop indicates poor performance.

Stones? A rarity! The condenser is made of soft copper or aluminum and it takes a BIG stone hitting the condenser at HIGH velocity to puncture it.

See Detailed Diagnosis for signs of poor condenser performance. When installing a replacement condenser, make sure the air MUST pass through the condenser. Often a condenser fails because the factory shrouding between the condenser and the radiator disintegrated and disappeared. This is usually a treated paper or foam glued or loosely attached. When it goes, the condenser

doesn't get air flow and it overheats and starts to leak. The replacement unit will not work properly unless sealed. The easiest way to get the air to go through the condenser is to use a piece of foam insulation for hot water pipes and squish the rad and condenser together against the foam. Then check the air flow with a cigarette or try to get a piece of paper to stick to the condenser. A rule of thumb is that the gap between the condenser and the rad should never be more than a thumb width.

Some late model luxury cars, for pure complication, have an extra section called the subcooling section which is activated by a solenoid. What for?

Pickups and SUV's usually have a larger gap between the rad and condenser which tends to fill up with leaves and debris after a hundred K. Farmers and off roaders will fill the condenser and rad with dirt. Look between them for this problem and separate the two heat exchangers and power wash them clean. Big difference in performance.

Watch for transmission oil coolers mounted directly onto a condenser.This is a favourite of transmission shops, but the transmission oil is 125C and the condenser is 60C. That means the tranny cooler heats up the condenser. That's the opposite of what a condenser does.

CONDENSER STYLES:

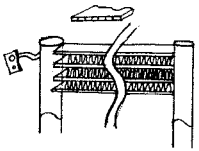
Parallel Flow: This is the latest and most popular type condenser. It is made out of aluminum and is very efficient. Small internal passages clog easy.

Piccolo Tube: Named because the two header tubes resemble a piccolo. Tiny tubes can clog with oil or small pieces of aluminum.

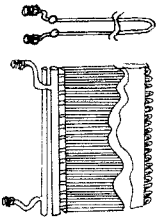
Serpentine: Snakes along just like its name. The flat bars are divided into as many as six internal passages. A clogger.

Tube and Fin: The old fashioned type, uses copper 5/16" or 3/8" tubes pressed into aluminum fins. Not quite as heat efficient, but seldom clogs up due to only 2 passages and open tubing.

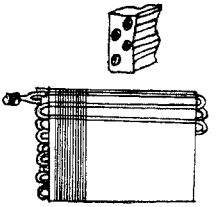
PARALLEL FLOW



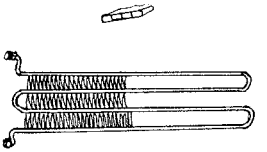
PICCOLO



TUBE & FIN



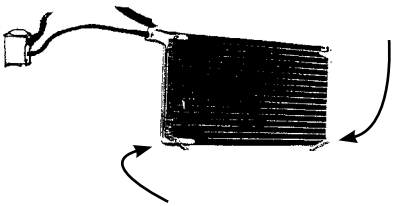
SERPENTINE



When high side pressures are very high, run a water hose over the condenser. If the pressures drop dramatically (400psi drops to 175) then the condenser is not working. Improve the airflow or replace the condenser. If it only drops a hundred psi or less, (400psi drops only to 300) then what's inside won't condense. Its either overcharged or there is incondensable gas inside. (air or contaminated refrigerant)

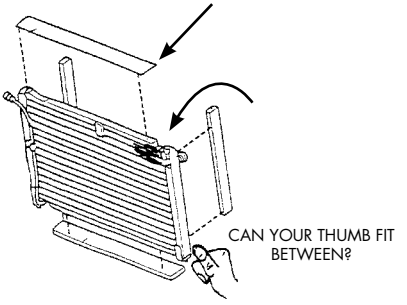
CONDENSER LEAKING AT THE BOTTOM

1. TXV CLOSES WHEN SYSTEM IS NOT RUNNING
2. ACID BACKS UP INTO BOTTOM OF CONDENSER (ROTS IT OUT)
3. ROAD SALT AND MOISTURE ATTACK FROM THE OUTSIDE



CONDENSER LEAKING AT THE TOP

1. WHEN AIRFLOW DOES NOT THROUGH CONDENSER (AT IDLE) PRESURE BUILDS UP
2. CONDENSER LEAKS AT TOP WHERE IT IS HOTTEST
3. SOLVE THE PROBLEM BY SHROUDING THE CONDENSER TO THE RAD WITH STYROFOAM OR PIPE INSULATION



FLUSHING AND FILTERING

Whenever the oil has turned black or dark brown, the system must be flushed. Also, if a compressor has failed, the high side must be flushed.

MANUAL METHOD:

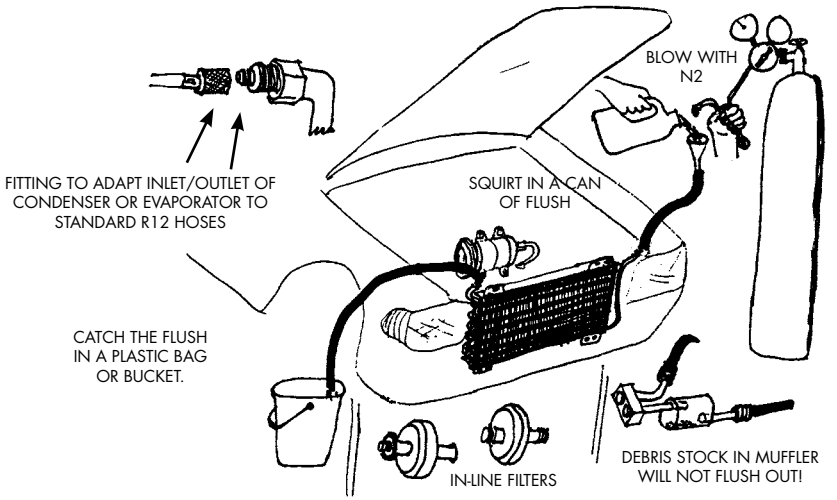
Flush each component separately. Use flush in a can. Catch the flush in a plastic Ziplock bag. This will allow you to examine what you have. Blow the flush through using the Nitrogen (remove the valve depressor and rubber seal from the hose). About 200 psi is good. The best way is to use a rubber tipped air gun. Examine the catch bottle for debris and oil and keep flushing until it comes clean.

MACHINE METHOD:

Flushing attachments are available for some recovery/recycling machines that flush the recycled liquid refrigerant from the tank, through the component and then back through the machine's internal filters. Dedicated flushing machines are now available that pump the flush through the component and in a closed loop back through the machine and its filters. Fittings are available for adapting any inlet or outlet of a condenser or evaporator to accept the common ¼ male tube thread air conditioning nipple which makes connections of the flushing equipment simple. Most important, whenever flushing use Dry Nitrogen or shop air that has been dried with a good drier. Never use normal compressed air as it contains a lot of moisture which will eventually do more harm than good.

Whenever flushing is done, the oil removed by flushing must be replaced. See the chart.

Add an in-line filter in the liquid line after flushing to catch the remaining particles. Mufflers never flush out completely, so some debris will begin to travel in the system after recharging. In line filters are available in many configurations, the best being the type that can be disassembled and cleaned. Add a filter ahead of the component to be protected from plugging. Usually this will be the orifice tube or the expansion valve. But it is a good idea to cut open a receiver dryer to examine the filter at the bottom. If it is plugged, add a filter before the new dryer.



ADDING OIL

Total Oil Quantity is usually 25% of the refrigerant charge. The oil quantities on this page are for a **32 oz** system. Reduce the quantities proportionately for smaller capacity systems. Too much oil is just as bad as too little oil.

HOW TO ADD OIL

Oil must be added to the components when installed new or after flushing. Oil quantities are shown for a 32oz system (1.9kg or 2 lbs). Methods of adding oil are:

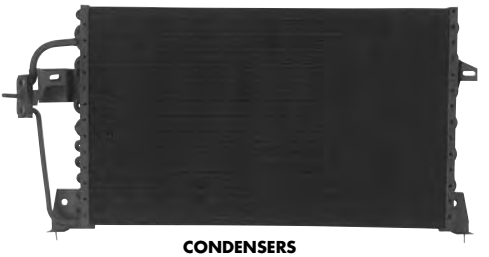
- Pour it into the component before installation
- Use a syringe to add oil to the accumulator or dryer
- Machine method, using the procedure on the charging machine
- Oil injectors, which allow oil to be forced in to a fully charged system
- Fill a hose with oil and charge through it

In any case, ensure the compressor does not flood with oil. Any time oil is installed in the suction line or directly into the suction side of the compressor, hydraulic damage can occur on startup. Always put 1/3 in the suction, 2/3 in the discharge.

TYPES OF OIL

PAG oil comes in may different OE part numbers, but it really comes down to the CS (centistokes) viscosity. The old R12 systems used Mineral oil. The four CS ratings of PAG oil are 46, 100, 130 or 150. Naturally, every manufacturer of compressors recommends a particular oil for their units. BUT, you can always use 100 for wetting a replacement component. Universal replacement oils are available that work well. But of course, OE's won't approve them because they sell their own. Ester oil in 100CS is also widely used, mainly for R12 conversions which are of course, dying out. PAG or Synthetic work better in very hot temperatures.

EVAPORATORS
3 OZ (OT SYSTEMS)
2 OZ (TXVS)



CONDENSERS
1 OZ

COMPRESSORS
2-6 OZ
CHECK QUANTITY BY MODEL

ACCUMULATORS / RECEIVER DRYERS
3 OZ 1 OZ

COMPRESSOR TYPES AND OIL QUANTITIES

Always add 1/3 of the oil quantity in the suction port and the rest in the discharge

6 OZ

Harrison A6

3 OZ

Harrison DA6, HR6, HD6

2.5 OZ

Harrison V5, V7
Oil goes in the plug

3 OZ

Chrysler/Denso 6C17

1.5 OZ

Harrison R4

3 OZ

HT6

3 OZ

Ford FX 15, FS10

2 OZ

Denso 10P series

2 OZ

Denso 10S series

3 OZ

Denso
10PA17 series

2 OZ

All Scroll types

1.5 OZ

All Vane types

6 OZ

York Piston
(Check with dipstick)

4 OZ

Sanden SD series
508,510,709
(Check with dipstick)

VACUUMING

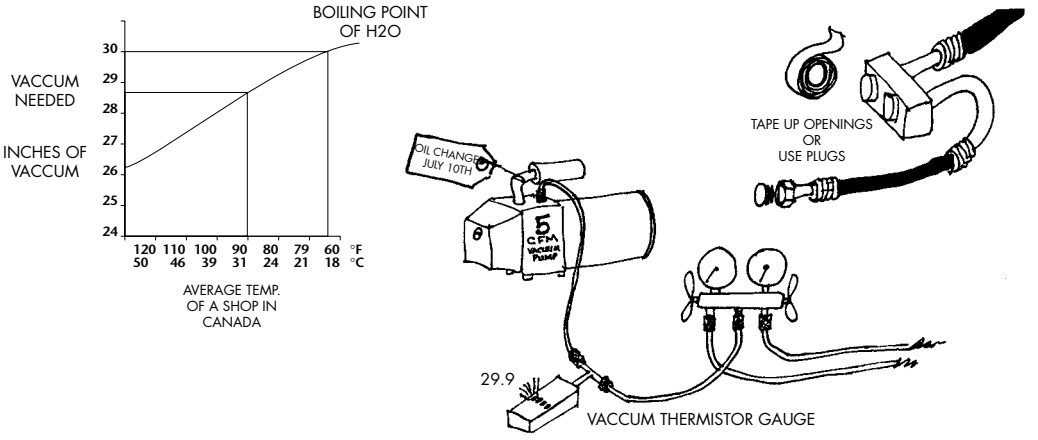
After finishing a repair, the system will be full of air and the moisture that the air brought in. It is important to have a good vacuum pump to remove the moisture. After starting the vacuum pump, the air comes out fast, usually it only takes two minutes to get into a deep vacuum. Then the moisture begins to evaporate inside the system and come out as vapour through the vacuum pump. However, it requires a deep vacuum to get the moisture to evaporate.

The chart shows that at normal shop temperatures, a REALLY good vacuum pump is required. As the moisture is removed by the pump, it passes through the pump, which contaminates the oil in the pump. Then even a good pump loses performance due to its oil becoming thick and sludgy. The oil in the pump needs to be changed frequently and special Vacuum Pump Oil must be added. This should be done at least every 10 days in a busy shop in the summer. Tag the pump with the date of the last oil change.

To avoid all this, just use nitrogen to check the system for leaks after repairs and then leave the N2 attached to the low side. Put a hose on the high side and leave the end open to the atmosphere. Then bleed the N2 slowly so that it travels through the system and exits out to the atmosphere. Since the humidity level of the N2 is ZERO, this will remove a lot of moisture prior to vacuuming, which will make vacuuming time shorter and save the pump from the inevitable rot that comes from being used as the sewer pump.

HOW LONG TO VACUUM?

