Turn Up The Heat

Summer 2000 A/C Report

For so long and so often, you've heard R-12 supplies are running out, you've probably stopped believing it ever will happen. EPA officials at the Mobile Air Conditioning Society (MACS) 2000 convention don't blame you, but they say they have hard numbers now and suggest this summer will be the last with enough R-12. The total supply may be so close that all bets will be off late in the season, especially if this summer is a scorcher.

The EPA's numbers: 25 million pounds are available now, and 19 million will be needed through this season, leaving six million for 2001 (when EPA predicts 15 million will be needed). So should you retrofit any good candidate now? If you're replacing a compressor, the new pump was built for R-134a, so why not? Well, because nothing ever is that simple. The joker in this deck could be the condenser.

At low speeds and in very hot weather, R-134a doesn't perform as well as R-12. So this raises the next critical question: Are you in a location where the A/C could be under a cooling load that could result in a dissatisfied customer? If so, that often makes it worthwhile to stick with R-12, *unless* … unless you also install a new condenser — and not just any condenser that fits, either. See **Figures 1-4**.

Condenser Designs

There are four mass-production condenser designs, three of them are 'more efficient' than the first and earliest. The long-produced 3/8-inch tube-and-fin condenser is a perfectly good design, reasonably priced and used for a long time in R-12 systems. But size for size, it can't condense as much refrigerant gas to liquid as any of the newer designs. And with the higher pressures of R-134a, that becomes a cooling performance difference. Consequently, the 3/8-inch condenser has few remaining applications in R-134a systems.

You can find the 3/8-inch round tube condenser as a replacement. But never use it to replace any of the following later-design condensers:

- 6 mm round tube-and-fin (smaller diameter tubes, more densely packed to transfer more heat in less space), and with an improved refrigerant flow pattern,
- serpentine (snake- or wave-like tubing pattern from inlet to outlet, typically several flow paths within that tube),
- parallel multipath (a series of oval tubes with parallel flow paths, each oval tube with more than nine passages in the superhigh-efficiency designs).

Condenser design seems to be the most critical for ‘underbody breathers,’ cars with the radiator/condenser air inlets below the bumper, drawing cooling ram air from just above the pavement. Among imports, Honda Accords with R-134a systems long have used high-performance, parallel-flow multipath condensers, and nothing less will work. Today, you can get aftermarket replacements in reputable name brands. Most Toyotas needing a replacement condenser will require the equal of their original condenser, some of which are high-performance serpentines.

Unfortunately, these high-efficiency condensers are more expensive, so replacing a 3/8-inch tube-and-fin condenser with one of these could add hundreds to your retrofit bill. If the compressor failed and has to be replaced, too, this could make the job a very tough sell. When a compressor fails, the scattered debris often restricts flow through the condenser. A 3/8-inch condenser has large openings and a simple flow path, so you can often flush out failed compressor debris.

The more efficient condensers typically have very tiny flow passages to achieve a higher surface-to-volume ratio and thus improved heat-transfer. After a compressor failure, they often plug with debris and defy all attempts to flush (see **Figure 3**). In fact, there’s no way you can tell how successful (or unsuccessful) flushing has been on a car, until you put the system back in service. Installation of an in-line filter on the high-pressure side is the *only* way to catch debris residue. This keeps debris from circulating through the system and causing restrictions or a repeated compressor failure. Finding a suitable location, however, isn’t always possible. Few imports have orifice-tube systems, but on those that do, inspect the orifice tube for compressor debris, and replace it if necessary.

Given all of these potential problems, are you better off just flushing a 3/8-inch condenser and reusing it for retrofit? As with many automotive A/C problems, there are no perfect answers.

If your customer simply wants moderate cooling and can tolerate the limits of R-134a in an older-design condenser even when the weather is torrid, a basic retrofit can serve his interests ‘enhancements,’ such as an auxiliary pusher fan, can be left to a later ‘let’s-see’). Just do the job ‘by the numbers’ so it holds up.