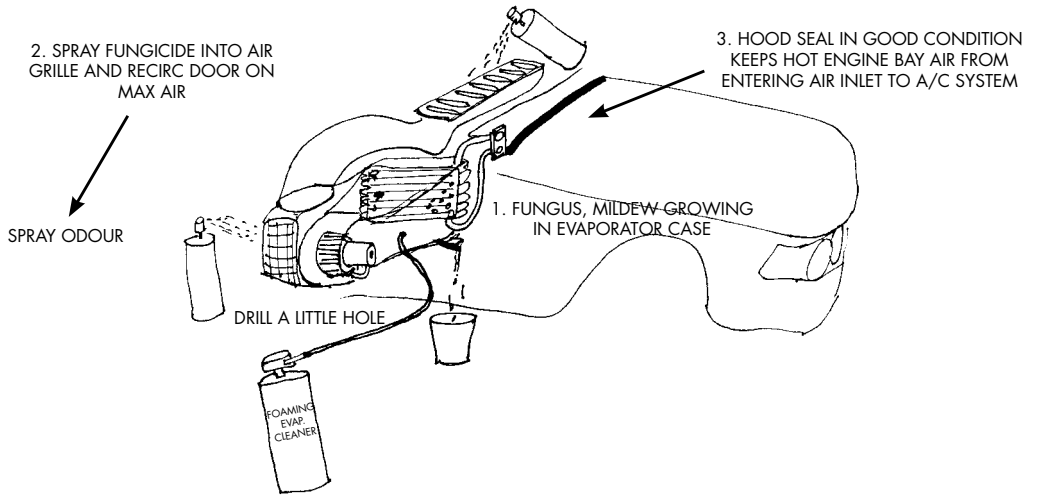
The new receiver dryer or accumulator will adsorb lot of moisture which is left in the system. A used one will not. With a new dryer/accumulator, only 20 minutes of vacuum is necessary. Vacuuming can be done for as long as the shop has time to leave the pump running without causing any problems in the system. It will not remove oil in any quantities that are of concern. So, when repairs have been done to a very badly contaminated system, vacuum longer. There is a tool, called a Vacuum Thermistor gauge which can be "T" ed into the vacuum hose. Essentially, the gauge tells how close the system is to perfect vacuum, something that cannot be seen on the low pressure gauge. When the gauge approaches a perfect vacuum, the technician knows that the moisture is gone as it is no longer coming even as a gas and a near perfect vacuum is possible. Always tape up or plug components when working on repairs to prevent circulation of air and moisture in and out of the parts



ODOURS

Occasionally, odours develop in the evaporator case from fungus, mildew and bacteria that live on the cool wet evaporator environment. This is usually reported as a locker room smell or musty odour. To eliminate the smell, the evaporator case must be disinfected. A purpose made cleaning agent is the best way to clean up this problem. Some cleaners are sprayed into the evaporator through the outside air inlet and the recirculate door. In difficult cases, remove the blower assembly and replace the packing. The best way is clean the evap is to use a foaming cleaner with a wand. Drill a small hole in the evaporator case and spray it into the box. It turns to foam and completely fills the box. As the foam bubbles break the liquid saturates the entire evaporator and gradually drips out. The filth that comes out the drain tube is like black water. Now that the fins are clean, the evaporator transfers heat better, usually 2 deg.F. lower vent temps!

Some vehicles are equipped with an afterblow feature which keeps the blower motor on for a few minutes after the vehicle is shut down to dry out the evaporator case and prevent odours. Afterblow modules are also available as an add on for vehicles prone to odours. The seal at the end of the engine compartment must be in good shape and in proper position to prevent hot, smelly engine compartment air from getting into the inlet for the A/C system.



NITROGEN: THE AC TECH'S BEST FRIEND

Nitrogen is supplied with zero humidity. It has many uses

- Leak checking
- Blowing apart seized spring lock fittings
- Removing front seals from compressors (your momma won't tell you how)
- Drying out the system before vacuuming and recharging
- Blowing out components
- Test running systems

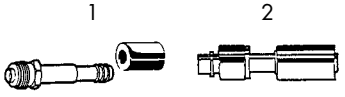
HOSE REPAIR

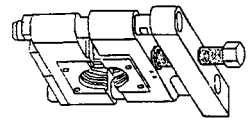
Hoses are used in five sizes:

Function	Size	I.D.	Use
Liquid line:	#6	5/16"/8mm	All vehicles
Discharge hose:	#8	I3/32"/10mm	All vehicles
Suction hose	#10	1/2"/12.7mm	used on TXV systems only
	#12	5/8"/16mm	used on all OT & some TXV systems
	#14	¾"/19mm	used on some OT systems

HOSES ARE MADE IN ONE OF TWO WAYS:

1. Held from the inside using barbs
2. Held from the outside using captive crimping shells (held onto the pipe) (Best way)





Repairs are made using new fittings and shells.
If a fitting is to be reused, it must have barbs or an extension with a captive shell welded on. These weld on bits are available in steel or aluminum. If welding is not possible, a compression extension is available which does the same thing, if not as elegantly. A separate, non captive shell will not hold if there are no barbs on the fitting. The original captive shell fitting can be re-used by sawing off the old shell and using a special shell and a snap ring.

Step 1
Cut the original ferrule, remove and discard. Remove hose and clean barb making sure there are no rough edges.

Step 2
Now install the replacement ferrule supplied with the kit. Install the proper retainer ring from the assortment (supplied).

Step 3
Slide the replacement hose onto the bard end of the existing tube or fitting. Slide ferrule over the hose. Be sure that hose is installed all the way up the barb.

Step 4
Re-crimp the replacement ferrule and you're done! That's it! Now the hose is replaced and recrimped to OE appearance and specifications.

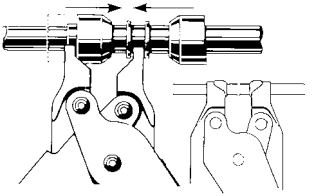
STEP 1 STEP 2 STEP 3 STEP 4




REPAIRING METAL TUBING

COMPRESSION FITTINGS

Metal tubing can be rejoined by using compression fittings or the more reliable Lokring system. Make sure that the correct anaerobic sealant is used, either the Lokring product or the Green Loctite. This is the perfect repair for a seized condenser fitting which causes the condenser inlet or outlet to twist and crack.

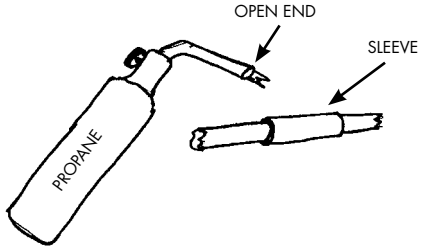


BRAZING ALUMINUM

Its so easy and convenient! You can repair hoses and make up your own fittings. These are the steps

1. Get the matched aluminum brazing rod and flux. The flux comes as either powder or paste. Make sure the supplier sends the correct flux for the rod.
2. Put the two parts to be welded together by some sort or mechanical method. For example, if joining two tubes of equal diameter, use a piece of aluminum of slightly larger diameter to act as a sleeve. Or slide one part into the other. Butt welding is very difficult.
3. Clamp a long bolt into the vice and slide the parts onto it. The bolt should be loose fitting so that it doesn't provide a heat path into the vice. Clamping aluminum parts directly into a vice doesn't work because the vice acts like a big heat sink.
4. Clean the aluminum parts until they shine with a new piece of sandpaper or a stainless steel brush. If the brush get used for something else, then don't use it for this purpose again.
5. Heat up the work with a propane torch only. Use the one with the open tip, not the pencil tip.
6. Heat up the rod so that when you stick it into the flux container, the flux will melt onto it. Then transfer the flux to the joint to be welded.
7. After the joint is entirely coated with flux, continue heating until the flux melts and becomes liquid. Some fluxes turn colour.
8. Then test the rod into the work. Let the work melt the rod. Just push the melting rod around the joint and its done.

9. Cool off the whole job in water and wash off the flux. It comes off with water.
10. Leak test the fitting by pushing one end onto a piece of rubber and put some pressure in the other end with a rubber tipped air gun. Put some soap on your weld to check for bubbles.



HOSE CLAMPS

Even though a hose clamp is sometimes included with a fitting, do not use them in Northern climates. Only the band is made of stainless steel. The driving screw is plain steel and always rusts in under hood environments and then they always leak after a year or two. There is only one application that is acceptable. Some Fords have the accumulator crimped into the suction line. It is possible to purchase an accumulator that has a barbed outlet. In this situation, you cut off the suction hose from the old accumulator and push it onto the barbed outlet of the aftermarket replacement. Then use a hose clamp. At least in this case it is at the back of the engine compartment where it will stay dry and the pressures are low.

SPRING LOCKS

Many A/C systems are connected together using Spring Locks. They leak because the O rings inside the fittings are flattened by vibration. To disconnect springlocks, use the tool. After cleaning out the spring with Solvent and air. The spring itself is replaceable and should be replaced if the joint was stubborn. After you get the tool into the spring cage, it may not come apart. Just fill the system with Nitrogen. Start with 100psi and wind up the pressure as high as 300. If you are using the correct Ford clamshell type tool, it will only come apart a bit and hiss out the nitrogen. But if you are using the little white ring type tool, the joint will come apart with an exciting boom!. Of course, you can only do this with one fitting at a time.

FAN CLUTCHES

There are three types of fan clutches; centrifugal, thermostatic and electronic.
Centrifugal types engage the fan at low RPM and Thermostatic types lock up at a preset temperature and can easily be identified by the bimetal strip or coil on the front. The electronic types are found on newer Pickups and SUV,s and need to be diagnosed with a Scan Tool to ensure correct performance.

Only thermostatic types may be used in Northern climates as the centrifugal unit will cause the fan to run while the engine is at low RPM in the winter and cause the vehicle to not warm up.

HOW TO IDENTIFY A FAULTY FAN CLUTCH

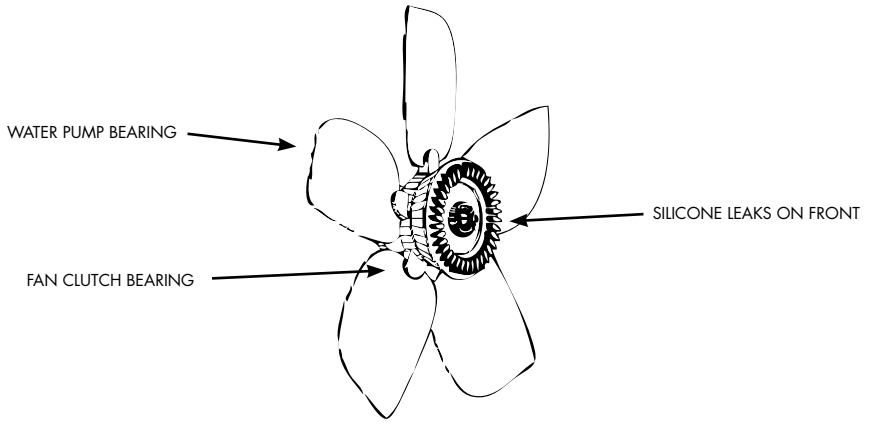
1. Fan clutches use silicone inside to lockup the driven plate and driving plate. If the silicone has leaked out, it will attract dirt and grime to the front. Check it by reaching between the fan blades and wiping a finger around the front of the clutch assembly to check for leakage.

2. A worn bearing will cause the whole fan and fan clutch assembly to move forward and backward. A slight amount of rocking is normal but not fore and aft movement. A worn or loose bearing in the fan clutch will cause the water pump bearing and seal to wobble and fail also. If a vehicle has a water pump which was replaced twice, it is usually the fan clutch that caused it.

3. To check for deteriorated viscosity in the silicone, run the engine until the thermostat has opened for a couple of minutes. Then shut off the motor. Just look at the way it stops. A good fan clutch will actually buck backwards as the engine stops and the last piston comes off compression. If the fan rotates for more than two revolutions more than the motor, its a comeback in the making.

4. Fan clutches can break up inside and seize. This is easy to spot. The vehicle may be in for a complaint of no heat, roaring noise on acceleration or poor fuel mileage.

   After installing a new fan clutch, you will be surprised to find that the high side pressures are very high for the first few minutes. Remember that the new fan clutch will not engage until the air temperature in front of it has reached 150F! (65C)



CLUTCH FAILURE

Some variable displacement compressors do not have a clutch. Almost all compressors have a double row bearing in the pulley. Only some York, Tecumseh and Matsushita models have a single row bearing which can wear out.

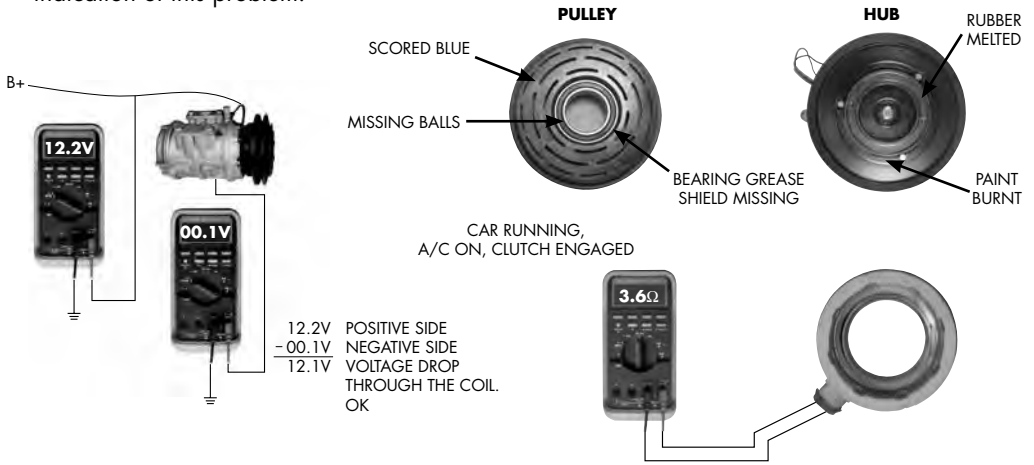
The failure of a double row bearing is due to overheating of the clutch which causes the grease seal to bake and all the bearing grease to run out. This heat is caused by friction developed when the pulley and hub slip.

This is a result of one or more of the following:

1. WEAK MAGNET

The magnetic coil requires a minimum of 12 volts at the coil. Voltage drops through the control circuits can cause loss of voltage at the coil. This will not deliver the amperage required to keep the pulley and hub locked together. This loss of voltage can also occur on the ground side.

Also a high resistance in the coil will cause loss of amperage and poor attraction. Coil resistance is normally between 3 to 4.8 Ohms Look for rusty dust on the pulley which is an indication of this problem.



2. TOO MUCH HEAD PRESSURE

Even a properly working clutch cannot lock up if pumping over 350 PSI consistently. The most common causes are:

A. Overcharging. Even though a slightly overcharged system will show normal high side pressures in the shop, when it is subjected to severe heat and low RPM such as a vehicle stuck in a traffic jam on a hot, sunny July day, idling in Drive, the extra refrigerant will turn into gas and build tremendous pressure.

B. Moisture and Air left in the System. Sloppy workmanship, air not properly bled out of recycled refrigerant. What more is there to say

C. Poor Condenser cooling. Caused by gaps between the rad and condenser, Electric fan not coming on properly , fan clutch worn out, poor air flow.

D. Blocked condenser or Discharge line This can be a blockage in the discharge muffler, or more insidiously, one row (back or front) of the condenser blocked, usually caused by compressor debris.

3. IMPROPER GAP

The gap between the pulley and hub should be .020-.025. This gap is set up by press fit on Harrison units and by shims on almost all others. Too much gap results in a weak attraction as the magnet attempts to pull in a hub by stretching the release springs or the rubber ring on the hub. Sometimes the rubber or spring simply pulls the hub away from the pulley harder than the magnet can pull it in.

Many compressor clutches wear out through normal cycling and should be checked for correct gap when the A/C system is in for service, especially for repair of a leak. After repairing a leak and restoring the system to original refrigerant volume and pressures, the worn out clutch may not be able to drive the compressor. The clutch will slip and fail shortly after.

4. INTERNAL COMPRESSOR PROBLEMS

When the compressor pistons are difficult to move, the clutch will slip. The only condition that can be repaired without replacing the compressor is if the system is low on oil. If the body of the compressor is very hot, add oil 1oz at a time to see if it runs cooler.

5. OIL LEAKING ONTO THE CLUTCH

Oil leaking from the compressor front seal will cause slippage. If it's a new seal, run it for a few hours, then use intake cleaner to clean off the oil. Spray between the pulley and hub.

6. SLIPPING BELT

When the belt slips, it will heat up the pulley. This will make the compressor appear to start and stop when the belt grabs and lets go. If allowed to continue, the plastic parts of the coil will melt and later turn solid after the engine stops. Then the plastic re-solidifies and the clutch rips apart or seizes when restarted. The pulley may need replacement if it is very polished. V belts need to go through a complete heat cycle and then retensioned to get the correct amount of grip. Rusty pulleys need to be replaced. Big Problem on Chryslers!

7. SEIZED TENSIONER

Occasionally the bearing can be damaged on vehicles that have the compressor installed just before the automatic belt tensioner. If the tensioner doesn't move smoothly, or at all, the shock is taken up in the compressor bearing. Also, look for a change in the pattern where the belt runs on the pulley. That indicates the pulley has shifted due to wear at the pivot. If a worn bearing is found on a good compressor with nothing else wrong, change the tensioner as well.

If you are replacing a clutch or compressor with a broken or cracked pulley, change the belt tensioner. They stop bouncing and taking up the tension at about 140,000KM and the excess belt load will crack the pulley and/or ruin the bearing.

After installing a new clutch or compressor, turn it on and off 40 times and then blow out the metal dust from the air gap and if needed, reset the air gap. This is called 'burnishing' the clutch.

ADJUST AIR GAP BY CHANGING SHIMS

CLUTCH TOOL FOR HARRISON PRESS FIT HUB

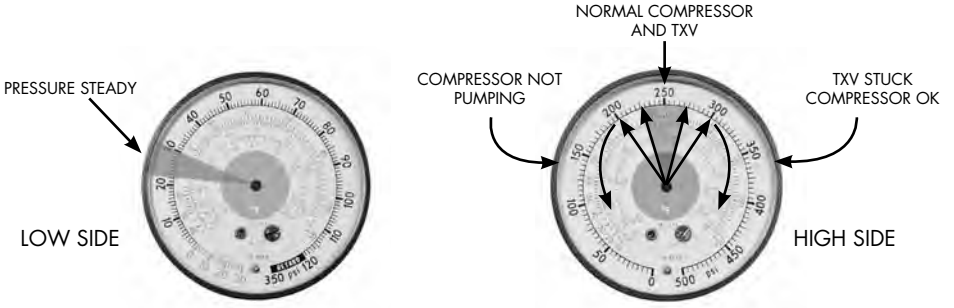
DON'T MOUNT A COMPRESSOR IN A VICE ON IT'S BODY (IT WILL DISTORT AND LEAK) USE THE MOUNTING EARS

VARIABLE DISPLACEMENT COMPRESSOR DIAGNOSIS

Many vehicles are using this type of compressor. It doesn't cycle on and off, some are clutchless, only the internal displacement changes. They try to keep the low side at about 30 psi all the time. The problem is that since the low side stays at 30, it's the high side that fluctuates. So when you encounter a system that is not cooling and has too little high side pressure, it could be:

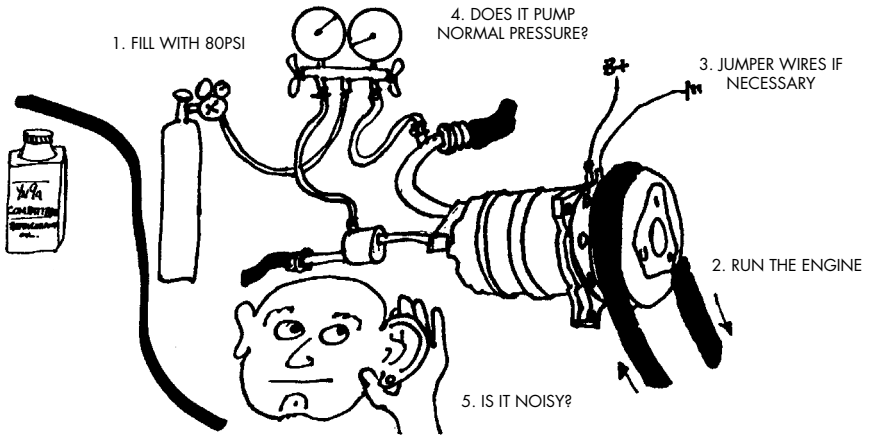
- A leak, so that the refrigerant is low
- A bad compressor
- A stuck expansion valve.

To identify which one it is, fill the empty system with exactly 100 psi of nitrogen. Then run the system. A normal running system will take the high side to 225-275psi. Then you know it has a leak. A bad compressor won't take it over 200 psi and the compressor may make some noise. A stuck expansion valve will trap the nitrogen in the condenser where it will make over 300 psi. Of course, this proves out the compressor as being OK.



TEST RUNNING A COMPRESSOR

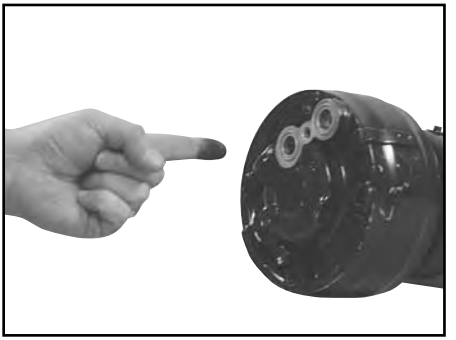
Test run a suspected bad compressor on an empty system by filling the system with 80 psi of nitrogen and running the system for 40 or 50 seconds. A noisy or poor pumping compressor can then be diagnosed before other components are replaced and then finding the bad compressor.



COMPRESSOR FAILURE DIAGNOSIS

A compressor in a properly working system should last the life of the engine. Failure of the compressor is usually due to other A/C or engine defects. It is important to find the cause of the compressor failure and correct the defect or the result will be the early failure of the replacement compressor.

CHECK SUCTION PORT
FOR OIL AND COLOR



LACK OF LUBRICATION

A: No OIL

Check the suction port of the compressor for presence of oil. Lack of oil will cause the compressor to wear on the crankshaft or wobble plate surfaces. This interruption of oil flow can be the result of either low oil volume or blocked flow. Low Oil is caused by a leak on the high side which leaks out oil or by a previous service during which a component was repaired or replaced and no oil was added. Blocked oil supply is usually the result of a clogged orifice tube, Expansion valve or blocked oil flow in the condenser.

B: Contaminated Oil

If there is oil present at the suction port, check its colour. Black oil has lost its lubrication value, causing severe wear of the crankshaft or wobble plate and causes the compressor to be hot. The oil turns black from deteriorated high pressure hoses, oxidation, sludge formed from excessive moisture or contamination with aluminum shavings. Another source of contamination is chemicals that were installed by hopeful techs. Some of these can react with each other to thicken or thin out the oil, neither of which is desirable. This oil must be completely flushed from all components and replaced with fresh oil.

C: Wrong Oil

Some compressors have aluminum wobble plates and some have steel. This calls for two different types of oil. The wrong oil will not lubricate properly and cause wear of the aluminum wobble plate types. Usually its just the viscosity of the oil.

Also, PAG oil can only be used in R-134a systems, mineral oil can only be used in R-12 systems, but Synthetic or Ester oil can be used in either. This is because of the ability of the refrigerant to mix with the oil and carry it through the system. It is always safer to use the correct PAG oil in R134a systems, especially in hot climates. PAG oil is available in 46, 100 and 150 viscosity but most manufacturers recommend using 100 if only a small amount is being added, such as when replacing a condenser.

HYDRAULIC LOCKUP

If a liquid is allowed to enter the compressor and it gets past the suction reed valve, the piston will not be able to compress it and something will break. Shattered pistons and valves indicate Hydraulic lockup. Caused by:

A: Liquid Refrigerant

The A/C system must not operate when the underhood temperatures are below 0 C, 32F. There is not enough heat to evaporate the liquid refrigerant in the evaporator and liquid will return to the compressor. An out of range ambient sensor, low pressure cutout or pressure cycling switch can be the cause of this.

An overcharged system or a stuck open Expansion Valve can also flood the evaporator to the extent that the liquid travels through the evaporator in a liquid state. But the most common cause is a technician charging liquid refrigerant through the low side, when the fitting it close to the compressor.

B: Excessive Oil Charge

If a technician is careless about adding oil and adds more than 30% over the total oil quantity for the system (TXV types), the oil can enter the cylinder and lock the compressor. Compressors which suck through the pistons (Harrison R-4, HD6, HT6) or if the compressor is mounted low on the motor are especially sensitive to excess oil.

EXCESSIVE HEAD PRESSURES

A system which is overcharged, has air inside or has poor condenser cooling will have high discharge pressures. This loads the compressor so that wear on the wobble plate occurs (aluminum types) or piston to bore wear on steel wobble plate types or bending of the reed valves (both types).

This condition can be spotted by overheating of the compressor, sometimes to the degree that the paint will discolor and the internal gaskets and case O rings will become hard and brittle resulting in failure and leakage.

PARTICLE CONTAMINATION

If a compressor fails due to severe wear of the pistons to the bores (especially after replacement), it is usually due to particles returning to the new compressor which were left in the system. This is a result of incomplete flushing or failure to change the receiver dryer.

Many compressors route the refrigerant and oil coming in the suction port to the crankcase area. The spinning parts can mechanically toss particles of aluminum into thte suction line when they disintegrate. Then these particles are washed into the compressor when it is charged. If you can see moving parts through the suction opening, then its likely there are aluminum parts stuck in the oil in the suction line. CLEAN IT OUT before replacing the compressor or the new one will instantly fail. Examples of this type are: Harrison R-4, all scroll compressors, most vane compressors and most Denso piston units.

LEAKAGE

When a compressor leaks, oil and refrigerant will come out either the front seal or the body O rings. Often the seal will leak because it has been overheated by a slipping clutch. When the body O rings leak, it is from either general overheating of the compressor, from corrosion or

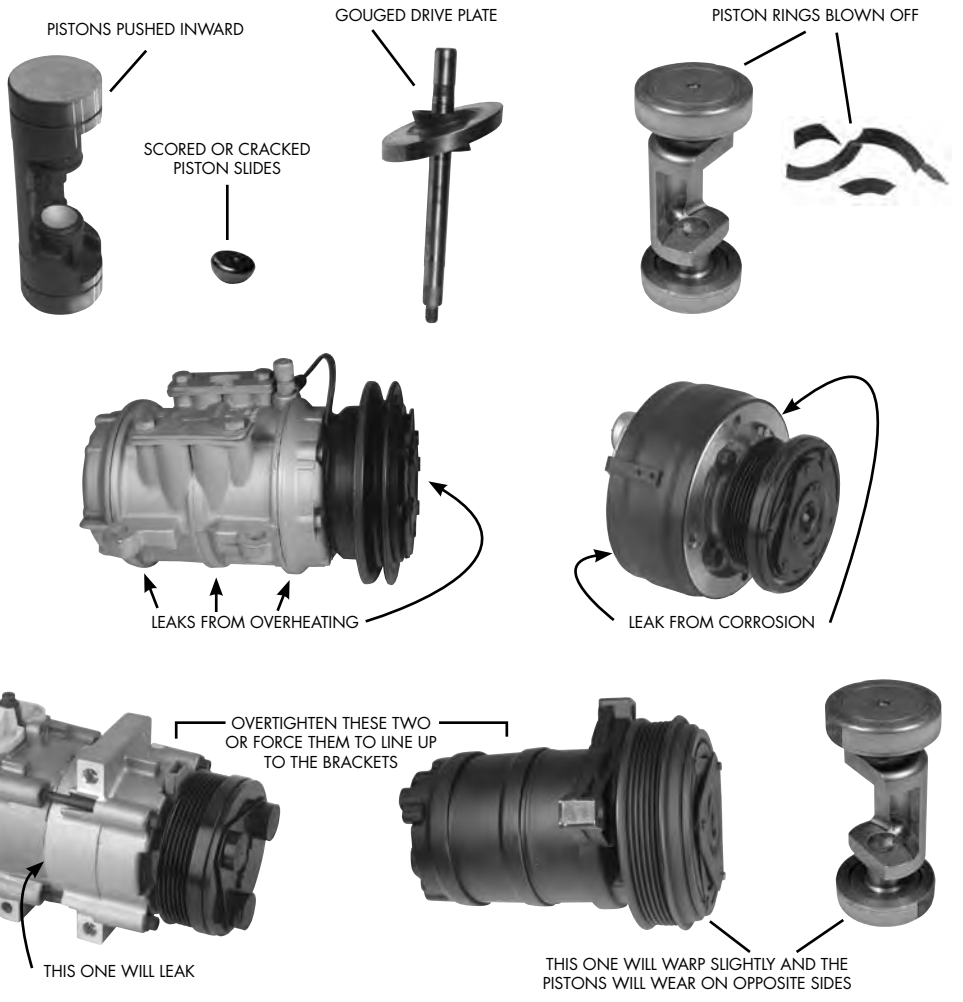
improper mounting. Overheating occurs from excessive high side pressures or poor lubrication.