Retrofit ‘By the Numbers’

1. Check the manufacturer’s recommendations for retrofit. They should be in your CD-ROM service information system. Or get a retrofit manual from MACS (215-679-2220). You might find the system you’re servicing requires some special seals or other parts.

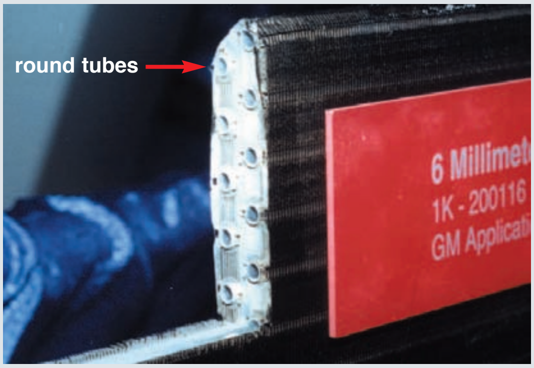


Figure 1: *Cutaway of 6 mm tube-and-fin condenser. The tubes are round, and because they’re narrower than the previous 3/8-inch tube-and-fin, more fit into a smaller package. Because of that and other design features, this condenser is a more efficient heat exchanger.*

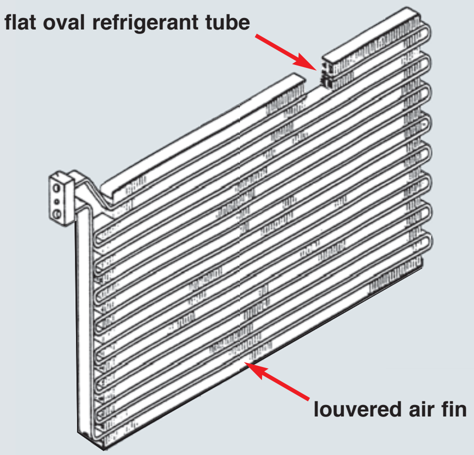


Figure 2: *Serpentine condenser is made from a flat oval tube, usually with multiple passages. The tubing snakes horizontally as shown, from inlet to outlet and with heat-transfer fins in between. Flat oval tubing of the serpentine condenser is cut away in the photo, showing this one has five passages across each tube.*

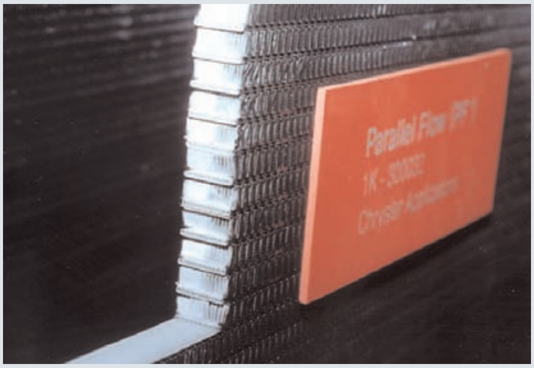


Figure 3: *There are 19 paths in the flat-oval tubing of this parallel-flow multipath condenser, a very high-efficiency design. Of course, the paths are so tiny that if the condenser plugs with debris from compressor failure, it’s impossible to flush.*

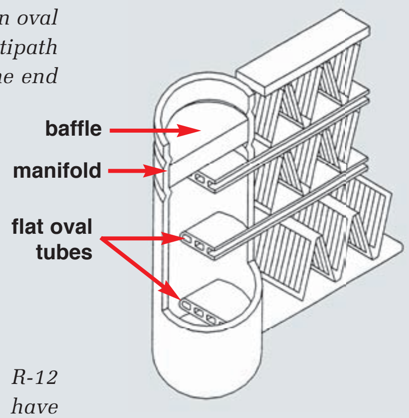


Figure 4: Cutaway of an oval tube parallel-flow multipath condenser. Baffles in the end manifolds produce the flow paths.

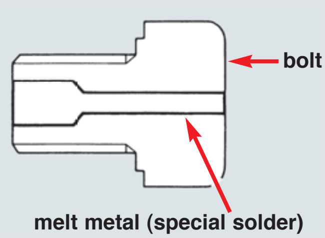


Figure 5: Japanese R-12 compressors typically have 'melting-bolt' pressure-relief valves. High pressure produces high refrigerant temperature, melting the special solder in the bolt and venting the refrigerant into the atmosphere. Because this relief valve cannot 'reset,' you must replace it if it opens.

Examples: Nippondenso compressors normally require new O-ring seals. Sanden compressors for European cars may require new shaft seals. And you can forget about retrofitting vehicles equipped with Panasonic (rotary) or Keihin (piston) compressors.

2. Draw a deep vacuum, allowing the system to outgas any refrigerant and any moisture. If the system won't pull down to 28 inches and hold for a few minutes with the pump off, find and fix the leak. R-134a may be less expensive than R-12, but that doesn't mean a leaking system is acceptable.

3. Replace the accumulator or receiver-dryer with one using XH-7 or XH-9 desiccant. There are no options on this one, since that R-12 system must now be at least six years old. Recharge the system with the specified amount of R-134a, typically 85 percent of the original R-12 charge. Charge accurately, as discussed in this report. Don't add extra refrigerant to compensate for a small leak. Instead, find and fix the leak.

4. Use the PAG (*p*oly *a*lkylene *g*lycol) oil recommended by the compressor supplier Every compressor supplier that ships 'dry' compressors recommends a PAG oil and will void the warranty if you use a *p*olyol *e*ster (POE) oil instead (and that difference can be identified easily).

5. Install a high-pressure cutout switch if the vehicle came without one. Again, this is not an option; it's the law. If the old compressor still is usable, your best choice is a switch that cuts out at 400 psi. or lower (to protect the compressor clutch) and cuts back in about 280-300 psi. (so there's some cooling without a long delay). Japanese compressors in R-12 systems often use a 'melting-bolt' pressure-relief valve, and if this opens, it can't reset (**Figure 5**). You'll have to replace it. Install the cutout switch with a fitting on a service valve or with a saddle fitting on the liquid line, both of which you can get from all the major A/C service parts distributors.

6. Pay attention to details. Fit plastic foam strips into front-end gaps around the condenser and radiator, around the headlamps, etc., so all the air *must* pass through these heat exchangers and *none* can pass around them. If there's a fan shroud, make sure it fits properly. On systems with an accumulator, wrap it with insulation (household foil-backed foam tape works). Secure refrigerant lines to their brackets, adding any brackets necessary to shield the lines from the exhaust or other hot surfaces of the engine.

7. Check the fan operation. A fan clutch that slips or an electric fan that comes on late will raise system pressures, reducing cooling.

8. Don't forget an R-134a-retrofit label to go with the new fittings. And be sure to put a new retrofitting on *both* service valves, not just the one you use to charge the system.

9. If you're replacing a compressor that failed, explain your condenser decision to the customer, too.

Replacement Condensers

The condenser, part of the car's crush-zone, is one of the first parts to go in a front-end collision. Both the motorist and the insurance company will put the pressure on to do the repair for less. Saving money by installing a 3/8-inch tube-and-fin replacement condenser is tempting. But that solution may mean a 25-percent reduction in cooling capacity (maybe even lower capacity than that).

How to tell a good replacement condenser? It's not simple. Sticking with the major brands and picking the recommended replacement type are your best bets. The big companies (and most smaller suppliers) just won't list a woefully inadequate condenser.