Corrosion occurs from moisture and salt creeping into the compressor body seams. In either case, the compressor must be completely disassembled and cleaned before installing new O rings. Excessive or improper use of Sealants will cause the chemical to harden inside the compressor and separate the seal from the shaft. In this case the sealant actually causes the leaks.

INCORRECT INSTALLATION : HARRISON HR6, DENSO 10PA AND FORD FX10/FS10

Its important to install these compressors correctly. If installed with an air gun, the HR6 will warp slightly and since it has NO DOWEL PINS holding the cylinders in alignment, the pistons will wear on one side and within a year, wear out the cylinders. The Ford unit will simply start leaking from the center O ring due to case distortion. Torque the mounting bolts on these units to 20 ft/lb. And do it evenly.

High pressure causes:



WATCH FOR THESE COMPRESSOR FAILURES

ALWAYS CHECK THE ORIFICE TUBE TO DIAGNOSE COMPRESSOR CONDITION!

Harrison A6:

Normally a very reliable compressor, but has a rubber sprung clutch hub which will not tolerate excessive pressures or oil on the clutch surfaces. Don't forget the felt oil absorber when replacing the front seal on these units.

Harrison DA6/HR6/HR6HE:

The HR stands for Harrison Redesign, HE for High Efficiency.

Harrison HD6/HT6:

This is Delphi's replacement for the HR6. However, it breathes through its pistons and is very sensitive to hydraulic damage. Undercharge and slightly underoil this compressor. Be sure to charge this model slowly as it will disintegrate quickly if liquid charged. These units fail usually due to oil leaked out somewhere else in the system, and they will blow off their piston rings and the piston rings will travel to the condenser, where they usually lodge in the condenser tubes. If all the piston rings are not accounted for after flushing the system, change the condenser and discharge muffler before adding a filter before the orifice tube. Also leaks a lot due to single lip type seal which hardens over time and from overheating. Be careful when installing this unit as it has NO DOWEL PINS aligning the cylinders! Loosen off the rear bracket from the block, tighten it to the compressor first, after tightening the pulley end. Then find the new position on the block and tighten that. If you are installing one of these with 6" pulley (GM 3.8L), replace the belt tensioner. Otherwise the pulley will crack.

Harrison V5:

This unit runs continuously, but has an unusual clutch wear problem. An internal spring gradually weakens and pulls the hub inward towards the pulley. Eventually the pulley and hub rub and the friction burns out the bearing and front seal. Check the air gap on these units and re-set it if the gap has collapsed. These can be tricky to diagnose because their high side pressure can fluctuate but the low side remains constant. V5's are usually mounted low on the motor and will fill up with excess oil after shutdown. Then they rattle for about 30-50 seconds on startup. Drain some oil before it seizes.

Before condemning this (and other variable displacement compressors), add 100 psi of Nitrogen and turn on the system. A good compressor will pump over 225psi on the high side. Higher pressures indicate a blocked TXV. The low side always stays at 28-35psi. See page 33.

Harrison R4:

This radial type unit sucks through the pistons. The suction port enters the crankcase. It carries very little oil so is sensitive to correct oil feed and charge quantity. Also, the steel housing over the aluminum crankcase has leakage problems due to corrosion and the fact that the high pressure is applied internally against the O ring. Always clean out the suction hose as well as the discharge hose when replacing this compressor as the crankshaft can mechanically spit

parts of a grenaded compressor into the suction line. This unit uses oil mist lubrication and will NOT TOLERATE ESTER OIL. Use PAG 150 only. Pulley bearing failure on these units is almost always the fault of a seized belt tensioner. Look for other recently replaced parts on the same belt. (alternator, water pump, power steering pump)

Ford/Nippondenso FX15/FS10:

The grandaddy of all compressor failures! While this unit is not inherently a bad one, it lives in an environment whereby the condenser clogs up with residue at high temperatures and blocks the oil supply while backing up pressure into the compressor. Ford says to use a filter on the condenser outlet, run the vehicle with air flow through the condenser blocked (to heat up the residue and get it to flow into the filter). Then change the filter. Simpler to just change the condenser, accumulator, liquid line and add a filter.

Denso 10P, 10PA and 10S series:

Great compressors except for their all aluminum construction which causes severe drive plate and piston wear if subjected to excessive pressures and poor lubrication. Most failures on the newer 10PA series when installed on Chryslers is due to lack of oil. This is usually because the parallel flow type condenser has partially clogged, trapping oil and raising pressures. It is a good practice to replace the condenser and receiver dryer when changing one of these. A lot of these models are equipped with a rubber centered clutch hub which is supposed to melt through before the compressor is damaged (by high pressure) Ha Ha. Chrysler uses V belts on some of their applications. Put on a new one and heat cycle it once then retighten. Make sure the new belt sits flush with the top of the groove in the pulley. Use the OEM or 13A series belts. Replace or sand rusty pulleys (all of them) to prevent stretching of the belt and howling because of slippage.

Matsushita/Panasonic/Sanden/Denso Vane:

Like all vane type compressors, the oil must be moisture free so that the oil sludge which forms when oil and moisture mix does not make the vanes stick. Some of these units however, are made with a nose that is too small to carry the weight of the clutch. So it wears and the clutch appears to have failed. When oiling, put only a half ounce in the suction port and the rest in the discharge. Oil in the suction bends the discharge valves on startup and will tick loudly at idle, with poor compression. These units have very tight internal tolerances that will stick and seize if overheated. Most of them have a heat sensor.

Sanden SD series:

A reliable unit but is sensitive to overpressure and bending of the relatively thin connecting rods. The sign of this is a noisy unit that pumps well otherwise. They have their own internal oil reservoir, so suction oil goes directly into the cylinder. Don't overoil. Older Jeeps have manual service valves on these units. Never front seat the valve or the refrigerant will not be able to enter the discharge line. Pressure can build over 1500psi and blow out the head gasket. (for starters)

York/Tecumseh 2 cylinder:

These units are still in common use on equipment and trucks. Their only weakness is that there is no place for any liquid in the compression chamber. Overcharging these units will blow them up!

Chrysler/Nippondenso 6C17:

The noise and howling often heard with these units is usually due to overcharging and/or a worn out tensioner. If the noise is actually internal, the most common cause is a single worn out piston and bore. Overoiling causes this problem. Always start these in a vacuum and then let the refrigerant slowly enter in the low side.

Chrysler A590-C171:

These might have been the best units ever built but for the scanty desiccant installed in the tiny receiver dryers by Chrysler. When the condenser rots, there is a good chance that the compressor is rusty inside! This causes noise and poor compression at idle due to excess clearances and rusty bearings and valves. Always test run a C171-A590 before quoting a job.

Mitsubishi,Sanden and Denso Scroll:

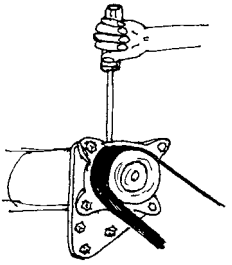
These are quiet and long lasting, provided the oil charge is correct. They are very forgiving, but like all compressors, will not tolerate an excess or lack of oil. Clean out the suction line when replacing these compressors

COMPRESSOR TEMPERATURE

Although its not mentioned in any shop manuals, I have found that measuring the temperature of the compressor after the vehicle is fully warmed up can tell you about the future. Cool oil and refrigerant returning to the compressor is there to lubricate and cool the compressor. That's why they have no cooling fins. Since the critical part of the compressor is the crankshaft bearings, the oil will usually be routed to that component first. Find a spot midway between the suction and discharge ports (which will be cold and hot) on the compressor body and measure the temp. Or take several readings around the compressor body and average them. The temperature will be a minimum of 40C and a max of 60C. Lower than that, and too much liquid is returning to the compressor. Over that and not enough. Simple.

NOISE:

Before wasting time replacing a compressor that is making a buzzing or grinding noise, try prying between the engine block and the compressor bracket. Then between the bracket and the compressor. If the noise changes, remove the bracket and check for stripped, bottomed out or broken mounting bolts. Also, check for cracks in the bracket and missing supports. (If you can see any weak spots)

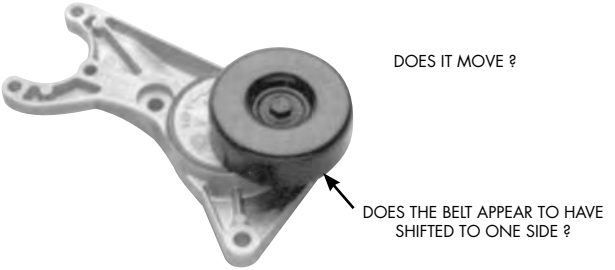


BELT TENSIONERS

These little suckers are the cause of power steering pump noise and leakage, water pump leakage alternator bearing failure and compressor clutch bearing noise and seizing. After about 130-150K, the tensioner wears on its pivot, the aluminum becomes egg-shaped and the tensioner no longer moves smoothly or stops moving completely. This increases the loads on the bearings by more than 10 times.

HOW TO TELL IF THE TENSIONER IS BAD.

- Does it move smoothly up and down as the engine is revved up and down?
- Has the belt moved over to the edge of the pulley? When the pivot becomes oval, the pulley moves a little, giving the appearance that the belt has shifted. It is actually the pulley that has moved.
- If it's a compressor clutch bearing that's noisy, look at the alternator and water pump. Have they been replaced within the last two years? The compressor clutch bearing will outlast these other two.



ELECTRONICS/ELECTRICAL

It is virtually impossible to diagnose electronic and electrical problems without the appropriate manual and a scan tool with an HVAC menu.

The most common problems are:

1. Compressor does not come on or erratic operation
2. Climate control does not give enough heat/cold, or does not respond to driver changes ..... quickly. Temperature not correct, especially in dual zone systems.
3. Condenser or rad fan does not engage at the correct pressure.
4. Air not coming out the correct outlet.

COMPRESSOR NOT ENGAGING

Compressor problems must be diagnosed using the wiring diagrams. Simply trace the circuit. On later model vehicles, the compressor relay must be activated by the control head or the PCM. Often the PCM will not let the compressor turn on because of information it is receiving from one of its sensors. Compressor operation adds load to the engine and heat to the radiator. Typically, readings from engine temp, power steering pressure, manifold vacuum, alternator voltage, start delay, high and low pressure, low side temperature and other sensors will tell the PCM not to turn on the compressor. Check the Electronic Engine Management Systems of the manual to see what the strategy is. Often the readings of one of these sensors is out of range and the PCM thinks the engine is about to stall or overheat so the compressor is not activated. Scanning system data is a quick way to determine inputs and outputs.

Never replace the ECM, PCM or A/C control head until after all the data has been scanned (if applicable) and all the sensor values have been checked. Even then, if it appears that the computer is faulty, it is possible that it has only temporarily "locked up". Disconnect the battery for ten (10) minutes and try again. If the computer seems to be failed after evaporator replacement the cause is almost always a wire connector pulled back in a harness connector.

If a computer or control board is replaced, check the clamping diode at the compressor. An open diode will allow the voltage spike to travel through the vehicle and will damage the computer. I have measured the spike and have seen 320V lasting for 8ms. This can be destructive.

Controllers such as fan and blower speed control units, will burn up due to passing excessive amperage. Before installing the replacement, check the Amperage draw of the unit being controlled, such as the blower or cooling fan. Normally, fans and blowers will not draw more than 25A on high speed. More than that will either burn out the replacement unit or shorten its life severely.

Climate control systems are either automatic temperature control or fully automatic which controls temperature, blower speed and air distribution (mode). If there is digital temperature display, the unit may have on board diagnostics. Use the shop manual to press the buttons on the control head which enters self diagnostics and read the codes. After changing components, there is usually a recalibration procedure for auto systems.

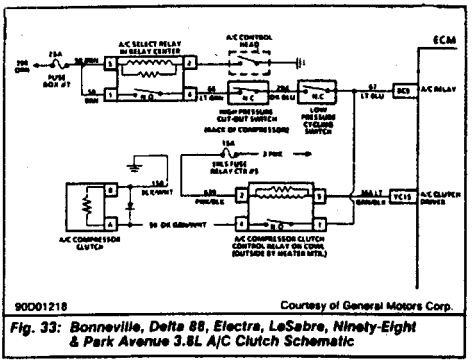


Fig. 33: Bonneville, Delta 88, Electra, LeSabre, Ninety-Eight & Park Avenue 3.8L A/C Clutch Schematic

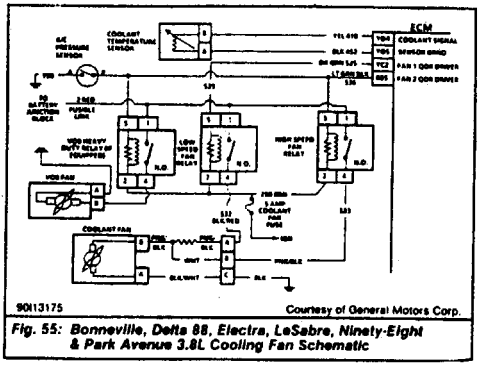


Fig. 55: Bonneville, Delta 88, Electra, LeSabre, Ninety-Eight & Park Avenue 3.8L Cooling Fan Schematic

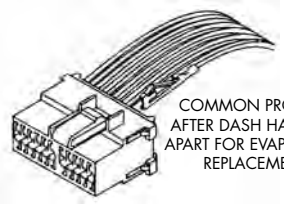
Often the sensor values can be read through the digital display so the technician can match the displayed value with the actual value. For example, the evaporator temperature sensor may be telling the computer that the evaporator is at -1C, so the compressor does not come on, but the technician can feel that the suction line is not that cold, so the sensor is not giving the computer the correct information. Engine coolant temperature sensors can do the same thing. It is important that the technician check the actual temperature of a component to the displayed value. Simply running a hand over the component being sensed is usually enough. Even air or foreign refrigerant in the system which will give normal running pressures will not cool the evaporator enough, so the computer thinks that the A/C system must be low on refrigerant, so it sets the code and shuts down the compressor.

CLIMATE CONTROL CHECKS

1. Problem codes through digital control heads self diagnosis (must be cleared after repairs are done). Check codes with scan tool. Clear codes after repairs. Look at engine data if the compressor won't engage. TPS, CTS, MAP, RPM can shut off compressors without setting codes. See if this data makes sense.
2. Check sensor values to actual and to charts, check at the computer terminal to include all connections. This will require a scan tool on some later model vehicles. The evap. Temp sensor is a favourite that prevents compressor engagement.
3. Check to see if in-car sensors are dirty or no airflow (use a piece of paper or cup of coffee if its infra-red)
4. If Control head failure, check diode in A/C clutch and power module. Electric mode or blend door motors that are seized can also cause this failure.
5. Check operation of doors and electric motors under dash to make sure the flaps are moving freely. Some vehicles have plastic shafts on the blend and mode doors which can snap off. Then there are no codes, but erratic operation. Its an expensive repair because the plenum box has to be removed and often replaced. Electric motors may be multiplexed, which means that two identical motors will have different part numbers. That is because they have their own 'address'. Be sure the right part number is being installed. Electric motors may have as few as 2 or as many as 5 wires. The 2 wire motors do not feedback to the Climate Control Module and will need to be recalibrated when replaced or the battery disconnected because the computer needs to see the amperage rise when the motor stalls at the end of the flap travel. Oh, and of course, the two wire motors tend to be the ones that break flap pivot shafts and burn themselves out.

Check for vacuum if doors are vacuum operated. Usually lack of vacuum causes the system to deliver all the air to defrost. The usual culprit is a cracked vacuum line or check valve under the hood.

HARNESS CONNECTOR



COMMON PROBLEM AFTER DASH HAS BEEN APART FOR EVAPORATOR REPLACEMENT

ONE WIRE PUSHED BACK MAKING INTERMITTENT CONTACT

MITCHELL MANUAL OR EQUIVALENT

MANUAL SAYS "PUSH [OFF] AND [FLOOR] TOGETHER THEN [AUTO] WITHIN 2 SECONDS"

PROBLEM CODES APPEAR IN DIGITAL TEMP AREA

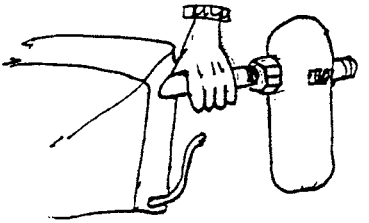
CODES ARE SET WHEN SENSORS FAIL COMPLETELY

LOOK FOR DIODE SYMBOL IN HARNESS

FINDING THE A/C CLAMPING DIODE

LITTLE PLASTIC BOX ON TOP OF COMPRESSOR NEAR CLUTCH

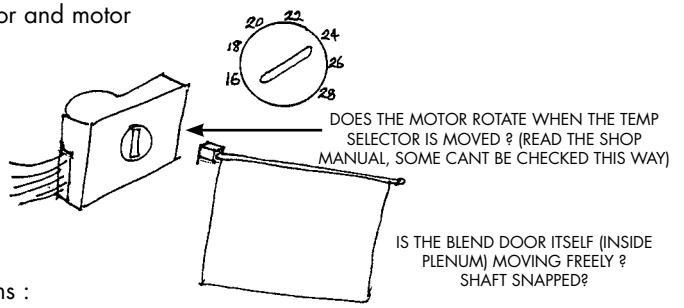
CHECK SENSOR VALUES TO THE ACTUAL COMPONENT



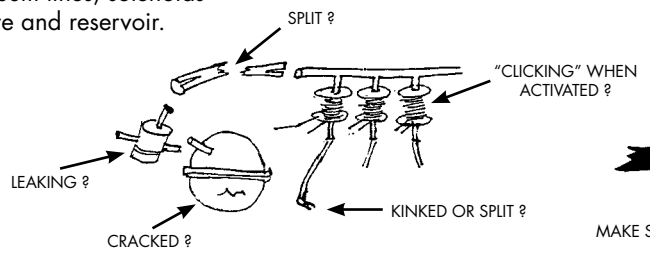
COMPUTER SAYS EVAPORATOR TEMP IS -1°C
DOES THAT FEEL CORRECT ?
IS THE SENSOR ACCURATE ?

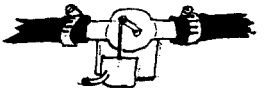
COMMON CLIMATE CONTROL PROBLEMS

Check the temperature blend door and motor

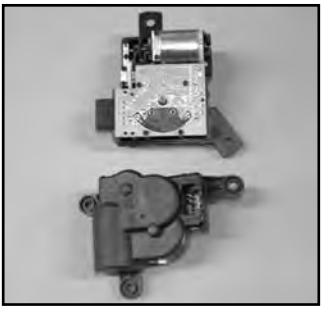


When vehicle has mode problems :
Check vacuum lines, solenoids
Check valve and reservoir.





MAKE SURE THE HEATER VALVE CLOSES IN "MAX" A/C MODE



NO HEAT CHECKLIST

1. Thermostat opening correctly? Heat range correct?
2. Check the coolant level. If it's low the heater won't fill. Find the leak and repair.
3. Heater hose from the manifold or cylinder head hot and return line slightly cooler, but not cool. A hot inlet and significantly cooler return hose indicates plugged heater core. Two hot lines indicate a partially plugged heater core.
4. Evaporator core plugged with oil and dirt, or a plugged cabin air filter, preventing proper air flow. This situation may result in very hot air, but poor air flow.
5. Water pump impellor rotted away, preventing good flow of coolant to the heater core.
6. Water control valve in the heater line not opening, check by feeling for temperature change in the heater hose either side of the valve. Try bypassing the valve by hooking up the heater hoses directly to the heater core.
7. Corrosion/rust buildup in the manifold where the heater hose starts, preventing proper flow. Usually indicated by more heat when the engine is at high RPM, but little heat at idle.

8. Fan clutch or electric fans stuck on.
9. Kinks in the heater hose. Look for temperature change in the hose.
10. Blend door cable jammed, linkage broken or loose, blend door motor not moving, blend door shaft broken. Often on Minivans, the kids have put a pencil or crayon down the defroster vents and it has jammed the blend door.
11. Air or gas in the heater lines. If its air, bleed it out at the high point. You can install a clear . plastic splicer from the hardware store to watch the flow and see if the hose is full. If it's combustion, check the rad for presence of combustion gas with a gas analyzer. Use the vacuum system to take out all the air in the cooling system then refill when its still in a vacuum.
12. If everything here checks out, start a campfire on the floor.

VACUUM FILLER

EQUIPMENT

There are three different SAE standards for Recovery, Recycle and Recharge equipment, the most recent is for machines that can recover 95% of the refrigerant and are more accurate with their charge. The latest standard is SAE J2788. Many different configurations of manual, semi and fully automatic service equipment are available. Regardless of its capability of being programmed or manually operated the basic components are present.

The Basic equipment required for Air Conditioning service are:

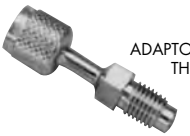
I. Gauge set

2. Leak detection equipment

3. Recovery/recycling machine

4. Vacuum pump

5. Refrigerant measuring method



ADAPTORS CHANGE FROM 1/4 NPT (R12) THREAD TO 1/2 ACME (R134A)

R134A HOSE END, CLIPS ON THEN TWIST TO OPEN

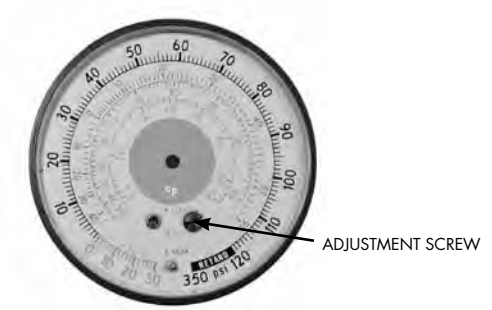
SAFETY NOTE! Even though we are warned in school that safety goggles are required when doing A/C work, technicians seldom wear them. BUT...the law requires that the refrigerant be contained in the equipment which means that often there is liquid refrigerant inside a hose attached to a piece of equipment. This is dangerous. I froze my right eye by getting just a little shot of liquid freon in it. It bounced off the inside of my glasses from a hose that I disconnected from a bottle. DON'T let this happen to you! Now I wear safety glasses or goggles when connecting or disconnecting from any liquid source.

GAUGE SETS

Are available in a number of configurations, increasing in features and cost. Some features are:

- silicone filled, which prevents fluttering of the needle, which is common with two cylinder compressors
- front mounted valves which makes it more convenient to lay the gauges flat
- sight glass in the manifold to see the refrigerant passing through. Gauge sets are made for R-12 and R-134a, the main difference being the threads and connectors to the system. Hint: don't discard old R12 equipment as it can be easily upgraded to fit R134a with thread adaptors.

ALSO TIF AND CPS ARE EXCELLENT AND REASONABLY PRICED



CHECK YOUR LOW SIDE GAUGE WHEN EMPTY. IF IT'S NOT ON ZERO, RECALIBRATE IT.

LEAK DETECTION

Must be performed with at least three different methods. An electronic detector is a must. And the use of Nitrogen is also important. Electronic leak detectors must conform to the SAE J2670 standards for R12 and R134a. The tip on the Electronic detector must be kept clean of dirt and grease. Keep a spare tip handy and on the type that use it keep the protector clean. Also, a UV or "Black Light" and dye detection system is mandatory if you expect to find leaks on R134a systems. Get the one with the smaller, brighter light. You can also buy a device that looks like a caulking gun which pumps oil/dye mixture into a fully charged system. Really neat.

THE YOKOGAWA LEAK DETECTOR (NOT SHOWN) IS CONSIDERED TO BE THE MOST SENSITIVE AVAILABLE. BUT IT'S CONSTANT TICKING MAKES IT THE MOST ANNOYING !

RECOVERY MACHINES

These units use a compressor to provide the suction that recovers the gas from the A/C system. Always recover gas, if the service port hose is on the liquid line, don't recover from it. The liquid may cause the compressor to seize, despite the safety valve which many machines have built in. Many compressors in recovery machines have been destroyed from this mistake. Even if the compressor doesn't seize, recovering liquid will bring some oil (which may also contain Sealant) out as well since the liquid refrigerant and the oil mix together. When recovering, the gas will come out fairly quickly, but the liquid in the Receiver dryer or Accumulator must evaporate to come out. This process will cause ice to form on the outside of the can. Providing some heat by putting the trouble light on it will speed it up. Warm water poured over a frozen accumulator or dryer will help the liquid refrigerant inside it to turn to vapour. The system is not empty until the gauges are in 10" vacuum and the Receiver dryer or Accumulator is ice free. Then shut off recovery because air will enter through the leak and mix with the recovered refrigerant.

Also, the air which mixes in the recovery stream must be separated from the recovered refrigerant. recovery machines separate the air by one of two methods, automatic or manual. The automatic method has a pressure operated valve which releases excess pressure (the air). Manual method calls for the technician to release the excess pressure from the machine with a manually operated valve. Normally, manual air release machines will require air release several times as the air is dissolved in the liquid and it percolates out slowly. It is good practice to check the pressure of any recycled refrigerant against the normal Pressure/Temperature chart. Excessive pressures for the temperature (even a couple of pounds) indicate the presence of air. Don't use recycled refrigerant before checking its pressure!

The newest standard for Recycle/Recovery equipment is SAE J2788. This new standard certifies that the machine can recover 95% of the refrigerant and accurately charge to .5oz.

Some features to look for are:

- Automatic Air Purge, to release the air from the recovered refrigerant
- Automatic shut off and restart after recovery
- Weight measurement of recovered refrigerant
- Oil purge bottle, which could be manual or automatic oil purge
- Oil charge capability

A separate machine must be used to recover different refrigerants, although machines are available that have R-12 and R-134a dual systems.

Service Tip: Have your recyclers serviced each fall before putting it away for the winter. A/C recyclers have a high moisture content and long storage periods cause rust and corrosion in compressors. Then they fail when you need them in the spring

Some machines have a purge bottle to drain waste oil that was removed from the vehicle during recovery. Remember to purge the oil out after recovering from a vehicle for two reasons. First, you now know how much to add to the vehicle and secondly, if the oil remains in the machine, the plumbing and the machine's compressor will fill up and the compressor will seize.

Use a Recycle Guard to prevent chemicals and sealers from entering your recovery machine. Its an expensive surprise when it stops working because its all stuck up with sealer.

RECOVERY
RECYCLING ONLY

CHANGE THE COMPRESSOR OIL AND
REFRIGERANT FILTERS

COMPLETE SERVICE CENTER

COMPLETE SERVICE CENTER

LATEST J2788 CERTIFIED MACHINE

VACUUM PUMPS

Vacuum pumps are available in CFM ratings from 1/2 up to 8. The vacuum charts indicate that the moisture inside the system will not boil out until the vacuum is greater than 29 ". This requires a REALLY good pump. A two stage pump of about 3CFM is best. A higher CFM pump would not be able to push more air out than the 1/4" line would allow. Also, the oil inside the pump gets contaminated automatically as it sucks the moisture out. As the oil gets thicker and gummier from the moisture passing through, the pump gets less efficient. Change the oil every ten cars and tag the pump just like you would do on a customers oil change. If you need a new pump, buy the biggest, best, kickass, two stage pump available, which is an three CFM. The job gets done quicker and better. Watch for dye in the oil sight glass, which indicates that oil has been removed from a vehicle and now needs changing. Brown colour indicates that there is rust inside the pump and now its time for an overhaul. A vacuum thermistor gauge can be used to check vacuum over 29". The low side gauge is not accurate enough to know if vacuum is below 28". The thermistor gauge STARTS at 28".