Figure 6: *This recovery/recycle/recharging A/C service equipment is what GM dealers must use for all A/C warranty work. It's electronically-controlled and designed for extreme accuracy in system charging. Although it includes a lot of features designed for GM dealers (including a humidity gauge to tie in to GM diagnostics), it's also led the industry to produce machines that work faster, charge more accurately and require less maintenance. Machines are available to the aftermarket this year reflecting improvements spurred by the GM development program.*

Figure 7: *A clean machine is less likely to ingest dirt through the air intakes for its compressor (shown) and vacuum pump, and a clean machine performs better. So cover you're A/C machine when it's not in use.*

Figure 8: *The refrigerant tank should fit squarely on the scale. In this case, there's a raised retaining ring.*

However, even among the 6 mm serpentine and parallel-flow multipath designs, there's significant variation in design and manufacturing quality and therefore, in performance.

The details are still being worked out, so nothing is for sure in the following:

The real answer is a heat-exchanger rating system, and MACS supports a program to produce ratings for all automotive heat exchangers. The Performance Review Institute, an affiliate of the SAE (Society of Automotive Engineers) in cooperation with committees of industry technical specialists, has been asked to help produce and then administer the program. If it goes into effect, each condenser from a participating manufacturer would be compared with the original equipment specification part, for heat-exchange capacity, for fit and for durability.

Charge Accuracy

Today's R-134a systems take as little as 16-18 ounces of refrigerant. The systems are leak-tight, and the low capacities leave little margin for error, low or high. A 10-percent margin still is the rule of thumb for charge accuracy. However, on late models that translates into 2-3 ounces, not the 6-8 ounces of older systems with their 3 to 4-1/2 lb. capacities and their giant receivers (handy reservoirs because the old systems leaked a lot).

So did every shop that invested in charging equipment that promised '0.1 lb.-pinpoint accuracy via digital scales and electronically-controlled solenoid valves actually get that accuracy? The short answer is "no."

Folks, there's a big difference between a machine's capacity to *display* a resolution of 0.1 lb. (1.6 ounces) and its capacity to *meter* refrigerant into an A/C system with such precision. In the early '90's, General Motors had its dealers buy then-state-of-the-art machines, and GM soon found these machines typically delivered refrigerant with 15-20 percent variation in charge volume — on three-lb. systems. With system-capacities coming down, the charge variation percentages would go up, and that was a disaster in the making. Too much refrigerant raises pressures and causes noise; too little affects lubrication and causes noise; either reduces cooling.

New Machines

A/C performance after service wasn't good in too many cases, and perfectly good compressors were being replaced unnecessarily. So GM and Delphi (its former parts division) teamed up with equipment manufacturers to develop a new generation of machines that not only recovered, recycled and recharged a lot faster, but also did so more accurately.

The so-called "Y2K technology" was promoted among all the equipment manufacturers, not just those who competed for the GM contract (**Figure 6**). So if you look at what's new, you'll find Y2K technology widely available and at a modest premium over the older models. The Y2K technology machines have microprocessors that not only calculate the amount of liquid refrigerant left in the line during a high-side charge, but may pull it back into the machine after the recharge is complete. If you want to use longer or shorter hoses, the machine can be reprogrammed to compensate. These features can overcome charge-variance inaccuracies, which may occur if different technicians use different recharge techniques.

The refrigerant scales are an improved, higher-accuracy design whose calibration can be confirmed in the shop — no more excuses. There's a new built-in refrigerant identifier that's more robust, so it won't die from a few drops of refrigeration oil. If you already have a hand-held identifier that can read percentage of air in the system, you can hold off on this purchase.

Figure 9: This tank was simply placed on *the scale, but not* in *the retaining ring. The tank is tilted against the side and the scale cannot register accurately, so charging weight may be incorrect.*

Figure 10: An R-12/R-134a-compatible conventional leak detector that meets the most recent leak detection standards is an acceptable substitute to find refrigerant leaks when trace dyes are not permitted by the manufacturer.