Service Tip: Check the oil level in the vacuum pump when it is running to avoid shooting the excess oil out the discharge.

VACUUM PUMPS

VACUUM PUMP OIL

VACUUM THERMISTOR GAUGES

MEASURING EQUIPMENT

Refrigerant must be carefully measured into the vehicle. The two most common methods of measuring are:

-Sight, using a measuring cylinder,
-Weight, using a weigh scale.

The sight methods is usually a two step routine, whereby the refrigerant must be loaded from the tank into the measuring cylinder and then into the vehicle, These cylinders can be heated which can make the recharge process quicker. Some single pass recovery machines put the recovered refrigerant directly into a measuring cylinder for immediate re-use.

The weight method involves simply placing the refrigerant cylinder on the weigh scale and recharging the vehicle directly

SIGHT METHOD
TEDIOUS BECAUSE
IT MUST BE FILLED FIRST

WEIGH SCALE
FAST AND DIRECT

IDENTIFIERS

Because of the chance that a vehicle could have mixed gases in it from poor service or confusion, using a Refrigerant identifier is a good idea. It will prevent contaminating the tank of recycled refrigerant and the machine. The best features in an identifier is the ability to identify R-12, R-134a, R-22, air, hydro carbons and "other" gases. Sample the car by attaching at the highest gas point or run the A/C system for a few minutes then sample the gas after shutting the engine off. The new generation of A/C machines have built in identifiers. Very convenient. Buy a new filter for your identifier as you will need it. Keep one in stock. Vehicles with "other" gases in the system could have R-22, R-502, Propane, or who knows what. These must be collected into a container and sent to a disposal company. Vehicles with contaminated refrigerant will display weird problems, such as evaporator freezeup at higher than expected pressures, or lower or higher pressures but no cooling.

FLUSHING MACHINES

Several flushing machines are available. Robinair offers an attachment to their recovery machine that lets the reclaimed refrigerant flow through a component to flush it. Other machines are available that use shop air to propel the flush. One caution, the best machines have a water trap to dry the shop air before it is blown into the system. Do not let wet shop air be used for flushing. Expensive flushing solvents can be filtered through a coffee filter and re-used. But the solvent is used up if it feels oily to the touch. Take out the valve cores for faster operation.

THERMOMETERS

These are available in analog and digital format. A really neat unit is the laser guided digital temperature gun. It is pointed at the component and measured at the point lit by the laser beam. A very handy and impressive tool to show the customer.

THE BEST WAY TO RECHARGE A VEHICLE

1. After leaving the vehicle in deep vacuum for 5 minutes to check for leaks, change the service hose to the refrigerant tank, purging out the air with a small amount of refrigerant gas. (This step is not necessary with pre-plumbed equipment)

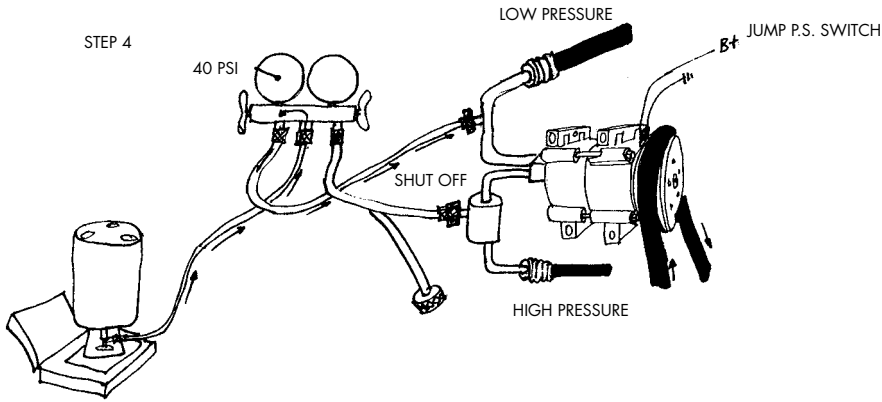
2. Charge the vehicle through both sides with gas or a small amount of liquid (about a quarter pound) until pressures equalize. This will give the system enough pressure to allow the compressor to turn on.

3. Start the engine and turn on the A/C, bridging the switches if necessary to get the compressor to run continuously

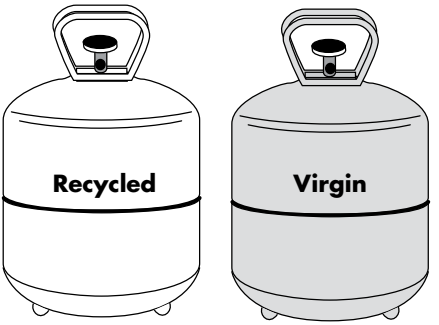
4. Charge the rest of the refrigerant through the LOW side as a Liquid, but do not allow the liquid to enter the low side at a rate exceeding 40 PSI at the gauge. This allows for fast , accurate charging without liquid entering the compressor, as it atomizes as it passes by the valves. If the rate of flow is increased, the liquid stream will damage the compressor.

5. After the charge has been measured in, shut off & disconnect the high side hose from the vehicle and feed the refrigerant charge from the high side hose to the low side hose through the gauge or machine valves, again not exceeding 4O PSI on the suction side. This ensures a correct charge as no refrigerant will be left in the high side hose. Be careful to follow this step carefully on a late model R-134a equipped vehicle as the refrigerant removed in the high side hose is enough to cause poor cooling. It is better to add a little refrigerant to the charge amount to compensate for the amount that will be removed when the high side hose is taken off still full of refrigerant.

    - Six foot lines hold 1.5 oz
    - Eight foot lines hold 2.0 oz
    - Twelve foot lines hold 3.0 oz



BEFORE USING ANY RECYCLED REFRIGERANT, CHECK ITS PRESSURE!



AIR CAN BE BLED OFF UNTIL CORRECT PRESSURE IS REACHED.

COMPARE THE PRESSURE TO A VIRGIN TANK OR THE P/T CHART.

TOO HIGH = AIR
TOO LOW = CONTAMINATED

PRESSURE/TEMPERATURE CHART OF R134A

This is also on the face of the pressure gauge, with the temperatures on the inner dial

F	C	R-134a (PSI)	F	C	R-I34a (PSI)
60	-51.1	21.5*	60	15.6	56.9
-50	-45.6	18.5*	65	18.3	64.0
-40	-40.0	14.7*	70	21.1	70.7
-35	-37.2	12.3*	75	23.9	78.6
-30	-34.4	9.8*	80	26.7	86.4
-25	-31.7	6.8*	85	29.4	95.2
-20	-28.9	3.8*	90	32.2	104.2
-15	-26.1	0.0	95	35.0	113.9
-10	-23.3	1.8	100	37.8	124.3
-5	-20.6	4.1	105	40.6	134.9
0	-17.8	6.3	110	43.3	146.8
5	-15.0	9.1	115	46.1	158.4
10	-12.2	11.6	120	48.9	171.9
20	-6.7	18.0	125	51.7	184.5
25	-3.9	22.1	130	54.4	199.8
30	-1.1	25.6	135	57.2	213.5
35	1.7	30.4	140	60.0	230.5
40	4.4	34.5	145	62.8	245.6
45	7.2	40.0	150	65.6	264.4
50	10.0	44.9	155	68.3	280.9
55	12.8	51.2	160	71.1	301.5

R-134a is in sky blue tank.
* indicates vacuum

CONVERTING FROM R-12 TO R-134A

Despite the many procedures offered by different vehicle manufacturers it is actually quite simple to covert a vehicle which is used in Northern climates. The usual concern of manufacturers in the conversion is that R-134a will generate higher pressures than R-12. However, a quick look at the pressure/temperature chart will show that the higher pressures occur at temperatures over 100F (38C). Since these temperatures are very seldom experienced in Northern climates, a vehicle can be reliable converted to R-134a easily. The conversion should be done when major components are being replaced, which usually indicates Dryer/Accumulator replacement.

1. While changing the components during the repairs, use only the newer blue or green O rings or O rings which are known to be R-134a compatible. However, it is not necessary to change all O rings. One which should be changed whenever possible is the discharge O ring at the compressor discharge port as it is this O ring which gets the most pressure and temperature. Some older (pre 1988) vehicles used a material called BUNA which can weaken with R134a.

2. Change the receiver dryer/accumulator. All driers and accumulators sold today are R-12/ R-134a compatible. This indicates the upgraded desiccant (XH7 or XH9) is inside.

3. Add synthetic ESTER oil so that 40% of the total oil charge is made up of Ester oil. As long as the existing mineral oil is in good condition (clear in colour), it may be left in. The mix of ester and mineral also helps to slow down leakage of the small R-134a molecule if a leak should develop in the future. In fact, it behaves just like an R12 system when it leaks, leaving a nice glob of oil and dirt for the technician to find. You can use PAG if you want, but it doesn't mix as well with mineral oil if you are going to leave in the system. Also, it comes in various viscosities and it is expensive. The water soluble PAG washes off with rain or condensation so it's really hard to find leaks later. If you decide that PAG is the only way to go, flush out the mineral oil first so that the system is not double oiled.

4. Install the conversion fittings. Some require the removal of the schrader valves from the original gauge fitting. Some don't. Cap off any spare fittings with permanent aluminum caps coated with Loctite 262 (red) on the threads.

5. Evacuate for 40 minutes to boil any remaining R-12 out of the oil.

6. Recharge with R-134a using a Maximum of 90% of the original R-12 charge. Try 4 oz less than the full 90% first. If it's not cold enough, increase 2 oz at a time but no more than the max. Most systems work really well on between 26-30 oz of R134a.

7. Ensure that the condenser cooling is PERFECT. This means checking the electric fan or fan clutch performance and the air flow through the condenser. R-134a high side pressures should not be more than 25PSI higher than the R-12 pressures on the same day. Be specially careful with vans that have rear evaporators. Check their high pressures with both units running. These ones may require an electric helper fan regardless of which refrigerant used.

8. Add a label indicating the conversion and the new charge amount.
   This conversion method will result in a system that is 98% as efficient as the R-12 system was.

ALTERNATE REFRIGERANTS

R134 (GWP 1300) has been baned in the EU as of 2011. What will take it's place? As of April 2007 the contenders are R744(CO^2, GWP 1), R290 (HC, GWP 10) and H-Fluid (GWP 140).

If the industry goes to CO^2, you may as well throw this book away as these systems run at 2000+psi. Everything will be different.

HC may win the day and HC is already in the market. Its flammability will dictate new equipment.

H fluid is a synthetic blend of gases that mimics R134a. If the industry adopts this refrigerant, all is well. Same equipment, same techniques.

They all work as far as cooling goes. But the issues to consider are:

- a blend that isn't hydrocarbon will require its own machine to recover
- warranty on compressors used on alternate refrigerants may be a problem
- when a leak develops, the lightest component of the blend goes first
- some of them cause neoprene hose to deteriorate

HYDROCARBON REFRIGERANTS

There are many of these products being offered. Lots of them are blends of 3 or more refrigerants and are flammable hydrocarbons. The car also has flammable gasoline or propane for fuel which of course is present in large volumes. After having used HC refrigerants for the last 8 years and watching national statistics on vehicle fires, I am now a proponent of this type of refrigerant.

WHY?

There will only be less than a pound of refrigerant in there. What's to burn? I have never had a fire and apparently it so rare that one single ignition will generate a flood of magazine articles. But not the 290,000 vehicles that burn annually in North America from fuel fires. Besides the lower and upper explosive limits (mixtures with atmospheric oxygen) are so narrow that its unlikely to occur in a vehicle.

- They are scented so that a strong odour will be present in the vehicle if the evap is seriously leaking.
- The larger molecule leaks slower than R134a
- HC's cool better due to their different latent heat value
- The compressor on time is less, which saves fuel. (I overcharged my 4.0L Jeep by 2oz and it is only on 30% of the time at 28C)
- The HC propels the oil through the system better as evidenced by lower compressor body temps.
- They are completely unregulated, so no paperwork, certification and can be added to leaky cars.

PLAN C

When a customer is driving an older, leaky car, especially with a leaky compressor or evaporator (or both), and doesn't want to spend the money to properly replace these parts, HC comes to the rescue. This will give the customer cold air today, providing the problem isn't a seized compressor or clutch. How long will it last? Depends on how leaky it is. I have had some last 10 days and others last 2 years and still freezing. Just don't offer any warranty on this repair.

- Bleed lots of nitrogen through the system (see Nitrogen Bleeding)
- Vacuum to the lowest vacuum you can get in 3 minutes. No longer, as you will begin to draw air into the system through the leaks.
- Charge immediately with the recommended amount of HC plus 2 oz. (to allow for leakage)
- Then add a can of sealer. Or 2 cans if there is only one type in the can, because you need both types, the hole sealer and the seal sweller.
- Run the vehicle for 20 minutes to circulate the sealer.
- Sick but works. Take cash only.

THIS CONVENENT PRODUCT HAS BOTH TYPES OF SEALER IN THE CAN

SEALANTS

These quick fixes work best on small evaporator leaks, sealing about 80% of them. With other components, the success rate is somewhat less. When using sealants, be sure to follow the instructions, as the vacuum the system will hold is a good indication of the size of the leak. These chemicals activate with moisture. So just shooting in the sealant and charging up the system will sometimes cause the sealant to activate internally. Then you will have the problem of hardened sealer inside the system, causing blockages and even worse leaks in the compressor. Change the dryer or accumulator and nitrogen purge the system several times to dry it out. Don't offer warranty to your customers with these products and don't expect warranty on compressor that fail due to hardened sealant inside.

NEVER recover the oil from a system with sealant inside. If your recycler has moisture internally (probably because it has never been serviced) the sealant will congeal inside and ruin your machine. Put a Recycle Guard on your machine so this doesn't happen

CHEMICALS

There are chemicals available that serve some good purpose. Make sure they conform to SAE J2670. That means they wont harm the A/C system.

- Performance enhancers
- Acid neutralizers
- Drying agents

The general idea of a performance enhancing chemical is to keep the oil off the inner walls of the refrigerant lines. That permits faster heat transfer from the refrigerant to the atmosphere and has the added benefit of speeding up the oil flow through the system. That keeps the compressor running a little cooler without flooding it with oil. It comes in a can and the whole can is added to the system. They work as advertised

The others should only be added in small – one or two drops- amounts. That's because that's all that's needed and minimizes any reaction with other chemicals that may have already been added.

SERVICE CHECKLIST
Air Conditioning Service Sequence

		Checked by:
1. Verify the Complaint	Check to see if A/C comes on, check controls, listen to the compressor	
2. Check the A/C lines with your hands if the compressor does comes on.	Do the lines feel hot , warm and cool where they should be? If not, see quick diagnosis	
3. Identify the refrigerant and hook up the gauges. Check the pressures, standing and running	Do the standing pressures look right? If not, check for leaks or air in the system	
4. Visual Leak Check, dye check	Any Oil? Always check the evaporator on orifice tube cars. See if the service valve or cap has dye on it. If so, look with the black light.	
5. Twist the hoses, remove hose covers	Loose at the connections? Badly rusted or corroded lines under the foam covers?	
6. Recover the Refrigerant	Make sure it's OK to recover into your machine. Recover only gas, not liquid, drain the waste oil from your machine after recovery is complete	
7. Leak check using Nitrogen	Any leaks? Use soap and the electronic detector Follow the procedure in the book	
8. Test run the compressor if you haven't heard it run	Leave about 80 psi of nitrogen in the system and turn on the A/C. See if it pump, makes noise and if the electric fans come on properly	
9. Check the rad and hoses, fan clutch and belt tensioner If the vehicle has electric fans, check the charging rate	A rotten rad will overheat the condenser, a bad fan clutch or a seized tensioner will wreck the compressor See 5 System Diagnosis	
10. Do the necessary repairs,	Always change the receiver dryer or accumulator, and change the cabin air filter	
10. Add oil and dye to the new components	See adding oil page 23	
11. Check your work with Nitrogen, then bleed N2 through the system for a minute	Just puff it up and check your new parts and handiwork. Watch out on Fords for the big boom!	
12. Evacuate using the vacuum pump, verify that the system is sealed by seeing if it holds 29.9"vacuum.	At least half an hour, or until the green indicator light comes on if using a micron gauge	
13. Recharge the correct amount, by volume or weight. Add correct amount for the service hose if hi side is on a liquid connection.	Use the recommended method in the book Purge the air out of the recycled tank and lines first.	
14. Let the vehicle warm up, thermostat open and check high side pressures, fan operation and compressor body temperature	Don't forget this step, never let the car go if the electric fan comes on over 300psi. Check the fan clutch.	
15. Stop the engine, leak check with the beeper	Last quality control step	
16. Feed the high side hose back in if it was connected to a liquid line	Only if you forgot to add enough to compensate for the hose. But then check high side temperature.	
17. Recover the service line	Always store your equipment with empty lines	

If the customer complains that "It's Not COLD enough" (but the system is operating properly under the hood)

1. Is the heater control valve closed? Does the heater hose feel cooler after the valve?
2. Is the hood closed? And is the hood seal in place and in good shape?
3. Is there any leaks in the evaporator case, letting hot air in after the evap, or letting cold air out?
4. Is the blower turning in the right direction?
5. Is the blend door binding? Does it flap to both sides? Can you move it farther towards "cold" with your hand?
6. Is the thermostat sensor at the outlet of the evap?
7. Is the engine overheating?

Detailed Air Conditioning Service

DIAGNOSIS

1	Type of System			
2	Ambient Temperature			
3	Normal Pressures			
4	Observed Pressures			
5	Fan Operation			
6	Compressor Temperature			
7	Line Temperatures			
8	Diagnosis			

RECOVERY

	Step	Check	Notes
1	Check refrigerant	Make sure its R134a	Use a verifier or gas analyzer
2	Drain the Oil Bottle	Find out how the oil is drained	Could have automatic, manual or no oil drain
3	Open the recovery tank if external, check level if internal	If not sure, open the vapour. Make sure the internal tank has room for recovery	Some machines will record amount recovered
4	Attach hoses to vehicle	Open the low side only to minimize oil removal	Use a Recycle Guard to prevent sealer removal
5	Start Recovery	Check procedure for the machine	Use an Identifier if there is any question of which refrigerant is in the vehicle
6	Stop recovery when system enters a vacuum		Some machines stop themselves
7	Check to see if dryer/accumulator is frozen	Frozen dryers indicate liquid is still in the AC system	Use warm water to speed up evaporation of liquid
8	Re-start recovery if pressure rises	This will remove the last bit of refrigerant	Some machines re-start if pressure rises
9	Drain Oil bottle	This oil came out of the car	
10	Bleed air from tank	Wait for tank to cool	

LEAK CHECKING PROCEDURES

STEP	CHECK	NOTES
1. Check for oil stains	Look with a flashlight	Check the evaporator
2. Look for dye, if installed	Use the black light, check evap drain	Special glasses help
3. Twist the hoses	Loose hoses will leak	Look for rusty lines under covers
4. Fill with Nitrogen	200 psi through low side	Keep high side gauge attached. Stand back for 30 sec.
5. Check with soap	Look for bubbles	Soak the compressor
6. Check with electronic detector	Work slowly	Verify operation of detector on high side. Check switches, back of condenser, evaporator drain or inspection hole
7. Let Nitrogen out slowly	Make sure you don't lose the seal on the end of the hose	Nitrogen goes back into the atmosphere

RECHARGING

	PROCEDURE	CHECK	NOTES
1	Check your work with nitrogen	All connections and new parts	Spray soap on welds of new parts, let N2 out into the air
1a	Purge with Nitrogen		If flushed, contaminated or changing refrigerants
2	Vacuum to 29"	Make sure the pump can produce deep vacuum	Stop pump to see if vacuum leaks down for 5 minutes
3	Check the refrigerant	Make sure there is enough and its air free	Check the pressure of the refrigerant vs the PT charts
4	Charge with correct amount through the low side	Check tank pressure, bleed air. Use low side with engine running	Keep suction pressure below 40psi
5	Add correct amount of oil	Use guide for each new part. Max 25% of Refrigerant	Use the oil injector or other methods
6	Check pressures	Make sure fan comes on	Over 300psi is excessive
7	Check Compressor temperature	Find the center of the body	40-60C is normal, below 40, remove oil, above 70, add oil
8	Remove hoses from the vehicle	Recover hoses	Always store AC machine with empty hoses
8	Final leak check	Use electronic detector	Check everything again, when hot

5 SYSTEM DIAGNOSIS

There are 5 systems that must work properly for the AC repairs to survive. Many AC problems are caused by the other systems on which the AC relies. It pays to do a full diagnosis and let the owner know the health of his vehicle. Then advise what repairs are urgent and what can wait. Oh, and adjust your warranty accordingly

DRIVE BELT SYSTEM:

Since the load on the serpentine belt will be increased with a recharged AC system, the belt system will need to be working well. Its time to inspect for cracks, glazing, tears, missing chunks and delaminating. Also the tensioner needs checking (see 'Belt Tensioners'). Make sure the idler pulley bearings aren't dry or noisy. If any accessories have recently been replaced, make sure their pulleys are lined up.

With the V belt systems, be sure to check to see if the top of the belt is flush with the top of the pulley groove. If it is sunk down, then its worn out. A new belt must fit flush or slightly above the top of the pulley and needs to be re-tensioned after one full heat cycle. That is a MUST!

Then make sure all the pulleys, including the crank, are rust free. Rusty pulleys must be sanded clean before belt replacement.

COOLING SYSTEM

Repairing the AC system will cause the condenser to release more heat into the radiator. Don't trade a working AC system for an overheating vehicle.

1. Look at the fins, are they loose or corroded?
2. Check for leaks where the header meets the tubes, where the tank meets the core and all seams including overflow reservoir.
3. Check the coolant level, is it low? If so, pressure test to find leaks
4. With the engine running, put the positive end of a voltmeter into the coolant without touching the rad. Put the negative lead on a good ground. If the voltage is greater than .5VDC, then the coolant is acting as a miniature battery. That's because its carrying little electrons to ground due to poor engine or alternator to battery ground. Fix the ground problems and flush the coolant.
5. Does the thermostat open at the right temperature? Check with an infra-red thermometer.
6. It's a good idea also to see if the water pump has started to weep or a cylinder head gasket. They won't cure themselves and the repair will be needed sooner with the increase in load from a working A/C system.

ELECTRICAL SYSTEM

If the vehicle has electric fans, simply observe the battery. If it is old or wet on top, get out the VAT. See if it draws more than 20 amps after 5 minutes of engine running. That's 20 less amps available from the alternator to run the electric fans. It has to go.

Look at the compressor clutch. Is it all rusty looking? If a clutch is slipping every time it engages, the two metal surfaces, hub and pulley, will rub some steel dust off. The magnetism in the clutch will keep the powdered metal hanging around. Then of course, the fresh metal dust rusts.

Check the charging rate, with all accessories on. Is it still above 13V? If not, that could later cause the voltage at the clutch to be low and the slippage increase. Check the voltage at the clutch too.

Picture of checking amp draw of battery

ELECTRONIC SYSTEM:
The PCM controls the engagement of the clutch. Its no good to repair and recharge an AC system only to find the blinking blue light of mystery when the AC button on the control panel is pushed.

After leak testing, leave about 80 psi of Nitrogen in the system and simply start the engine and AC. The computer will think the system is full and you will be able to see if the compressor engages and at what pressure the electric fans come on, if at all. If it won't engage, then the scan tool and voltmeters will have to come out, but that cost can be added to the estimate. Its hard to come back to the owner after repairs are complete with the 'electronic problem' and expect to get paid for repairing it.

AC SYSTEM.
Now you are ready to do the performance and diagnostic tests on the AC system.

REFRIGERANT CAPACITIES IN OUNCES

1 pound =16 ounces
Light numbers indicate R-134a Bold numbers indicate R12

Some vehicles offer Rear Evaporators as an option. Quantities for these vehicles are shown as:
F= Front air only R= With front and rear air

ACURA

Model	Year									
	99/01	98	97	96	95	94	93	92	91	90/88
2.2CL			22							
2.3CL	24	22								
2.5TL			26	26	26					
3.0CL	24	24	22							
3.2TL		26	26	26						
3.5 RL	23	26	26	26						
Integra	24	24	24	24	24	23	33	33	33	33
Legend					26	25	25	26	26	33
NSX	27	27	27	27	27	27	33	33	33	
SLX	21	21	26	26						
Vigor						25	28	28	28	

AUDI

Model	Year											
	99/01	98	97	96	95	94	93	92	91	90	89	88-85
A4	24	24	24	24								
A6	29	29	24	24	24							
A8	21	22	22									
Cabriolet		24	24	24	24							
90					24	24	23	35	35	35	35	
100, S4						22	23	35	35	35	35	
Quattro V8						31	31	40	40	40	40	
5000												38

BMW

Model	Year											
	99/01	98	97	96	95	94	93	92	91	90	89	88
3series	*1	*1	*1	*1	*1	*1	*1	*1	35	43	43	43
5series	42	42	42	*2	*2	*2	*2	*2	*2	43	43	43
7series	42	42	42	42	42	55	55	*2	*2	43	43	43
8series		55	55	55	55	55	55	55	55			
Z3	36	36	36	36								

*1 3 Series
Serpentine Condenser..... 36
Tube Condenser..... 44

*2 5,/ 7 series w/ Serpentine condenser..... 54
-with 22.5" wide Tube condenser..... 69

BUICK

Model	Year							
	99/01	97/98	96	95/94	93	92/91	90/89	88
Century	30	30	28 (2.2L) 32 (3.1L)		38	44	44	44
Electra						44	44	44
LeSabre	32	32	32	36	38	44	44	44
Park Ave	32	32	32	36	38	44	44	44
Regal	30	30	32	32	34	44	44 HR6 36 V5	44
Riviera	32	32	32	32	38	38	38	44
Roadmaster, Estate Wagon		28	28	50	50	56	56	
Skylark			32	32	36	36	36	36

CADILLAC

Model	Year							
	99/01	98	97	96	95	94	93	92/89
Allante							38	38
Brougham							50	53
Catera	41	41	32					
Cimmaron								36
Concours				32	32			
DeVille	32	32	32	32	32	32	38	38
Eldorado	32	32	32	32	32	32	38	
EscaladeF	36							
EscaladeR	44							
Fleetwood				32	32	32	38	38
Seville	32	32	32	32	32	32	38	38

CHEVROLET

Model	Year							
	99/01	98	97	96	95	94	93/90	89/86
Beretta				32	32	32	36	36
Camaro	24	32	*2	*1	32	32	36	40
Cavalier	24	24	24	24	24	24	36	36
Caprice			28	28	28	28	50	50
Celebrity							40	40
Chevette								36
Corsica				32	32	32	36	36
Corvette	25	26	26	32	32	32		
Impala	26							
Lumina	30	30	30	32	32	32	36	
Malibu	28	28	28					
MonteCarlo	30	30	30	30	32			44