Your Old Machine

Want to get more use from your current A/C machine before you buy a new one? Then don't keep pressing the CONTINUE button (or bypass whatever tells you to change the filter), but maintain your machine. The simplest kind of all: Keep it clean and covered when you're not using it, so dirt doesn't accumulate and then get sucked in through the air intakes (**Figure 7**). Change your filters. Change the vacuum pump oil after each 10-15 hours of operation, so the pump can consistently pull a deep vacuum, and you don't chase imaginary refrigerant leaks (the new GM-dealership machine has an oil-less vacuum pump to eliminate this maintenance, but this approach has both pros and cons). Mount your tank squarely on the scale so your reading is accurate (**Figures 8, 9**), and call the equipment manufacturer to learn how to recalibrate it in your shop (often there is such a method, even if it isn't published in the operating manual).

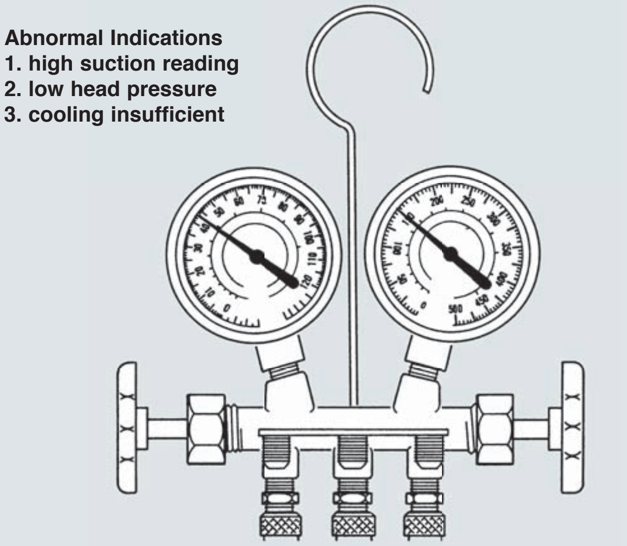


Figure 11: *This A/C diagnostic diagram has reinforced the idea among many techs that if the suction-side reading is high and the high-side pressure is low, the compressor is bad. However, a suction-side restriction can produce the same readings.*

Tracing Leaks

Nissan explained at the '99 MACS convention that its own dealer techs had trouble tracing refrigerant leaks and that Japanese techs did even worse than their U.S. counterparts. With trace dye in the system, however, both Japanese and U.S. techs found about 90 percent of the leaks, so Nissan approved a trace-dye kit. This year, Nissan tech executives said trace dye was installed in vehicles on the production line. Nissan started on Japanese-built models last August and on U.S.-built vehicles this January. If the system contains dye, the underhood refrigerant label color is green (instead of blue), and there's a green dot on the top of the receiver/dryer.

Toyota's U.S. tech people concede they would like to see a trace dye approved, but the hangups are in Japan, where the engineering work must be completed. And that hasn't happened yet. Until then, use an up-to-date conventional leak detector (**Figure 10**).

Hose Collapse

An *Import Service* reader reported this problem in the April 2000 issue, and it also was covered at the MACS convention. Today's barrier hoses have a multi-layer construction, and with the manufacturers tweaking the designs to increase hose flexibility, it wasn't surprising to find the innermost tube (through which the refrigerant flows) separating from the next layer.

The Toyota Camry and Lexus ES300 are the first car models on which the problems surfaced, but we'll bet they won't be the last. When the problem occurs in a suction-side hose (as it did in our reader's case), that delaminated hose section forms a restriction. Suction-side pressures go up, and high-side pressures hold or drop somewhat (depending on operating conditions). The pressures on both sides often end up close to each other, so it looks like a classic case of a bad compressor. A lot of compressors have been replaced unnecessarily as a result.

Just remember also that the suction side *can* form a restriction, even without an accumulator. In addition to internal hose collapse, there's a suction-side pressure regulator on Lexus LS and SC models. The Nissan Maxima/Infiniti I30 with R-12 systems had a suction-throttling valve, which performed a similar function. If one of these fails high, it also mimics a compressor problem (**Figure 11**).