Camaro *1 5.0L.....32
3.8L.....28

*2 5.0L.....32
3.8L.....26

CHEVROLET, GEO IMPORTS

Model	Year					
	99/01	95/98	94	93/92	91/89	88/87
Metro	21	21	18	18	18	
Nova						27
Prizm	25	25	25	25	18	
Spectrum					28	28
Sprint						25
Storm			21	26	26	
Tracker			21	26	26	

CHEVROLET & GMC Trucks

Model Year					
	2000/01	99/97	96/94	93	92/88
Astro/Safari F	32	32	32	48	48
Astro/Safari R	48	48	60	60	60
C, K, S, T Pickup/ 4wd Std Cab	32	32	32	40	40
Crew Cab	36	36	36		
Lumina APV, Silhouette, Transport F	32	32	36	42	
Montana ,Venture R	46	46	48	56	
Suburban, Yukon, Tahoe F	32	36	36	48	48
Blazer, Denali, Escalade R	48	64	64	68	68
G SERIES VAN F	48	48	48	48	48
G SERIES VAN R	72	78	78	78	68
P series		48	48	48	
Tracker		21			

CHRYSLER, DODGE, PLYMOUTH, EAGLE

Model	Year									
	2000/01	99	98	97	96	95	94	93	92/91	90/84
300M	28	28								
Acclaim					25	25	25			
Breeze, Cirrus	19	20	20	28	28	28				
Concorde	25	28	28	28	28	28	28	28		
Horizon/Omni										
Intrepid	25	28	28	28	28	28	28	28		
LHS	25	28	28	28	28	28	28	28		
Laser								33	33	33
LeBaron					24	24	26	33	33	33
Medallion									28	
Minivan F	34	34	34	34	34	34	34	34	30	32
Minivan R	46	48	48	48	48	48	48	48	40	40
Neon	27	28	28	28	28	28				
New Yorker					28	28	28			
Sebring	19	20	20	20	25	25				
Spirit						24	24			
Stratus	19	20	20	20	28	28	28			
PT Cruiser	25									

CHRYSLER, DODGE, PLYMOUTH, EAGLE (cont'd)

Model	Year									
	2000/01	99	98	97	96	95	94	93	92/91	90/84
Premier									36	36
Prowler	21									
Summit,							27	28	32	32
Wagon							27	36		
Talon						33	33	36	36	
Viper	30									
Vision						28	28	28		
FWD									34	30
RWD									36	42

CHRYSLER IMPORTS

Model	Year							
	97/01	96/94	93	92	91	90	89/88	
Avenger	26	27	28					
Colt		27	28	36	36	36	32	
Colt Wagon F					32	32		
Colt Wagon R					52	52		
Stealth		26	29	34	34			
Vista				32	32	30	32	

DODGE, PLYMOUTH Trucks

Model	Year						
		99/98	97/94	93	92/89	88/84	
D50, Ram50						32	
Durango F	28	28					
Durango R	32	32					
Pickups	32	32	32	44	44	44	
Minivans F	34	34	34	34	30	38	
Minivans R	46	48	48	48	46	52	
RamVan F	34	34	40	45	45	48	
RamVan R	46	46	60	65	65	65	

FORD/ MERCURY

Model	Year								
	2000/01	99/98	97/96	94/95	93	92	91	90	89/88
Aspire			26						
Contour									
Mystique	26	26							
Cougar	26	26	34	34					
Crown Victoria									
Grand Marquis	38	38	38	40	38	45	45	45	52
Escort	22	28	28	28	34	34	34	36	36
Focus	26								
Mustang	34	34	34	33	34	34	34	36	40

FORD/ MERCURY (cont'd)

Model	Year								
	2000/01	99/98	97/96	94/95	93	92	91	90	89/88
Probe		28	26	26	27	34	34	34	40
Taurus/Sable	34	34	34	32	36	36	36	40	44
Tempo/Topaz				31	36	36	36	36	36
Thunderbird		34	34	34	36	38	36	36	40
Tracer					34	34	34		

FORD/MERCURY Trucks

Model	Year				
	99/01	98/97	96/94	93/90	89/88
Aerostar F		38	38	48	56
Aerostar R		54	54	64	68
Bronco			38		
Econoline F	44	52	52	55	56
Econoline R	64	64	64	72	68
Excursion F	40				
Excursion R	68				
Expedition F	37	37			
Expedition R	62	62			
Explorer	30	30	30	32	
F Pickups	33	33	38	44	48
Mountaineer	30	30			
Navigator F	37	37			
Navigator R	62	62			
Ranger	30	25	25	32	36
Villager F	32	32	32	36	
Villager R	56	52	52	56	
Windstar F	44	44	44		
Windstar R	56	56	56		

HONDA

Model	Year									
	2001/99	98	97	96	95	94	93	92	91/90	89/88
Accord 2.7	23	22	21	21	21					
Accord 2.2	23	22	23	23	23	23	29	29	34	26
Civic, CRX	23	22	21	22	19	20	23	23	32	22
CR-V	24	23								
Del Sol				19	19	20				
Insight	19									
Odyssey F	23	22	22	22	22					
Odyssey R		32	29	29	29	29				
Passport	23	23	23	22	22					
Prelude	26	26	26	22	22	23	27	27	34	34
S2000	23									

HYUNDAI

Model	Year										
	2001/99	98	97	96	95	94	93	92	91	90-89	88-86
Accent	24	24	24	24	24	24					
Elantra	24	24	24	24	24	24					
Excel							32	32	32	35	35
Sonata	25	26	26	26	27	24	32	32	32	32	
Tiburon	26	25	25								

INFINITI

Model	Year									
	2001/99	98	97	96	95	94	93	92	91	90
G20	23			26	26	25	29	28	28	28
I30	24	24	24	24						
I30	26		27	27	27	26	26			
M30								32	32	32
Q45		24	24	28	28	29	40	40	40	40
QX4	24	24	24							

ISUZU

Model	Year									
	2001/99	98	97	96	95	94	93	92	91-89	88-86
Amigo	23	23								
Hombre	30	32	32	32						
Impulse							27	27	27	35
Oasis F	23	22	22	22						
Oasis R	29	29	29	29						
Pickup					23	23	27	30	34	30
Trooper	21	21	26	26	26	26	30	20	34	33
Rodeo	23	23	23	23	23	26	35	24	34	
Stylus							27	27	27	
Vehi-Cross	23									

JAGUAR

Model	Year								
	2001/99	98	97	96	95	94	93	92-88	87-85
S type									
XJ8	26	41							
XJR	40	41	41	41	41				
XK8	26	31	30						
XJ6			41	41	41	41	40	40	56
XJ12				44	44	44	44	40	56
XJS				41	41	41	44	40	56

JEEP

Model	Year								
	2001/99	99	98	97	96/95	94	93/92	91/90	89/84
Cherokee	22	22	22	22	32	34	38	38	36
Comanche						34	38	38	36
Grand Cherokee	24	26	26	28	28	28	28		
Grand Wagoneer								38	38
Wrangler	22	22	22	22	32	38	38	38	38
YJ									

LAND ROVER

Model	Year		
	2001/98	97	96
Discovery F	32	32	32
Discovery R	40	40	40
Range Rover	44	44	44

LEXUS

Model	Year								
	2001/99	98	97	96	95	94	93	92	91/90
ES250									27
ES300	28	29	30	30	29	29	34	34	
GS300	21	23	29	29	30	29	34	34	
GS400	21	22							
LS400	25	23	30	30	30	34	35	37	37
LX450			30	30					
LX470	37	34							
RX300	28								
SC300	33	33	33	33	33	29	34	34	
SC400	33	33	33	33	33	29	34	34	

LINCOLN

Model	Year							
	99/01	98	97/95	94	93	92	91/90	89/84
Continental	38	38	34	34	40	40	40	40
LS	28							
Mark 7, 8		32	35	35	34	40	40	40
Navigator F	37	37						
Navigator R	62	62						
Town Car	38	38	38	38	36	36	40	48

MAZDA

Model	Year									
	2001/99	98	97	96	95	94	93	92/91	90/89	88/86
323								30	30	30
626		26.5	25	25	25	25	32	32	34	
929					28	28	38	38	38	34
B2300			22	22	22					
B2500		30								
B3000		30	22	22	22					
B4000	30	30	22	22	22					
Millenia	26.5	26.5	26.5	26.5	26.5					
MPV F		35	35	35	35	35	37	37	42	
MPV R		32	32	32	32	32	51	51	51	
Miata	20	21	21	21	21	21	28	28		
MX-6	27		25	25	25	25	34	34	34	
Navaho							29	29	29	
Pickups								27	30	30
Protege	21	21	21	21	21	21	28	28		
RX-7					19	20	28	28	28	28

MERCEDES-BENZ

Model	Year									
	2001/99	98	97	96	95	94	93	92/91	90/89	88/86
190E							35	36	38	38
C class	29	30	30	33	33	33				
E class F	34	35	35	35	35	35	42	42	35	42
R		41	41	41	41	41	50	50		
S class F	39	42	42	42	42	42	42	42	35	42
R	42	45	50	50	50	50	50	50		
SLK	29	35	35							
ML320	27	27								

MERKUR

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NISSAN

Model	Year									
	2001/99	98	97	96	95	94	93	92/91	90	89/87
200SX			23	24	24	24	32	32	32	32
240SX			23	24	24	24	30	30	29	
300ZX				22	22	22	28	28	34	
Altima	28	28	28	28	28	26	26			
Axxess, F										
Van R								36	36	50
56										
Frontier	24	24								
Maxima	24	24	24	29	29	32	32	32	38	38
Pathfinder	25	24	24	29	29	27	32	32	32	

NISSAN (cont'd)

Model	Year									
	2001/99	98	97	96	95	94	93	92/91	90	89/87
Pickup		24	24	29	29		28		32	32
Quest F	32	32	32	32	32	28	35			
Quest R	52	52	52	52	52	44	56			
Sentra, NX		24	24	24	24	24	26	26	32	
Stanza								28	34	32
Xterra	25									

OLDSMOBILE

Model	Year								
	2001/00	99	98	97	96/95	94	93	92/91	90/88
88, 98	32	32	32	32	34	34	36	38	38
Achieva					36	36	40		
Alero	28	28	28	28					
Aurora	32	36	36	36	32				
Calais								36	36
Ciera 2.2L					28	28	38	38	
3.1L					32	32			
Custom Cruiser								56	56
Cutlass		28	28	28					
Cutlass Custom Cruiser							36	44	
2.2L					28	28			
3.1L					32	32			
Cutlass Supreme					32	32	36	36	36/52
Firenza									36
Intrigue	30	30	30	30					
Toronado								36	36

PONTIAC

Model	Year					
	2001/00	99	98/94	93	92/90	89/88
6000					44	44
Bonneville		32	32	38	38	44
Fiero						40
Firebird 3.8L	24		26	26	48	48
5.7L	24	40	32	32	48	48
Grand Am	28	28	28	40	40	40
Grand Prix	30	30	30	36	36	36
LeMans			35	35		
Safari Wagon						56
Sunfire/Sunbird	24	24	24	36	36	36

PORSCHE

Model	Year					
	2001/99	98/97	96/94	93/92	92/90	89/84
911	30	30	30	37	37	38
Boxster	30	30				
968			32	36	36	
944					34	34
928			32	36	36	33

SAAB

Model	Year				
	2001/99	98/95	94/93	92/90	89/86
900		26	26	36	35
9000		33	33	39	35
9-3	28				
9-5	31				

RENAULT

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SUBARU

Model	Year						
	2001/99	98/95	94	93	92/90	89	88/83
DL,GL,RX						28	28
Impreza	21	23	22				
Forester	23	22					
Outback	24	23					
Legacy	23	23	26	30	30	30	30
Loyale			28	28	29	29	29
SVX		22	23	23			
XT, XTS					28	28	28

SUZUKI

Model	Year		
	2001/99	98/94	93/89
Esteem	31	21	
Grand Vitara	21		

SUZUKI (cont't)

Model	Year		
	2001/99	98/94	93/89
Samurai		17	19
Sidekick		21	19
Swift	19	19	19
Vitara	16		
X90		21	

TOYOTA

Model	Year									
	2001/99	98	97	96	95	94	93	92	91/90	89/87
4Runner	23	23	24	24	24	26	30	30	30	30
Avalon	21	30	30	30	30					
Camry	28	29	29	29	29	31	34	34	34	34
Celica		24	24	24	24	24	28	28	28	28
Corolla	23	24	24	25	25	28	28	28	28	28
Cressida								36	36	36
Echo	16.5									
Landcruiser F	28	22	29	29	29	31	34	34	32	32
Landcruiser R	39									
MR2	17				26	26	30	30	32	32
Paseo			26	26	26	26	29	29		
Previa, Van F			31	31	31	31	35	35	35	29
R			40	40	40	40	44	44	44	40
RAV4	26	26	26	26						
Sienna F	29	29								
R 4dr	44	46								
R 5dr	48									
Supra		26	26	26	26	26	28	28	28	30
T100 Pickup		24	24	24	24	24	29	29	30	30
Tacoma	22	22	22	22	22					
Tercel	16	22	25	25	25	26	29	29	29	29
Tundra	21									

VOLKSWAGEN

Model	Year							
	2001/99	98	97/95	94	93	92	91/89	88/86
Beetle	25	26						
Cabrio	28	29	29	29	40	40	40	40
Corrado				36	40	40	40	40
Eurovan F	34			34	34			
Eurovan R	48			48	48			
Fox					38	38	40	42
Golf	26	29	29	29	40	38	40	42
GTI		29	29		40	38	40	42
Jetta	26	29	29	29	40	38	40	42
Passat	23	24	42	43	44	42	40	
Vanagon	50	50					51	51

VOLVO

Model	Year							
	2001/99	98	97/95	94	93	92	91/90	88/86
C70	29	26						
S40	31							
S70	29	26						
S80	35							
S90	31	32						
V70	29	26						
V90	31	32						
240					26	39	46	45
740					33	43	38	41
760								41
850			26	29				
940			34	34	33	43	38	
960			32	34	31	43		