One MACS member flushed a suction hose and saw no evidence of a restriction. But the high pressure of the flush probably just flexed the innermost layer out, because once he cut the hose open, he found it permanently deformed inward.

Belt Lock Controller Failures

They may not happen often, but as Toyota and Mitsubishi tech trainers told the MACS convention, Belt Lock Controller failures often are misdiagnosed. The BLC is commonly used on Japanese cars with an accessory belt shared by the A/C compressor and such critical components as the water pump, alternator and power steering. It's supposed to sense belt slippage and, at a certain slip threshold, open the A/C clutch electrical circuit so the other more critical components continue to function.

Figure 12: *The belt lock controller is a separate electronic module as shown, or it may be part of the A/C module ("amplifier") on Japanese cars where the A/C compressor shares a drive belt with other accessories.*

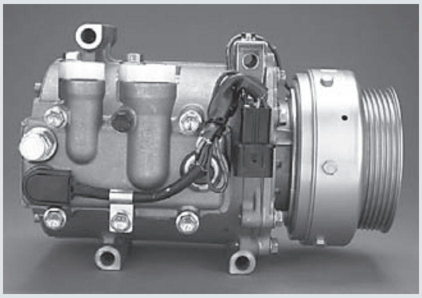


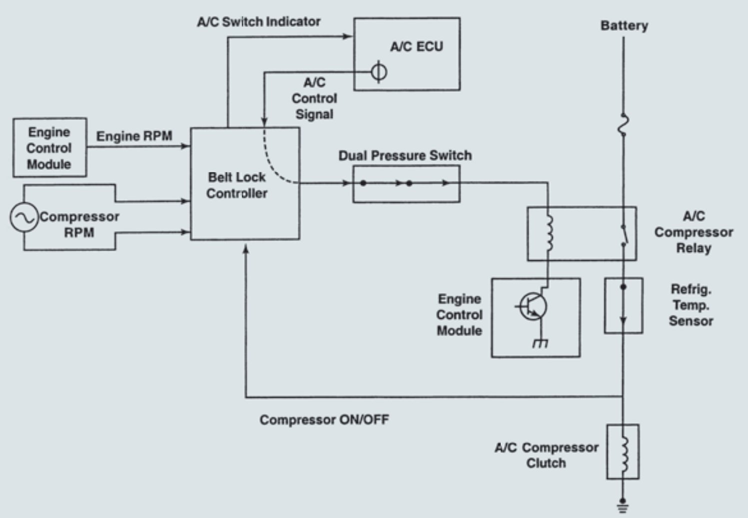
Figure 13: *The compressor rpm sensor is at front of compressor, as shown on the inboard side. Remove compressor for access and replacement.*

Figure 14a

Figure 14b

The warning light flashes when the belt-lock-controller circuit triggers. In this illustration above the light is in the car outline, and the outside air arrow points to it (14a). Warning light on the model below is a red snowflake (14b). On Mitsubishi Expo LRV, warning light may be at the underside of the dash, close to the steering column.

The BLC is an electronic module under the dash – **Figure 12** (or part of the A/C module – called the "amplifier"). It receives an A/C-on signal from the control head (or a pressure switch) and compares compressor rpm (sensor signal, **Figure 13**) with engine rpm. If it detects belt slip, the module should open the clutch circuit and trigger a blinking red light on the HVAC display (**Figures 14a and 14b**). Refer to the schematic in **Figure 15**. If the clutch doesn't engage but the warning light also doesn't flash, the engine idle doesn't increase, etc., forget the BLC system: Your problem is elsewhere. But if the light flashes and the A/C clutch fails to engage or quickly disengages, you do know where to start.



- *The belt isn't slipping?* Then look for a BLC failure. But if you understand the circuit, you won't just throw parts at the problem until that light stops blinking. Start with a warmed up engine and press the A/C switch.

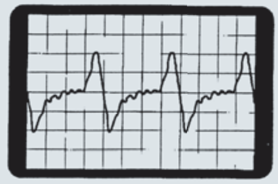
- *But the clutch doesn't click and engage!* Over a brief period, the engine idle increases, the warning light flashes, and that's it. Forget belt slippage or the compressor rpm sensor, because that compressor shaft didn't turn a degree. If a Toyota electric fan is running at high speed, that shows the powertrain computer believes the engine is overheating, and in that case it would not permit engagement of the A/C clutch. Denying an A/C request because the engine is running too hot is a standard strategy, so checking the engine coolant temperature sensor signal should be part of your routine diagnostic procedure. Depending on the computer strategy, the coolant temperature sensor issue may or may not trigger the BLC warning light. However, this is basically an electrical/electronic problem, in the circuit before the BLC module comes into play.

Figure 15: *Representative circuit for a belt-lock-controller system. The BLC module gets an engine rpm signal from the engine control module, a compressor rpm signal from the compressor and two A/C-on signals, one from the A/C switch and another from the A/C module.*

This article was developed using the following Snap-on air conditioning service equipment: the EEAC312B Refrigerant Identifier, the ACT725 Leak Detector, and the ACTR 5134 Manifold Gauge Set. Your Snap-on dealer has more than 14,000 items available for all your diagnostic and service needs. Visit Snap-on on the web at www.snapon.com.

Turn Up the Heat

RPM Sensor Signal



LOCK IN Signal Waveform

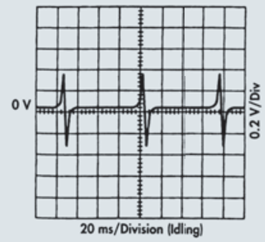


***Figure 16** (right): Representative waveforms for the compressor rpm sensor, as measured at the rpm sensor terminal of the BLC module under the dash, using a scope. The top illustration is from a Mitsubishi, the bottom one from a Toyota. Simple resistance checks also can be made, but are less accurate.*

- *The clutch clicks or tries to engage, but it doesn't succeed!* Within a brief period the engine idle increase cancels and then the warning light flashes. This time, you'll have to go through the circuit, checking all the inputs, connections and grounds, and the amplifier (which includes the BLC circuit on many cars). You'll also have to test the compressor rpm sensor, and although a simple resistance check is included in most shop manuals, the more meaningful test is with a scope. The patterns are similar from one make to another (**Figure 16**). The sensor is replaced easily once the compressor is removed.

Clean Out the Air Intake

If leaves and other airborne debris jam the fresh air intake, that's trouble. If the stuff packs up against a hot blower controller or resistor, that can set the leaves smoldering. Even if there's an intake air filter, this debris can prematurely plug the filter and reduce airflow. The manufacturers have tweaked their intake grille designs to keep debris out, but nothing is a perfectly satisfactory answer. Nissan has released a number of replacement grilles and seals for its vehicles, most recently for the 1992-95 pickup, the 1995-97 Maxima (cowl cover) and 1995-70 (wiper shaft seals) and 1993-97 Altima (cowl seals).

Volkswagen has a shield over its intake air filter, but somehow the filter on an *Import Service* test car accumulated a substantial collection of leaves and other debris in just a few thousand miles.

***Figure 17:** Plastic shield at the fresh air intake of a VW Passat. With an intake air screen above it (not shown) and this cover itself, you'd think the cabin air filter underneath was well isolated from anything but the finest airborne dust.*

***Figure 18:** But when the plastic shield is removed and we pull out the filter, it shows a surprising amount of leaf debris after just a few thousand miles.*

If the motorist complains about poor cooling, maybe the real problem is poor airflow because of accumulated debris. And on cars with no filter, that debris coats the moist evaporator face and provides an ideal breeding pen for malodorous fungus. Put your shop vacuum to work early and often (**Figures 17 and 18**). ■

—By Paul Weissler